

Review began 09/15/2023
Review ended 09/25/2023
Published 09/28/2023

© Copyright 2023

Dias et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Unveiling Realities: Exploring and Uncovering Young Adults' Views on Navigating Confidentiality and Disclosure in Healthcare Settings in Bangalore, Southern India

Andrea N. Dias ¹, Shirin Laturkar ², Jeevitha K M ³, Anand D. Meundi ⁴

1. Surgery and Public Health, Shri Atal Bihari Vajpayee Medical College and Research Institute, Bangalore, IND 2. Anesthesiology and Public Health, Shri Atal Bihari Vajpayee Medical College and Research Institute, Bangalore, IND 3. Data Science, Prasanna School of Public Health, Manipal Academy of Higher Education, Udipi, IND 4. Community Medicine, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Bangalore, IND

Corresponding author: Andrea N. Dias, andreadias131@gmail.com

Abstract

Introduction

Research on the healthcare available to young adults in India is negligible. There is little to no data available to describe the Indian young adults' knowledge and attitude toward a doctor-patient interaction and their perceptions on what might be a barrier to confidentiality. Young adults in India, often face the unique dilemma of being old enough to make their own medical decisions and yet often finding themselves without the freedom or knowledge to do so. Understanding factors that young adults perceive to be affecting confidentiality and a barrier in their healthcare checkups can greatly improve the quality of healthcare provided to them.

Objective

The objective of the study was to assess knowledge and attitudes among young adults in Bangalore City regarding the maintenance of confidentiality by a doctor while seeking healthcare and to identify perceived factors the young adults believed to be affecting confidentiality and information disclosure when seeking healthcare.

Method

A cross-sectional, descriptive study was carried out using multi-stage random sampling. Four colleges were randomly selected from four geographic zones in Bangalore City (North, East, South, and West).

The investigators developed a 30-question questionnaire, comprising sections on patient details, perceptions regarding confidentiality, factors influencing history disclosure, etc., which was validated by a panel of four faculty members from one para-clinical and two clinical departments each, belonging to the investigators' medical college.

Subsequently, a pilot study with 33 participants was conducted and a sample size of 60 was arrived at assuming an 83.87% favorable knowledge regarding the right to refuse to disclose information to a doctor, with a 95% confidence interval and a 10% absolute allowable error. Further validation was done following the pilot study.

Student lists from the chosen colleges were obtained, and the required sample size was distributed based on probability proportional to size (PPS): 19, 19, 12, and 10 participants from the respective colleges. Random number tables were utilized to select the required number of participants from the student population. The participants of the pilot study were not included in the study. The questionnaire was administered digitally by the investigators, and in cases where a student declined to participate, an alternative participant was chosen using random number tables.

Results

Results demonstrate that 21.7% (13) of respondents were unaware that a doctor is legally bound to keep details of the visit confidential. A total of 93.3% (56) of the respondents report that a parent/guardian plays an active role in their doctor's visit. Only 16.7% (10) of respondents strongly agreed that they felt comfortable enough to have an honest conversation with their doctor. Respondents report that they were most likely to withhold history regarding sexual practices (55%), alcohol use (35%), and smoking (31.7%).

Conclusion

How to cite this article

Dias A N, Laturkar S, K M J, et al. (September 28, 2023) Unveiling Realities: Exploring and Uncovering Young Adults' Views on Navigating Confidentiality and Disclosure in Healthcare Settings in Bangalore, Southern India. Cureus 15(9): e46158. DOI 10.7759/cureus.46158

Healthcare providers should take all possible measures to ensure confidential and quality care to the vulnerable young adult population. Breach of confidentiality, often in the form of a parent or guardian being present during the history-taking process, can be a barrier to building good rapport and negatively impact the doctor-patient relationship.

Categories: Family/General Practice, Public Health, Health Policy

Keywords: doctor-patient interaction, young adults, parent, guardian, confidentiality

Introduction

Young people are a diverse group with specific needs when it comes to their health and well-being [1]. Young adulthood ages approximately 18 to 26 is a critical time in life [2]. Although considered a relatively healthy demographic group, during this period, a high degree of exploratory behaviors are common as part of the process of establishing and developing self-identity. Meanwhile, the cognitive capacity for balanced reasoning is not yet fully developed. For these reasons, adolescence and young adulthood are characterized by increased likelihood of engaging in risky behaviors such as illicit drug use, binge drinking, and unprotected sex [3]. Efforts to provide preventive care to young adults are complicated by the fact that navigating the healthcare system during the transition from pediatric to adult providers is confusing and difficult [4].

Confidentiality protections are critical in the provision of comprehensive primary care for young adult patients [5]. Existing literature suggests that actual or perceived limits to confidentiality could influence the decisions of young adults about whether, and where, to seek care [2]. Indifferent treatment of patients and lack of patient privacy are common, yet are rarely acknowledged by traditional quality assessment methods [6]. When concerned about privacy, young adults are less likely to communicate openly with healthcare providers, particularly about issues related to substance use, mental health, and sexual behaviors, which influences information exchange about key health issues for this age group. Privacy concerns also influence these young adults' willingness to receive services such as pelvic examinations and testing for STIs or HIV, which should be a part of routine care for many youth [7]. Furthermore, qualitative analysis reveals that youth worry about privacy and may lie about their risk behaviors or not seek healthcare when concerned about confidentiality [8].

Young adults often forgo important sensitive services when they face a breach of confidentiality, which most likely occurs when their parents have access to the adult child's health information [9]. The presence of "informal" healthcare advocates during physician visits represents a unique privacy challenge [10].

Young adults should have access to developmentally appropriate high-quality confidential healthcare within professional, ethical, and legal guidelines. Clinicians and healthcare systems who provide this care have a higher likelihood of being able to effectively address the types of sensitive health issues linked to major causes of morbidity and mortality in this age group. These include health issues related to sexual behaviors, substance use, and mental health. Strategies to facilitate the ability to provide confidential healthcare include explaining its importance to parents and youth, routinely spending part of each visit alone with the patient, discussing confidentiality, and addressing issues that increase the risk of unintentional disclosure of protected information [11].

The primary objective of this study was to assess the knowledge and attitude of young adults in Bangalore city regarding doctor-patient confidentiality in seeking healthcare. Additionally, the study aimed to identify the perceived factors affecting confidentiality and information disclosure when seeking healthcare among these young adults.

Materials And Methods

A cross-sectional, descriptive study was carried out using multi-stage random sampling. Four colleges were randomly selected from four geographic zones in Bangalore city (North, East, South, and West). All medical colleges and other healthcare-associated colleges were excluded.

The investigators developed a 30-question questionnaire, comprising sections on patient details, perceptions regarding confidentiality, factors influencing history disclosure, etc. (multiple choice questions). A panel of four faculty members from one para-clinical and two clinical departments each, belonging to the investigators' medical college performed face validation and content validation.

Subsequently, a pilot study with 33 selected participants was conducted to calculate the required sample size. Assuming an 83.87% favorable knowledge regarding the right to refuse to disclose information to a doctor with a 95% confidence interval and a 10% absolute allowable error with a sample size of 60 participants was reached. Necessary changes were made to the questionnaire based on the feedback received by the participants of the pilot study. Another round of face and content validation was done following which the questionnaire was administered to the participants of the study.

Student lists from the chosen colleges were obtained, and the required sample size was distributed based on probability proportional to size (PPS). This resulted in the selection of 19, 19, 12, and 10 participants from the respective colleges. Random number tables were utilized to select the required number of participants from the student population. The participants of the pilot study were not included in the study. The questionnaire was administered digitally by the investigators, and in cases where a student declined to participate, an alternative participant was chosen using random number tables.

Data obtained from the study were managed using MS Excel (Microsoft Corporation, Redmond, Washington), and data analysis was performed using R software. The study obtained approval from the Institutional Ethical Committee, i.e., the Ethics Committee of Bowring and Lady Curzon Medical College and Research Institute, approval no. BLCMCRI/IEC/RP/105/2021-22.

Results

Sociodemographic characteristics

Among 60 respondents, 31 (51.7%) of respondents were male, and (29) 48.3% were female. The age group of respondents ranged between 18 and 25, with the majority of respondents aged 21 (45%), 20 (35%), and 22 (10%) years. The majority of respondents were heterosexual (86.7%) and unmarried (96.7%). They were largely Hindu (53.3%), Christian (25%), and Muslim (10%). Of the respondents, 36.7% were sexually active, 43.3% were not sexually active, and the remaining 18.3% preferred not to say (Table 1).

Demographic characteristic	n (%)
Gender	
Male	31 (51.7)
Female	29 (48.3)
Age	
18	0 (0)
19	5 (8.3)
20	21 (35.0)
21	27 (45)
22	6 (10)
23	0 (0)
24	0 (0)
25	1 (1.7)
Sexual orientation	
Heterosexual	52 (86.7)
Homosexual	1 (1.7)
Bisexual	1 (1.7)
Pansexual	1 (1.7)
Asexual	3 (5.0)
Prefer not to say	2 (3.3)
Marital status	
Unmarried	58 (96.7)
Married	1 (1.7)
Prefer not to say	1 (1.7)
Level of education	
College - first year	1 (1.7)
College - second year	14 (23.3)

College - third year	38 (63.3)
College - fourth year	7 (11.7)
Level of education of father	
Graduate	28 (46.7)
Profession or honors	27 (45.0)
Intermediate or diploma	4 (6.7)
not formally educated	1 (1.7)
Level of education of mother	
Graduate	29 (48.3)
Profession or honors	23 (38.3)
Intermediate or diploma	5 (8.3)
Not formally educated	3 (5.0)
Religion	
Hindu	32 (53.3)
Christian	15 (25.0)
Muslim	6 (10.0)
Jain	1 (1.7)
Atheist	2 (3.3)
Agnostic	3 (5.0)
Prefer not to say	1 (1.7)
Personal income	
None	38 (63.3)
Less than Rs. 25,000/month	5 (8.3)
More than Rs. 25,000/month	9 (15.0)
Prefer not to say	8 (13.3)
Sexually active	
yes	22 (36.7)
No	26 (43.3)
Prefer not to say	11 (18)

TABLE 1: Demographic details

Knowledge of confidentiality during doctor visits

When knowledge of laws regarding doctor-patient confidentiality was assessed, 21.7%(13) of respondents did not know doctors are legally required to keep visit details confidential. 30%(18) were unaware they can refuse to disclose information (Table 2). Only 61.3%(19) of males knew about doctor-patient confidentiality, compared to 96.6% (28) of females (p=0.0012). Likewise, 64.5% (20) of males knew they could withhold information, while 75.9% (22) of females were aware (Table 3).

Question	Yes n (%)	No n (%)	Total n (%)
Are you aware that a doctor bound by law keeps details confidential?	47 (78.3)	13 (21.7)	60 (100)
Are you aware that you may refuse to reveal information to doctor?	42 (70)	18 (30)	60 (100)

TABLE 2: Perceived knowledge of respondents regarding confidentiality

Question	Male			Female		
	Aware n (%)	Not aware n (%)	Total n (%)	Aware n (%)	Not aware n (%)	Total n (%)
Are you aware that a doctor bound by law keeps details confidential?	19 (61.3)	12 (38.7)	31 (100)	28 (96.6)	1 (3.4)	29 (100)
Are you aware that you may refuse to reveal information to doctor?	20 (64.5)	11 (35.5)	31 (100)	22(75.9)	7 (24.1)	29 (100)

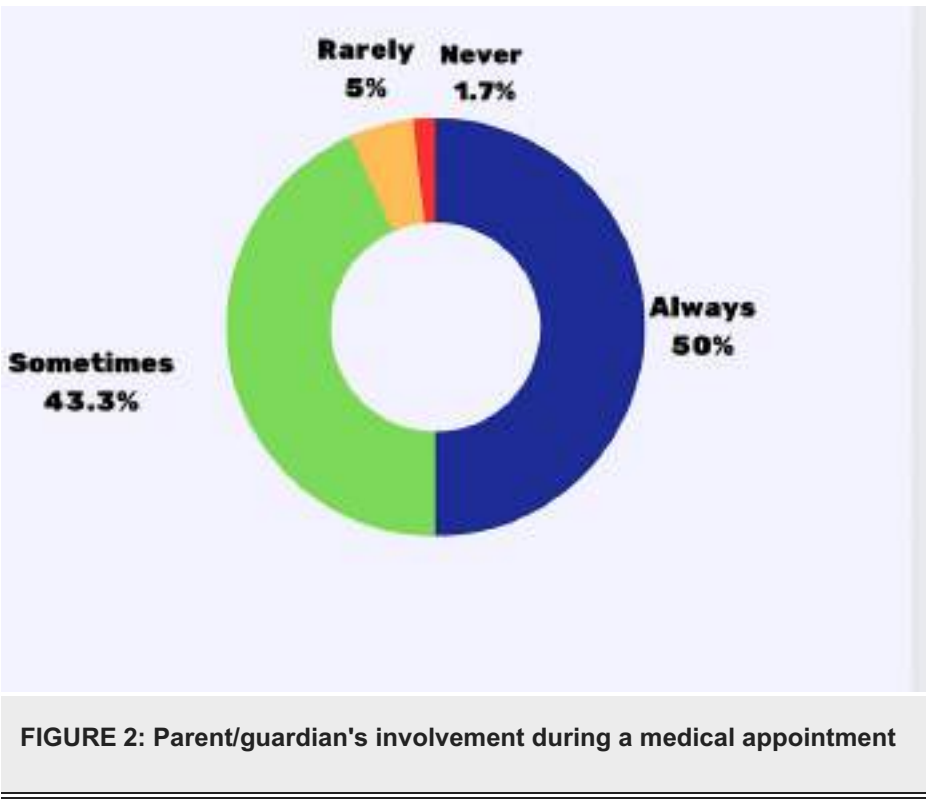
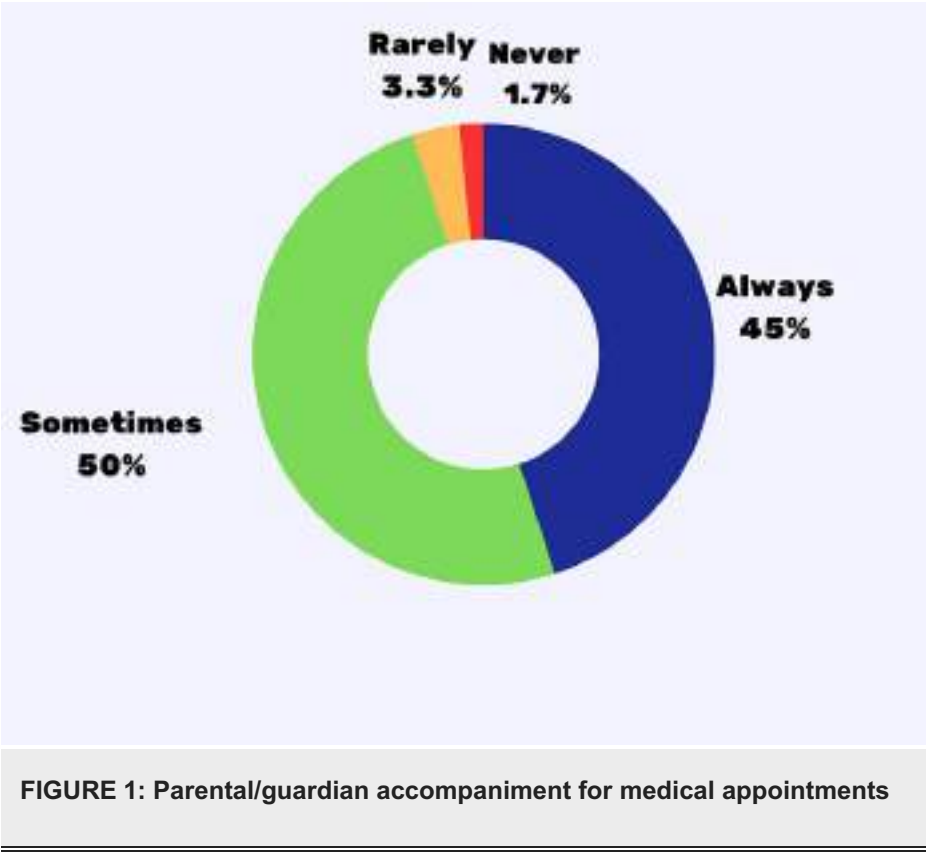
TABLE 3: Comparison of perceived knowledge of confidentiality between males and females

Involvement of parent/guardian in doctor's visit

In the study, only 5% (3) were rarely or never accompanied by parents for doctor's visits (Table 4, Figure 1). Most respondents' parents always (50%, 30) or sometimes (43.3%,26) played an active role (Table 4, Figure 2). 53.5% (32) restricted information due to a parent/guardian's presence (Table 4).

	Always n (%)	Sometimes n (%)	Rarely n (%)	Never n (%)
Are you accompanied by a parent/guardian for a doctor's visit?	27 (45)	30 (50)	2 (3.3)	1 (1.7)
Is your parent/guardian active part of the visit?	30 (50)	26 (43.3)	3 (5)	1 (1.7)
Do you restrict the amount of information you give your doctor on account of your parents/guardian being present?	5 (8.5)	27 (45)	8 (13.3)	18 (30)

TABLE 4: Parental/guardian involvement in medical appointments



Comparative analysis showed that 32.2%(10) of males were always accompanied by a parent/guardian for medical appointments, while 58.6% (17) of females were (Figure 3). 35.5% (11)of males claimed parental involvement, compared to 65.5%(19) of females, nearly double the number (Figure 4).

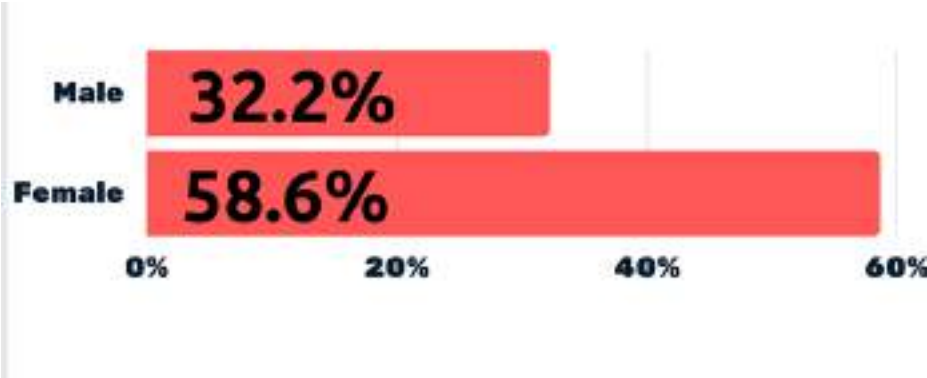


FIGURE 3: Comparison between males and females with regards to accompaniment of parent/guardian for a medical appointment

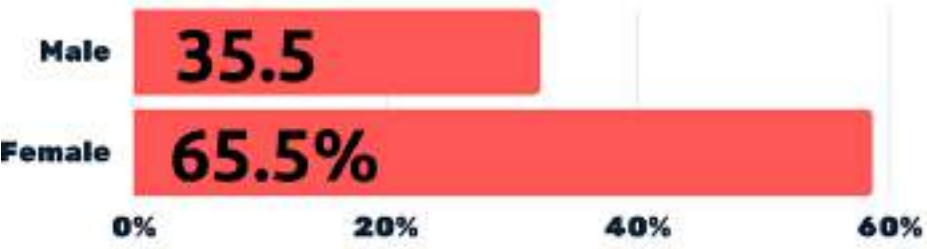


FIGURE 4: Comparison between males and females with regards to the involvement of parent/guardian in medical appointment

Attitude of respondents regarding confidentiality during doctor visits

In assessing respondents' attitudes toward confidentiality during doctor visits, only 16.7% (10) strongly agreed to feel comfortable having open conversations with their doctor. 55%(33) agree they prefer going alone. Additionally, 61.7% (37) agree they would like consent before allowing parents/guardians to be part of the appointment (Table 5).

	Strongly agree n (%)	Agree n (%)	Neutral n (%)	Disagree n (%)	Strongly disagree n (%)	Total n (%)
I feel comfortable having an open and honest conversation with my doctor	10 (16.7)	20 (33.3)	26 (43.3)	3 (5)	1 (1.7)	60 (100)
I trust my doctor to keep details of my consultation confidential under all circumstances	11 (18.3)	28 (46.7)	19 (31.7)	2 (3.3)	0 (0)	60 (100)
I prefer going in for my appointment alone	14 (23.3)	19 (31.7)	19 (31.7)	7 (11.7)	1 (1.7)	60 (100)
I am comfortable with my parent/guardian being in the room during my doctor's appointment	3 (5)	20 (33.3)	22 (36.7)	12 (20)	3 (5)	60 (100)
I feel confident/capable of going for my doctor's appointment alone	16 (26.7)	24 (40)	15 (25)	4 (6.7)	1 (1.7)	60 (100)
I would prefer being asked for consent before allowing my parents/guardian to sit in for my appointment with me and be an active part of it	19 (31.7)	18 (30)	23 (38.3)	0 (0)	0 (0)	60 (100)
I would prefer a parent/guardian present for procedures that do not cause embarrassment	5 (8.3)	20 (33.3)	29 (48.3)	5 (8.3)	1 (1.7)	60 (100)
I possess the resources/knowledge to make an appointment without help from a parent/guardian	17 (28.3)	21 (35)	17 (28.3)	5 (8.3)	0 (0)	60 (100)
I am satisfied with the medical care currently offered to me	9 (15)	31 (51.7)	18 (30)	1 (1.7)	1 (1.7)	60 (100)
I think better maintenance of patient confidentiality will help improve my consultation with the doctor	19 (31.7)	22 (36.7)	17 (28.3)	2 (3.3)	0 (0)	60 (100)

TABLE 5: Respondents' attitude regarding confidentiality during doctor visits

Practices regarding history disclosure

Results showed that respondents were most likely to withhold sexual history (55%), alcohol use (35%), and smoking (31.7%). Among males, sexual history (64.5%, 20), alcohol use (41.9%, 13), and smoking history (41.9%, 13) were commonly withheld. Among females, sexual history (44.8%, 13), psychiatric history (37.9%, 11), and alcohol use history (27.6%, 8) were commonly withheld (Figure 5).

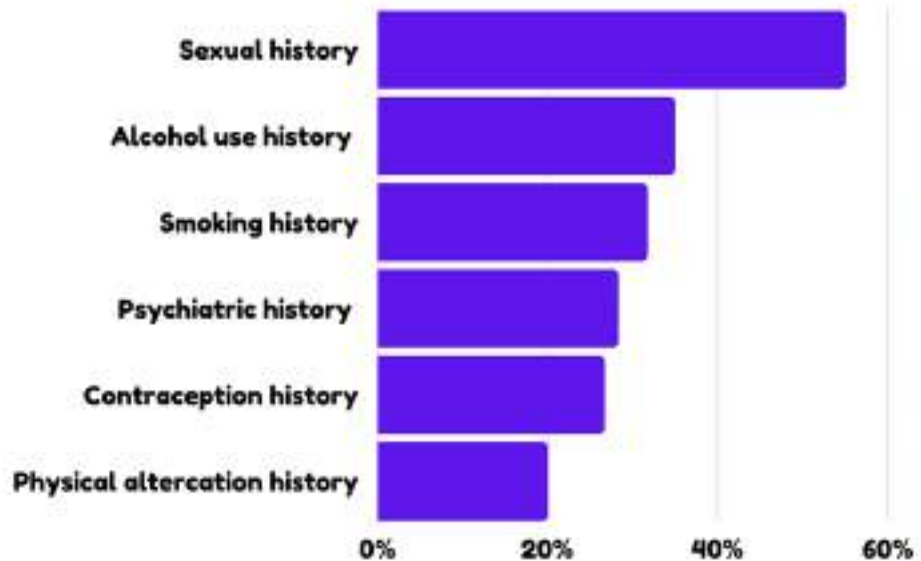


FIGURE 5: Medical histories most likely to be withheld from the physician by young adults

Discussion

In a study by Stephanie A. Grilo et al. (2016), examining factors associated with private time and confidentiality discussions among 1,918 US adolescents and young adults (13-26 years old), slightly over half of young women reported ever having private time with their provider (55%) or discussing confidentiality (55%). Young men had significantly lower rates, with 49% reporting private time ($p=0.046$) and 44% discussing confidentiality ($p<0.001$) [12].

The study revealed that 21.7% (13) of young adults surveyed were unaware of doctors' legal obligation to maintain visit confidentiality. This highlights situations where young adults lack awareness of their rights within doctor-patient interactions. Lack of awareness of rights creates potential for exploitation, as rights protect individuals' dignity. Additionally, 30% (18) were unaware they could refuse to disclose information to their doctor, impacting issues of consent. This highlights situations where consent and information may be given without a sense of choice.

These findings indicate a gap in confidentiality and privacy discussions between healthcare providers and young adults, with grave implications for patient privacy and the healthcare system.

The study findings reveal that a mere 16.7% (10) of the respondents strongly agreed that they felt comfortable engaging in open and honest conversations with their doctors. This glaring communication gap poses a significant threat to the reliability of the healthcare system, especially in developing countries like India, where the population of 18- to 23-year-olds alone is 1.48 lakh [13]. Enhancing patients' experiences of care is a cornerstone of healthcare quality [14]. In fact, the 2012 National Institute for Health and Care Excellence Patient Experience Guideline has identified "comfort" as one of the seven outcomes of a good patient experience [15].

Several factors including lack of privacy, fear of judgment, feelings of insecurity, embarrassment, and the perception of harsh scrutiny significantly impact the comfort of young adults when interacting with healthcare providers. These elements may hinder young adults' willingness to disclose vital information to their doctors. Notably, a 1999 study conducted by JD Klein et al. examined factors associated with access to care among adolescents, including gender, insurance coverage, and having a regular source of healthcare. The study revealed that while girls and boys were equally likely to visit the same health professional as their parents, girls were slightly more inclined to prefer a different provider. Moreover, girls were more likely to report feeling too embarrassed to discuss a problem with a healthcare professional compared to boys [16].

A more recent study by Antionette Davey et al. (2013) explored the needs and experiences of young adults regarding healthcare services, aiming to identify reasons for lower satisfaction. The findings indicated that

familiarity with the doctor played a significant role in the ease of communication and the young adults' confidence in providing relevant information. The study also revealed that young adults preferred having a single physician, and pre-existing personal relationships, such as blood relatives or family friends, often negatively impacted their comfort during visits to the physician [17]. To address this issue, healthcare providers should consciously reaffirm that the care provided will be completely confidential and professional. By creating an environment where young adult patients feel at ease and genuinely listened to, healthcare professionals can positively influence the doctor-patient interaction. This, in turn, encourages young adults to disclose their medical history with greater confidence, ultimately leading to improved diagnostic accuracy and healthcare outcomes [17].

In a study by Bradley E. Iott et al. (2019) on trust and privacy in doctor-patient interactions, a significant association was found between trust in confidentiality and patients withholding information from their doctors [18]. Surprisingly, the current study reveals that only 18.3% (11) of the respondents strongly agreed to trust their doctors to keep the details of their visit confidential. Bora Kim et al. (2017) propose that trust and emotional safety play a crucial role in communicating with young clients during healthcare visits, promoting open and engaging communication [3].

The 1999 study by JD Klein et al. further found that nearly one-third of the 6,748 adolescents surveyed had missed necessary care, with the most common reason being the reluctance to tell their parents (35%). Girls were more likely than boys to miss care (29% vs. 24%). Additionally, confidential visits varied by ethnicity, with Asians having the lowest rate of private time with physicians (49%) [16].

In this study, 55% (33) of the respondents either agreed or strongly agreed that they preferred to go for their doctor's appointment alone. Interestingly, 45% (27) stated that they are always accompanied by their parents or guardians, and 50% (30) said they are sometimes accompanied. Although parents or guardians may have good intentions, their presence during a doctor-patient interaction presents a confidentiality challenge. Older generations often believe it is their right and duty to be present and make medical decisions for their children, which can infringe on young adults' privacy. Going along with this dynamic may give the false impression of support but leaves young adults feeling neglected and apprehensive. Bora Kim et al. (2017) emphasize the importance of including young clients and promoting autonomy during health communication [3]. Healthcare providers must find a balance between the needs of young adults and the involvement of their parents or guardians.

Data also reveals a clear disparity between male and female respondents. Twice as many females are always accompanied by a parent or guardian compared to males (58.6% vs. 32.2%). Similarly, a higher percentage of females report their parents or guardians being actively involved in the doctor's visit (65.5% vs. 35.5%) compared to males. While it may be argued that the presence of an attendant is a legal and ethical requirement when examining female patients, it does not justify the presence of a guardian or parent during the history-taking process.

Data from the National Survey of Family Growth 2016 highlights that females aged 15-17 and 18-25 who had concerns about seeking sexual or reproductive healthcare due to potential parental discovery were less likely to receive such services compared to those without such concerns [19]. Alone time with the physician is crucial for young adult females, enabling them to discuss sensitive topics such as sex, contraception, pregnancy, abortions, and STIs. The presence of a parent or guardian, while well-intentioned, can hinder these discussions leading to unanswered healthcare concerns. This ultimately may cause patients to seek uncertain and potentially risky solutions from the internet or peers.

According to the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019, alcohol-attributable burden ranks as the second-highest risk factor contributing to disability-adjusted life years among adolescents and young adults aged 10-24 years (GBD 2019 Risk Factors Collaborators, 2020). In a systematic review titled "Alcohol use in adolescents in India," Nadkarni et al. found that 55.3% of college-going students (aged 17-21 years) believed there was no risk of harmful effects from alcohol. A higher percentage of females compared to males held this belief (69.4% vs. 43.4%). The study also highlighted associations between alcohol consumption and tobacco use, illicit drug use, symptoms of attention deficit hyperactivity disorder (ADHD), suicidal thinking, planning, and attempts, as well as non-contact sexual abuse and perpetuation of violence [20].

In a 2002 study titled "Adolescent reports of Physician counseling for smoking," Catherine M Alfano et al. emphasized the need for more intensive interventions delivered by healthcare providers. They suggested that efforts should focus on helping providers accurately identify smoking habits and effectively communicate prevention or cessation messages. Special attention should be given to boys, experimental smokers, and youths with chronic health conditions, as their lower willingness to disclose smoking behaviors may hinder identification and intervention [21].

The study "Mental health help-seeking behaviors in young adults" compared access to mental healthcare across different age groups in Europe. It revealed that while three-quarters of psychiatric disorders in adults emerge before the age of 25, participants aged 18-24 were the least likely to seek care for mental health

problems. The study also highlighted a UK survey where 35% of young adults experiencing current emotional or mental health difficulties did not seek any formal or informal help. Barriers to accessing care and support included perceived stigma, difficulty expressing concerns, accessing help, and a preference for self-reliance [22].

The respondents in this study reported being most likely to withhold information regarding sexual practices (55%), alcohol use (35%), and smoking (31.7%). A comparative analysis revealed that males were more likely to withhold sexual history (64.5%,20), alcohol use (41.9%,13), and smoking history (41.9%,13), while females were more likely to withhold sexual history (44.8%,13), psychiatric history (37.9%,11), and alcohol use history (27.6%,8). These findings highlight the high prevalence of alcohol use, smoking, high-risk sexual behaviors, and poor mental health among young adults. Paradoxically, these are the specific histories that young adults are most reluctant to share with their healthcare providers. This disparity raises important questions about the underlying reasons. Such information is crucial for physicians, not only as important contextual information but also as an opportunity to address risk behaviors, knowledge gaps, and discrepancies in health-related information, enabling the provision of holistic, preventive, and promotive healthcare.

The study conducted in 1997 by Ford CA et al. titled "Influence of Physician Confidentiality Assurances on Adolescents' Willingness to Disclose Information and Seek Future Health Care" demonstrated how assurances of confidentiality increased the number of adolescents willing to disclose sensitive information about sexuality, substance use, and mental health. The study showed an increase from 39% (68/175) to 46.5% (178/383) in disclosure rates ($\beta=0.10$, $P=0.02$) and an increase from 53% (93/175) to 67% (259/386) in the willingness to seek future healthcare ($\beta=0.17$, $P<0.001$) [23]. These findings underscore the importance of confidentiality assurances in promoting open communication and improving healthcare outcomes for young adults.

When adolescents seek healthcare, privacy concerns can significantly impact the quality of care they receive. Unfortunately, a substantial number of primary care physicians do not provide confidential health services to adolescents, discuss confidentiality with patients, or train their staff to provide accurate information about the confidential services available [7]. Encouraging health-related questions and answering them in a polite and neutral manner can help address these concerns.

In a 1997 study by Jonathan D. Klein et al., it was found that 30% of respondents preferred to have medical examinations without their parents present. Boys were less likely to prefer an examination without a parent present (19% vs. 41%), but they were more likely to have spoken with the doctor privately (62% vs. 53%). Older adolescents were also more likely to have had private conversations with their healthcare professionals (71% vs. 45%) [16].

Interestingly, in this study, it was found that 91.7% (55) of those who had a non-emergency personal procedure with a parent or guardian present did not feel significant embarrassment. The reasons for this difference are not fully explained, but it can be assumed that it is influenced by socio-cultural factors and differences in healthcare systems between the study populations. In countries like India, where confidentiality and privacy for young adults as patients are still developing concepts, access to confidential care is often restricted due to cultural and economic constraints. This practice is widely accepted as the norm in such contexts.

Research has shown that young adults are the least likely to respond to surveys about healthcare experiences and are generally less satisfied with the care they receive [18]. In this study, 61.7% (39) of respondents either strongly agreed or agreed that they were satisfied with the current medical care they received. However, 67.7% (41) also agreed or strongly agreed that better maintenance of patient confidentiality would help improve their consultations with doctors.

The study's limitations include a small sample size. The sample size was also restricted specifically to college students, i.e., an educated population leading to a possible respondent bias. A lack of previous studies conducted in India regarding the same led to the authors having to develop their own questionnaire and get a validation done for it. This validation, however, was done by faculty belonging to the investigators' college thus leaving a scope for improvement. Subsequently, due lack of previous studies no comparisons of significance could be made.

Conclusions

Educating young adults about their patient rights and effective utilization of healthcare services is essential to addressing their health needs. Establishing trust in physician confidentiality practices is crucial for building a good doctor-patient relationship, which ultimately leads to better treatment outcomes. While the current healthcare offered to young adults is not inherently dissatisfactory, there is room for improvement, especially regarding confidentiality in clinical settings. Strategies to enhance confidentiality include explaining its importance to parents and young adults, spending part of each visit alone with the patient, and addressing potential issues that may unintentionally disclose protected information. However, there is a

lack of sufficient data on these specific subjects, particularly concerning young adults in India. Further research is needed to better understand the barriers young adults face during doctor's appointments and to identify potential solutions to improve the healthcare experience for this population.

Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. Ethics Committee of Bowring and Lady Curzon Medical College and Research Institute issued approval No. BLCMCRI/IEC/RP/105/2021-22. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Acknowledgements

The authors would like to acknowledge Dr Amar Parampalli, Dr Aparna Sukumaran, Dr Swathi Santharaj, Dr Lakshmi Pandit, Dr Darshan Yallappa Jotibannad, Dr Anindita Menon, and Dr Pritik A. Shah.

References

- Thomson A, Christensen E, Wiklund M, Christianson M: A safe place - adolescents' and young adults' perceptions of youth clinics in northern Sweden. *Sex Reprod Healthc*. 2022, 33:100752. [10.1016/j.srhc.2022.100752](https://doi.org/10.1016/j.srhc.2022.100752)
- Frerich EA, Garcia CM, Long SK, Lechner KE, Lust K, Eisenberg ME: Health care reform and young adults' access to sexual health care: an exploration of potential confidentiality implications of the Affordable Care Act. *Am J Public Health*. 2012, 102:1818-21. [10.2105/AJPH.2012.300857](https://doi.org/10.2105/AJPH.2012.300857)
- Kim B, White K: How can health professionals enhance interpersonal communication with adolescents and young adults to improve health care outcomes?: systematic literature review. *Int J Adolesc Youth*. 2017, 25:198-218. [10.1080/02673843.2017.1330696](https://doi.org/10.1080/02673843.2017.1330696)
- Investing in the health and well-being of young adults. Bonnie RJ, Stroud C, Breiner H (ed): The National Academies Press, Washington (DC); 2014. [10.17226/18869](https://doi.org/10.17226/18869)
- Maslyanskaya S, Alderman EM: Confidentiality and consent in the care of the adolescent patient. *Pediatr Rev*. 2019, 40:508-16. [10.1542/pir.2018-0040](https://doi.org/10.1542/pir.2018-0040)
- Rao KD, Peters DH, Bandeen-Roche K: Towards patient-centered health services in India-a scale to measure patient perceptions of quality. *Int J Qual Health Care*. 2006, 18:414-21. [10.1093/intqhc/mzl049](https://doi.org/10.1093/intqhc/mzl049)
- Ford C, English A, Sigman G: Confidential health care for adolescents: position paper of the Society for Adolescent Medicine. *J Adolesc Health*. 1997, 21:408-15. [10.1016/j.jadohealth.2004.03.002](https://doi.org/10.1016/j.jadohealth.2004.03.002)
- Zucker NA, Schmitt C, DeJonckheere MJ, Nichols LP, Plegue MA, Chang T: Confidentiality in the doctor-patient relationship: perspectives of youth ages 14-24 years. *J Pediatr*. 2019, 213:196-202. [10.1016/j.jpeds.2019.05.056](https://doi.org/10.1016/j.jpeds.2019.05.056)
- Slive L, Cramer R: Health reform and the preservation of confidential health care for young adults. *J Law Med Ethics*. 2012, 40:383-90. [10.1111/j.1748-720X.2012.00671.x](https://doi.org/10.1111/j.1748-720X.2012.00671.x)
- Petronio S, Sargent J, Andea L, Reganis P, Cichocki D: Family and friends as healthcare advocates: dilemmas of confidentiality and privacy. *J Soc Pers Relat*. 2004, 21:33-52. [10.1177/0265407504039838](https://doi.org/10.1177/0265407504039838)
- Health promotion for children and adolescents. Korin MR (ed): Springer, New York; 2018. [10.1007/978-1-4899-7711-3](https://doi.org/10.1007/978-1-4899-7711-3)
- Grilo SA, Catallozzi M, Santelli JS, et al.: Confidentiality discussions and private time with a health-care provider for Youth, United States, 2016. *J Adolesc Health*. 2019, 64:311-8. [10.1016/j.jadohealth.2018.10.301](https://doi.org/10.1016/j.jadohealth.2018.10.301)
- India Population aged 18-23 years, 1950-2022. Accessed: Jan 27, 2023: <https://knoema.com/atlas/India/topics/Demographics/Age/Population-aged-18-23-years?mode=amp>.
- Population ages 15-64 (% of total population) - India. Accessed: Sep 29, 2023: <https://data.worldbank.org/indicator/SP.POP.1564.TO.ZS?locations=IN>.
- O'Flynn N, Staniszewska S: Improving the experience of care for people using NHS services: summary of NICE guidance. *BMJ*. 2012, 344:d6422. [10.1136/bmj.d6422](https://doi.org/10.1136/bmj.d6422)
- Klein JD, Wilson KM, McNulty M, Kapphahn C, Scott Collins K: Access to medical care for adolescents: results from the 1997 Commonwealth Fund survey of the health of adolescent girls. *J Adolesc Health*. 1999, 10:120-30.
- Davey A, Asprey A, Carter M, Campbell JL: Trust, negotiation, and communication: young adults' experiences of primary care services. *BMC Fam Pract*. 2013, 14:202. [10.1186/1471-2296-14-202](https://doi.org/10.1186/1471-2296-14-202)
- Iott BE, Campos-Castillo C, Anthony DL: Trust and privacy: how patient trust in providers is related to privacy behaviors and attitudes. *AMIA Annu Symp Proc*. 2019, 2019:487-93.
- Copen CE, Dittus PJ, Leitchliter JS: Confidentiality concerns and sexual and reproductive health care among adolescents and young adults aged 15-25. 2016. <https://www.cdc.gov/nchs/products/databriefs/db266.htm>.
- Nadkarni A, Tu A, Garg A, et al.: Alcohol use among adolescents in India: a systematic review. *Glob Ment Health*. 2022, 9:1-25.
- Alfano CM, Zbikowski SM, Robinson LA, Klesges RC, Scarinci IC: Adolescent reports of physician counseling for smoking. *Pediatrics*. 2002, 109:e47. [10.1542/peds.109.3.e47](https://doi.org/10.1542/peds.109.3.e47)

22. Mitchell C, McMillan B, Hagan T: Mental health help-seeking behaviours in young adults . Br J Gen Pract. 2017, 67:8-9. [10.3399/bjgp17X688453](https://doi.org/10.3399/bjgp17X688453)
23. Ford CA: Influence of physician confidentiality assurances on adolescents' willingness to disclose information and seek future health care. J Am Med Assoc. 1997, 24:278. [10.1001/jama.1997.03550120089044](https://doi.org/10.1001/jama.1997.03550120089044)

Participation of private providers in the National TB Programme in South India

A. D. Meundi,^{1,2} J. H. Richardus²

<http://dx.doi.org/10.5588/pha.23.0032>

SETTING: India has the highest number of new TB cases worldwide. The participation of private providers (PPs) in the National TB Elimination Programme (NTEP) has remained suboptimal.

OBJECTIVE: To explore the experiences, barriers and facilitators about their participation in the NTEP as perceived by PPs working in varied settings.

DESIGN: Focus group discussions and in-depth interviews were used to engage PPs to obtain their views on participation in the NTEP. Framework and thematic content analysis was used to analyse qualitative data.

RESULTS: Non-availability of a comprehensive range of diagnostics and lack of flexibility in the NTEP were barriers to participation in NTEP. PPs were predisposed to think that NTEP was for those who could not afford to purchase medications. Attitudes and previous experiences with NTEP made them sceptical about the NTEP regimen. Although more frequent interactions were sought with NTEP, some bitterness about previous interactions was perceived.

CONCLUSION: Challenges identified by PPs for the NTEP include improvement of the quality of TB care, especially at the lower levels of care, availability of a comprehensive range of diagnostics, being friendly to PPs and patients, more frequent interactions with PPs, and more caring conversations with patients at NTEP centres.

Globally, TB was the 13th leading cause of death and second leading infectious killer after COVID-19 in 2020. In 2020, 30 high-burden countries accounted for 86% of new cases of TB, with India leading the count.¹ The average contribution of private providers (PPs) to total TB notifications between 2011 and 2016 in Bangalore City, India, was 20%.² In 2021, a total of 2.1 million TB cases were notified in India, of which 68% were from the government sector and 32% were from the private sector, when in fact, about 50% of patients had consulted PPs.³ Between 2019 and 2021, the prevalence:notification ratio was 2.84, suggesting under-notification or that a substantial number of cases had been missed.⁴ With the National TB Elimination Programme (NTEP) envisaging a nationwide reduction of TB incidence by 80% by 2025 compared to 2015, involvement of PPs has risen in priority. The National Strategic Plan for TB Elimination in India includes private sector engagement as one of the four thrust areas.⁵ Studies have shown that half of suspected TB cases had visited a PP before approaching the government healthcare system.^{6,7} Only

one third of these TB presumptives who went to a qualified provider in the private sector went on to a government centre after the first consultation, the rest taking up to six consultations before reaching a government centre.⁸

The experiences of PPs in their interaction with the NTEP have been shown to influence the participation of PPs in the programme,^{9,10} and efforts to engage PPs have demonstrated improved contribution from the private sector in India.¹¹ The present study aims to explore the experiences of, barriers to and facilitators of PP participation in the NTEP as perceived by PPs working in varied settings.

METHODS

Qualitative methods, i.e., focus group discussions (FGDs) and in-depth interviews (IDIs), were used to engage PPs to obtain their views on participation in the NTEP. Participants of the present study were specialist faculty of medical colleges, private specialists and general practitioners. All were employed and/or practicing in Bangalore City under the city's municipal authority, Bruhat Bengaluru Mahanagara Palike (BBMP). Eight FGDs were conducted with faculty of medical colleges, including specialists from the Paediatrics, Internal Medicine and Pulmonology Departments. Three medical colleges were covered. Each FGD group consisted of a single speciality and participants belonging to all academic cadres (senior residents, assistants, and associate and full professors). Twenty-four IDIs were conducted with private specialists, which included 6 paediatricians, 6 internal medicine specialists and 6 pulmonologists (all outside medical colleges), 4 IDIs with general practitioners (with only a MBBS [Bachelor of Medicine and Bachelor of Surgery] degree) and 2 IDIs with hospital administrators (Table 1). Purposive sampling was used for the FGDs and snowball sampling for the IDIs. None of the potential participants who were contacted refused to participate.

The FGDs and IDIs were conducted between January 2018 and July 2019 by ADM, who is a faculty member of the Community Medicine Department at a private medical school holding the qualifications of MBBS and MD (Doctor of Medicine) using an interview guide (Table 2) until a saturation point was attained, and no new information was forthcoming. Reflexivity was applied during data collection and analysis. The interview guide was pilot tested before actual use. ADM has been trained in qualitative methods and has published qualitative research previously.

AFFILIATIONS

- 1 Department of Community Medicine, Dr Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Bengaluru, India;
- 2 Department of Public Health, Erasmus MC, University Medical Center Rotterdam, The Netherlands

CORRESPONDENCE

Correspondence to: Anand D Meundi, Department of Community Medicine, Dr Chandramma Dayananda Sagar Institute of Medical Education and Research (Dayananda Sagar University, Bangalore), Harohalli, Kanakapura Road, Ramanagara District, 562112, India. Email: anandmeundi@yahoo.com
Conflicts of interest: none declared.

KEY WORDS

barriers; facilitators; involvement; NTEP

Received 2 June 2023
Accepted 4 September 2023

PHA 2023; 13(4): 142–147
e-ISSN 2220-8372

TABLE 1 Demographic characteristics of the participants

Qualitative method	Participant characteristics	Total participants <i>n</i>
Focus group discussion (faculty working in medical colleges)	- Professors/Associate Professors (males: 15; females: 8) - Assistant Professors/Senior Residents (males: 20, females: 9)	52
In-depth interviews	- Internal Medicine specialists (males: 6; females: 0) - Pulmonology specialists (males: 4; females: 2) - Paediatric specialists (males: 6; females: 0) - General practitioners (males: 5; females: 1) - Hospital administrators (males: 2; females: 0)	26

TABLE 2 Topics included in the interview guide for conducting focus group discussions and in-depth interviews

Sl. no	Topics*
1	What has been your experience in participating with NTEP? Could you describe both positive experiences and negative experiences?
2	What do you think are the factors that are preventing and enabling the participation of private doctors in NTEP?
3	In what ways can the NTEP increase participation of doctors in the private sector?
4	In what way will the change of regimen from intermittent to daily impact the adoption of the NTEP regimen by PPs in India?

*Followed by appropriate follow-up questions and probes.
NTEP = National TB Elimination Programme; PP = private provider.

Written informed consent was obtained prior to the interview. The FGDs lasted an average of 50 min, and each IDI lasted approximately 25 min and were conducted in English, were audio recorded and later transcribed. The FGDs/IDIs were held at the participants' workplace. The interviewer ensured that the interaction took place with prior appointment in a quiet place.

A framework approach was used for data analysis.¹² The framework analysis was based on the following three theories: the Social Learning Theory, the Precede/Proceed Model¹³ and the Theory of Learned Behaviour.¹⁴ Additional themes were identified during the course of data analysis. Three themes derived from the abovementioned theories were retained in the final coding tree (Figure). Thematic content analysis was done to link emerging themes with the codes.

Two coders performed the content analysis. A licensed version of NVivo Pro v12 (Lumivero, Denver, CO, USA) was used for qualitative data analysis and management. The COREQ (Consolidated criteria for reporting qualitative research) criteria were adopted for presenting the qualitative results of the study.¹⁵ Data credibility was ensured by respondent validation. Two specialists who participated in the FGDs were selected randomly. These selected participants were given a draft of the report of this study for their critical comments. The comments obtained were integrated into the analysis and interpretation. An audit trail was maintained to ensure confirmability. Written informed consent was obtained from participants of all the above studies prior to data collection.

Ethical approval was obtained from the institutional review board of the Academy of Medical Sciences, Pariyaram, Kerala, India (letter reference No. G1.2747/12/ACME) where the author was working at the time of data collection.

RESULTS

Study findings are presented under the following themes (Table 3).

Barriers to participating in the NTEP

Limited range of diagnostics under the NTEP

Many PPs felt that diagnosis of extrapulmonary TB was relatively complicated and required special investigations which were not available under the NTEP.

...Patients really can't afford all of those diagnosis because they do not have money, for example Pott's spine may require an MRI which is not there in NTEP for free... (Internal Medicine specialist, private medical college)

Need for flexibility in the NTEP

Flexibility issues identified included 1) the inability to change the regimen when the patient experienced side effects, 2) difficulty in processing samples on holidays, 3) formalities involved in extending the regimen if required, 4) inability to individualise regimens, and 5) challenges faced by patients in medication collection and intake under DOT provider supervision (as reported by patients to PPs. One provider found it difficult to start

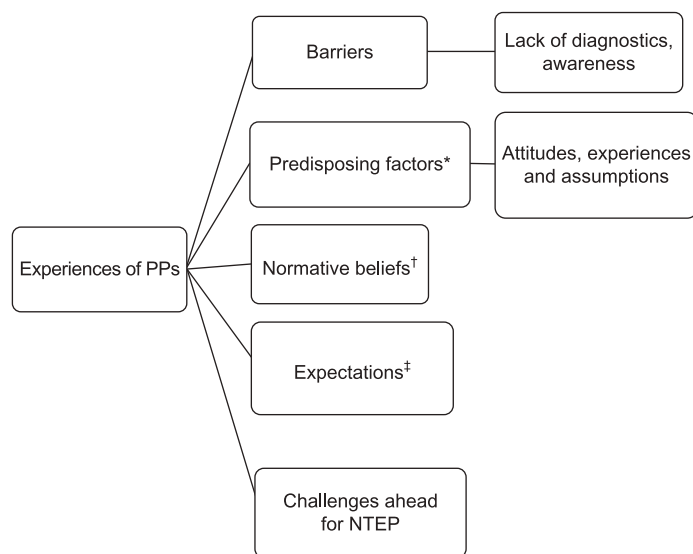


FIGURE Coding tree depicting the major themes derived from the interviews of PPs. *Predisposing factors derived from the Precede/Proceed Model have been used to collate responses regarding unfavourable attitudes about and unpleasant experiences with NTEP. †Normative beliefs derived from the Theory of Planned Behaviour cover responses of PPs relating to social pressure from peers and patients. ‡Derived from Social Learning Theory. This code represents the expectations of healthcare providers (PPs) regarding how the NTEP would respond once they became involved in the programme. PP = private provider; NTEP = National TB Elimination Programme.

TABLE 3 Organisation of results by broad themes and sub-themes

Sl. no.	Main themes	Sub-themes
1	Barriers in participating in NTEP	- Expanded array of diagnostics not available under NTEP - Need for flexibility in the NTEP - Lack of awareness about where NTEP services are available - Clarity needed on what NTEP expects from PPs
2	Facilitators in participating in NTEP	- Paediatrician-friendly guidelines for paediatric TB - Availability of TB drugs in weight bands for paediatric patients - Assured supply of full course of anti-TB medication
3	Beliefs and attitudes concerning NTEP	- Normative beliefs held by the PPs - Predisposing factors: - NTEP is a way of getting rid of problematic patients - NTEP is for patients who cannot afford to buy medication - Attitudes and experiences related to the NTEP - Expectations of PPs once they involve themselves in the NTEP
4	Challenges ahead for the NTEP	- The quality of TB care was not perceived to be uniform across the various healthcare levels - The presence of a pulmonologist at all centres where TB treatment is provided was thought to be essential - Improved quality of interaction between the NTEP staff and patients - Setting up of NTEP hubs in private hospitals with NTEP trained medical officers was suggested for the dissemination of guidelines and smooth referral

NTEP = National TB Elimination Programme; PP = private provider.

their patients on empirical anti-TB treatment in the absence of a tissue diagnosis:

...If I say there is an unexplained bone marrow suppression, ... and I want to take an empirical TB course, they (NTEP) will not budge. (Private pulmonologist)

Lack of knowledge about the location of NTEP facilities

Many PPs initially struggled to contact the NTEP for patient referrals:

...you have no way of accessing the nearest TB officer or DHO (District Health Officer) who can guide you and say, this is your nodal centre. (Private pulmonologist)

Lack of clarity on what the NTEP expects from PPs

The PPs were unsure about the scope of their participation in the NTEP:

What do you mean by participation? Participation may be just notification ... I have a case, how is he/she diagnosing it, treating it? (Pulmonology specialist, private medical college)

Facilitators of participating in the NTEP

All private sector paediatricians acknowledged that the newer guidelines for paediatric TB were more user-friendly and expressed satisfaction with the availability of TB drugs in weight bands. Furthermore, the guaranteed supply of full course of anti-TB medication under the NTEP was appreciated by all the PPs.

Beliefs and attitudes about the NTEP

Normative belief held by PPs

There was a general perception that patients expected prompt laboratory investigation results. Most PPs believed that request for a quick diagnostic test was possible in the private sector laboratories, but not at NTEP diagnostic centres:

...And in private practice, at least, the expectation of the patient is quite high. So, if I say suspected TB and if I say sputum AFB smear, they are asking me whether I will see them that evening only [get the report] (Private pulmonologist).

NTEP as a way of getting rid of problematic patients

Some PPs considered treating TB as being problematic, especially if it involved dealing with patients who defaulted, and were more likely to report such cases.

... To get rid of that headache, we refer. Let them (the NTEP) do the follow-up. (Internal Medicine specialist, private medical college)

NTEP is for patients who cannot afford to buy medication

One of the most common preconceptions about the NTEP was that it was meant for patients who could not afford to buy anti-TB drugs from private pharmacies, and that patients who could afford medicines should be given a choice.

We give them a choice whether you can afford for 9–12 months treatment or not. Some people who cannot afford, we usually refer them to Government Chest Hospital TB hospital. (Private Internal Medicine specialist)

Patient feedback on the NTEP

PP satisfaction with the NTEP depended on feedback from patients. Patients were found to be initially hesitant about availing free services as they were sceptical about the quality of such services. A general practitioner had this to say about referring to the NTEP:

...Now if you ask us to direct all the diagnosed cases to them (NTEP), all failures will be there. They will never visit their place, they will never take the tablets, and they may suffer... and tuberculosis will spread like anything. (General Practitioner)

PPs seldom received feedback on patients they had referred, which acted as a deterrent to further referrals to the NTEP. Although the NTEP has been using the daily regimen for several years, specialist PPs felt it had been introduced too late. Another common belief about the NTEP was that the patients put on treatment were rarely examined clinically.

Almost every participant PP sought more frequent opportunities for dialogue with the NTEP. However, interaction between the PPs and the NTEP was usually unpleasant, with unjust apportionment of blame on PPs. One PP questioned the logic of referring a patient to the NTEP if there was nothing to be gained from it:

...To make any person participate in something, they will see what I gain in this that is basic human mentality. So, I don't know what the gain is to a private practitioner... (Internal Medicine specialist, private medical college)

Patients sometimes refused to go to a NTEP centre because of the stigma attached to TB and requested PPs to keep their details confidential:

Expectations of PPs once they involve themselves in the NTEP

Many of the PPs who were not associated with a medical college felt that more attention was being given to PPs in medical colleges and wanted one-on-one training:

To tell you the truth, I would prefer it one to one and I would not mind spending a few hours learning it and I think it is more important. In a group, I think you tend to lose concentration... (Private General Practitioner).

Based on feedback from patients, study PPs suggested three strategies that could save patient travel time: 1) home treatment for patients with TB, rather than at a health centre/DOTS providers' home, 2) the establishing of more health centres, and 3) accreditation of private laboratories by the NTEP.

Challenges ahead for the NTEP

The quality of TB care was not perceived to be uniform across the healthcare system. Tertiary-level care tended to be better than at care offered at the lower levels.

If I send the patient to the key nodal centre for the state, the care tends to be quite good. But if they go to the secondary *taluk* [an administrative district for taxation purposes, typically comprising a number of villages] TB hospital, what is done, how they approach is not uniformly done. (Private pulmonologist)

The presence of a pulmonologist at all centres where TB treatment is provided was thought to be essential. Screening all contacts for TB and drug susceptibility testing at the point of care were also suggested. Treating patients weighing less than 40 kg and more than 60 kg using the adult fixed-drug combination (FDC) dosage was felt to be inappropriate, and weight band-based FDCs for these groups was recommended. Most of the PPs felt uneasy about the fact that anti-TB drugs were available in private pharmacies. Another recommendation was to enhance the quality of the interaction between the NTEP staff and patients. Setting up NTEP hubs in private hospitals with NTEP-trained medical officers was suggested for the dissemination of guidelines and a smoother referral process.

DISCUSSION

The present study set out to elicit experiences of, barriers to and facilitators of PP participation in the NTEP. The non-availability of a comprehensive range of diagnostics and lack of flexibility in the NTEP were barriers to participation in NTEP. Some common PP preconceptions included the belief that NTEP treatment was meant for those who did not have the means to purchase medications. Attitudes and previous experiences with the NTEP made PPs sceptical about the NTEP regimen, although the transition from the intermittent regimen to the daily regimen was widely welcomed. Although more frequent interactions with the NTEP were sought, some expressed bitterness about previous interactions.

In a public-private model implemented in Chennai, India, the self-identified needs of PPs were addressed. This resulted in a high provider participation and substantial contribution to TB case notifications.¹⁶ Another study aimed at costing scale-up of private sector engagement in TB care in three cities in India found the costs incurred to be similar to the costs incurred in the public sector.¹⁷ Private sector engagement in TB control in Indian cities was found to be cost-effective, particularly when it was specific to local settings.¹⁸

Lack of flexibility in the NTEP guidelines was one of the barriers to private sector involvement in the NTEP in Kerala, India.¹⁰ In an investigation into PP viewpoints regarding their role in TB control in India, the absence of flexibility in prescribing anti-TB medications was identified as a hindrance to their participation in the national TB program.¹⁹ Rigid work timings was an important concern raised by PPs as a deterrent to involvement in the NTEP in Southern India.²⁰ The inability to take independent decisions despite disagreement with clinical guidelines is known to decrease the use of these guidelines in daily practice.¹⁵ This was illustrated by the perception held by PPs concerning patients' expectations, which discouraged them from referring patients to the NTEP. This reluctance was partly due to inflexible treatment regimens and the low probability of receiving a speedy diagnosis.

There is limited evidence of PPs referring patients to the NTEP, as they perceive TB treatment to be fraught with challenges. However, one study in Southern India came across PPs referring patients to the NTEP as they could not ensure completion of treatment, and also, when it was felt that the patient could not afford diagnostic facilities.¹⁴ The inability of patients to afford private treatment emerged as the predominant reason for referring them to the NTEP. Several other studies from Southern India^{10,21,22} and one study from Bali, Indonesia,²³ have documented PPs referring some patients to the national programme as they felt the patients could not afford private treatment.

Our study findings are in line with the findings from other studies,^{9,17,20,24} which suggest that PPs occasionally had patients who refused to go to the NTEP for treatment—mainly due to concerns about the quality of NTEP treatment. Similar concerns about quality and TB stigma were voiced by PPs in Southern India.¹⁴ Although the daily regimen for TB had already been implemented in Bangalore City at the time of the present study, almost all PPs felt this switch had come too late. The belief that a daily regimen is better than an intermittent regimen had been expressed strongly in several studies in South India.^{10,14,15} Surprisingly, in one qualitative study from Kerala, South India, health workers perceived that patients were more comfortable with the intermittent regimen than the daily regimen due to drug side effects.⁹ Several PPs in the out study expressed unhappiness that patients were only subjected to sputum tests and rarely examined clinically during follow-up. This view was endorsed by a study in Kerala, where PPs were believed to ignore the public health aspects of TB (e.g., sputum positivity indicating infectiousness) and focus only on clinical management.¹⁰

Other studies have also reported that PPs sometimes do not adhere to guidelines because they consider these erroneous.²⁵ Studies from Southern India have shown that PPs considered the NTEP guidelines as being primitive and that regular dissemination of NTEP guidelines to the PPs would be necessary for them to implement it in their daily practice.¹⁴ Mathew et al. showed that PPs were not well informed about changes in NTEP guidelines, especially since the guidelines changed frequently.⁹

In a qualitative investigation into TB treatment delivery, the accessibility and quality of TB treatment emerged as crucial factors influencing patients' choices of treatment sources.²³ In this study, some PPs expressed concerns about the accessibility of NTEP services and suggested strategies that could increase accessibility. Some PPs even found locating the nearest NTEP facility problematic. However, the quality of TB care has consistently been a fundamental principle guiding the efforts of the NTEP.²⁶

Strengths and limitations

Opinions and beliefs expressed by the providers present a comprehensive view of the NTEP-PP interaction landscape. The applicability of the findings may be restricted to other urban conglomerations in India with comparable contexts. As only two hospital administrators were interviewed, theoretical saturation of the opinions of this subset of PPs may not have been achieved.

CONCLUSIONS

Challenges identified by PPs include improvement of the quality of TB care provided by the NTEP, especially at the lower levels of care, availability of a comprehensive range of diagnostics, greater flexibility and user-friendliness for both PPs and patients, fostering more frequent interactions with PPs for the dissemination of updates and changes and promoting more compassionate interactions with patients at NTEP centres.

References

- World Health Organization. Tuberculosis. Geneva, Switzerland: WHO, 2023.
- Meundi AD, et al. Voices of those who bear the brunt-experiences of programme personnel concerning private sector tuberculosis notifications in Bengaluru City, India. *Soc Work Public Health* 2021;36(7-8):759-769.
- Central TB Division (CTD), Ministry of Health and Family Welfare, Government of India Dashboard: Ni-kshay Reports. New Delhi, India: National Tuberculosis Elimination Programme, 2023.
- Central TB Division, Ministry of Health and Family Welfare, Government of India. National TB Prevalence Survey India, 2019-2021. New Delhi, India: MOHFW, n.d.
- Central TB Division, Ministry of Health and Family Welfare. National Strategic Plan 2017-2025. New Delhi, India: MOHFW, 2017.
- Charles N, et al. Care seeking behavior of chest symptomatics: A community based study done in south india after the implementation of the RNTCP. *PLoS One* 2010;5:1-6.
- Hazarika I. Role of private sector in providing tuberculosis care: evidence from a population-based survey in India. *J Glob Infect Dis* 2011;3:19-24.
- Kapoor SK, et al. How did the TB patients reach DOTS services in Delhi? a study of patient treatment seeking behavior. *PLoS One* 2012;7:1-6.
- Mathew G, et al. Revisions in TB programme—boon or bane? A qualitative study exploring barriers and facilitators among health care workers in private and public sector, Kerala. *Indian J Tuberc* 2021;68:356-362.
- Nair S, et al. Barriers for involvement of private doctors in RNTCP – qualitative study from Kerala, India. *J Fam Med Prim Care* 2019;8:160.
- Dewan PK, et al. Improving tuberculosis control through public-private collaboration in India: Literature review. *BMJ* 2006;332:574-577.
- Gale NK, et al. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med Res Methodol* 2013;13(1):1-8.
- Stålsby Lundborg C, Tamhankar AJ. Understanding and changing human behaviour—antibiotic mainstreaming as an approach to facilitate modification of provider and consumer behaviour. *Ups J Med Sci* 2014;119:125-133.
- Ajzen I. The theory of planned behavior. *Organizational Behav Hum Decis Process* 1991;50:179-211.
- Tong A, Sainsbury P, Craig J. Consolidated criterion for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus group. *Int J Qual Heal Care* 2007;19:349-357.
- Ananthakrishnan R, et al. Successfully engaging private providers to improve diagnosis, notification, and treatment of TB and drug-resistant TB: the EQUIP public-private model in Chennai, India. *Glob Health Sci Pract* 2019;7(1):41-53.
- Deo S, et al. What would it cost to scale-up private sector engagement efforts for tuberculosis care? Evidence from three pilot programs in India. *PLoS One* 2019;14(6):e0214928.
- Arinaminpathy N, et al. Engaging with the private healthcare sector for the control of tuberculosis in India: cost and cost-effectiveness. *BMJ Glob Health* 2021;6(10):e006114.
- Salve S, Sheikh K, Porter JDH. Private practitioners' perspectives on their involvement with the tuberculosis control programme in a Southern Indian State. *Int J Heal Policy Manag* 2016;5:631-642.
- Vijayashree Yellappa N, Devadasan, Rao NV. Evaluation of results based financing strategies for tuberculosis care and control in India. Bangalore, India: The Institute of Public Health, 2013.
- Philip S, et al. 'They know, they agree, but they don't do' - The paradox of tuberculosis case notification by private practitioners in Alappuzha District, Kerala, India. *PLoS One* 2015;10:1-13.
- Thomas BE, et al. Perceptions of private medical practitioners on tuberculosis notification: a study from Chennai, South India. *PLoS One* 2016;11:1-9.
- Watkins RE, Rouse CR, Plant AJ. Tuberculosis treatment delivery in Bali: a qualitative study of clinic staff perceptions. *Int J Tuberc Lung Dis* 2004;8:218-225.
- Hane F, et al. Identifying barriers to effective tuberculosis control in Senegal: an anthropological approach. *Int J Tuberc Lung Dis* 2007;11:539-543.
- Rand CS, et al. Why don't physicians follow a framework for improvement. *JAMA* 1999;282:1458-1465.
- Central TB Division, Directorate General of Health Services, Ministry of Health and Family Welfare. National Strategic Plan for Tuberculosis Control, 2012-2017. New Delhi, India: MOHFW, 2017.

CONTEXTE : L'Inde est le pays qui compte le plus grand nombre de nouveaux cas de TB dans le monde. La participation des prestataires privés (PP) au programme national d'élimination de la TB (NTEP) est restée sous-optimale.

OBJECTIF : Explorer les expériences, les obstacles et les facilitateurs de leur participation au NTEP, tels qu'ils sont perçus par les prestataires privés travaillant dans des contextes variés.

MÉTHODE : Des discussions de groupe et des entretiens approfondis ont été organisés afin d'obtenir le point de vue des professionnels de la santé sur leur participation au NTEP. L'analyse de cadre et de contenu thématique a été utilisée pour analyser les données qualitatives.

RÉSULTATS : La non-disponibilité d'une gamme complète de diagnostics et le manque de flexibilité du NTEP ont constitué des

obstacles à la participation au NTEP. Les PP étaient prédisposés à penser que le NTEP était destiné à ceux qui n'avaient pas les moyens d'acheter des médicaments. Les attitudes et les expériences antérieures avec le NTEP les ont rendus sceptiques quant au régime du NTEP. Bien qu'ils aient souhaité des interactions plus fréquentes avec le NTEP, ils ont ressenti une certaine amertume à l'égard des interactions antérieures.

CONCLUSION : Les défis identifiés par les PP pour le NTEP comprennent l'amélioration de la qualité des soins antituberculeux, en particulier aux niveaux inférieurs de soins, la disponibilité d'une gamme complète de diagnostics, l'amabilité envers les PP et les patients, des interactions plus fréquentes avec les PP et des conversations plus attentionnées avec les patients dans les centres du NTEP.



A CROSS-SECTIONAL OBSERVATIONAL STUDY ON ADVERSE DRUG REACTIONS OF ANTITUBERCULAR DRUGS AT TERTIARY CARE CENTER.

Dr Anusha SJ^{1*}, Dr. Puneet K Nagendra², Dr Pratibha D Nadig³, Uppada Vibha.⁴

¹ * Assistant Professor, Department Of Pharmacology, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, A Unit Of Dayananda Sagar University, anushasj.cdsimer@dsu.edu.in, contact no- 7411134489

² Associate Professor, Department Of Respiratory Medicine, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, A Unit Of Dayananda Sagar University. drpuneet.kn@gmail.com Contact no- 9945455774

³ Professor & HOD, Department of Pharmacology, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, A Unit Of Dayananda Sagar University drpratibhanadig.cdsimer@dsu.edu.in Contact no- 9901961964

⁴ Phase IV MBBS Student, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, A Unit Of Dayananda Sagar University, uppadavibha@gmail.com Contact no- 9972829333

***Corresponding author:** Dr.Anusha SJ

*Assistant Professor, Dr. Chandramma Dayananda Sagar Institute of Medical Education & Research . Devarakaggalahalli, Harohalli, Kanakapura Road Ramanagara Dt., Karnataka - 562 112 Mobile no-7411134489 ; e-mail: anushasj.cdsimer@dsu.edu.in

Abstract

The National Tuberculosis Elimination Programme (NTEP) in India implemented the daily weight-based Fixed Dose Combination (FDC) Anti-tuberculosis Treatment (ATT) regime to enhance compliance, and ultimately lead to better treatment outcomes. Adverse drug reactions (ADRs) are a significant element that can affect an ATT regime's treatment compliance and results. As a result, vigilant monitoring for adverse reactions in patients receiving anti-tubercular therapy (ATT) is necessary

Objectives: i) To assess the pattern and frequency of adverse drug reactions with a fixed-dose combination of anti-tubercular drugs ii) To determine the causality, severity, and factors that predispose to the development of adverse drug reactions.

Methodology: A 6-month cross-sectional observational study was undertaken at the tertiary care hospital Chandramma Dayananda Sagar Institute of Medical Education and Research (CDSIMER). 120 patients with tuberculosis were included in the study after obtaining informed consent. Data was collected and analysed on demographics, treatment regimes, and any adverse drug reactions (ADRs) experienced. The statistical analysis test chi-square aimed to identify significant factors linked to adverse drug reactions. Additionally, the WHO causality assessment scale and the modified Hartwig and Siegel scale were used to analyse the causality and severity of any reported ADRs.

Results- 43 out of 120 patients had an adverse reaction. Gastrointestinal adverse effects were most common followed by dermatological issues. According to the WHO causality scale, the majority of ADRs were probable and mild on the modified Hartwig-Siegel scale. The study found that urban, female, and employed individuals had higher rates of ADRs.

Conclusion- ATT-induced ADRs are frequent. As a result, monitoring and counselling patients about their lifestyle, as well as early diagnosis and care, will reduce the incidence of ADRs and enhance treatment adherence.

Keywords- Anti-tubercular therapy, Fixed dose combination, Adverse Drug Reaction.

Introduction-

Tuberculosis (TB) is one of the oldest diseases known to mankind and is a major cause of death worldwide. About 1/3 of the world's population is estimated to be infected with tubercle bacilli and hence at risk of developing active disease. The Revised National TB Control Program was transformed into the National TB Elimination Program (NTEP) at the start of 2020 and added certain protocols to eliminate tuberculosis in India by 2025. TB is a major contributor to the global burden of disease, particularly in low- and middle-income countries, due to its association with the human immunodeficiency virus.¹ India is one among six- high burden nations from Southeast Asia with a high prevalence of tuberculosis (TB), accounting for almost 28% of all cases globally.²

Tuberculosis disease can now be treated with adequate and ongoing therapy, thanks to advances in the improvisation of dosage regimens. Treating tuberculosis (TB) requires a combination of medications taken for an extended period, often leading to ADRs. The occurrence and severity of these reactions can vary depending on several factors, including demographic characteristics, genetic makeup, nutritional status, and existing health conditions. However, if the patient takes the medicines irregularly due to ADRs of anti-tubercular treatment it leads to poor patient compliance, resistance, and may lead to poor treatment outcome such as multi-drug-resistant (MDR) tuberculosis and extensively drug-resistant tuberculosis (XDR TB).^{3, 4, 5}

As a result, identifying adverse drug reactions and taking care to minimize them is critical in increasing patient compliance and decreasing the rate of drug-resistant types of tuberculosis.^{6, 7} Lack of adherence to anti-tuberculosis therapy is a major factor in the re-emergence of tuberculosis, and adverse drug reactions are the major reason for poor adherence.^{8, 9}

Implementing appropriate measures to minimize harm and manage ADR symptoms is crucial. In this context, Pharmacovigilance the active monitoring of medication safety becomes a critical component of global and national policies aimed at ensuring the safety of anti-tuberculosis treatment. There are very few studies and reports regarding revised regimens using fixed dose combinations (FDC). Hence, the present study was taken up.

Methods

Study Design and Population

A cross-sectional observational study was conducted between September 2022- February 2023 in pulmonology department of Dr Chandramma Dayananda Sagar Institute of Medical Education And Research. The study was initiated after obtaining Institutional Ethics Committee (CDSIMER/MR/0013/IEC/2022).

Inclusion Criteria

Included in the study were: i) All patients with tuberculosis on treatment with a fixed-dose combination after 15 days of treatment. ii) Patients of either sex or all age groups diagnosed with TB.

Exclusion Criteria

Patients excluded from the study were: i) multi-drug-resistant (MDR) tuberculosis; and ii) Extensively drug-resistant tuberculosis (XDR TB) patients.

After screening patients based on inclusion and exclusion criteria, written informed consent was obtained from patients. The patient's demographic information, adverse drug reaction, history of alcohol, smoking, or tobacco use, concomitant disease, and drug history were recorded in the case report form. Every patient was asked whether they had any unexpected symptoms. Further they were enquired for the following ADRs nausea, vomiting, epigastric pain, pruritis, rashes, joint pain, dizziness, numbness, visual disturbances and others if any.

If any ADR was detected it was reported to our Pharmacovigilance unit and NTEP. If they reported any of the above symptoms, detailed information about the ADRs was collected, and a correlation between the drug intake and the onset of ADRs was noted.

Analysis of ADRs

System-wise distribution of ADRs was tabulated. WHO-Uppsala Monitoring Centre (UMC) criteria were used to assess the causality of all ADRs as certain, probable or possible.¹⁰ The modified Hartwig and Siegel scales were used to determine severity of the reaction to categorise ADR as mild, moderate and severe.¹¹

Statistical Analysis

Demographic data and categorical variables obtained were analysed using latest SPSS 27 software. The categorical variables were represented using frequencies and percentages. The Chi square test used to understand the association of risk factors like demographic factor, alcohol, smoking, comorbid conditions with the adverse drug reactions.

Results

Table 1 shows out of the 120 participants in this study, the majority of participants (57.5%) of the study participants were < 50 years old. The study comprised mostly of males (65.83%) with females accounting for 34.17%. Majority were employed (77.5) and from rural area (64.2). Diabetes mellitus (12.5%) was the most prevalent comorbidity, followed by hypertension (8.3%) and systemic lupus erythematosus (0.83%).

Table -1 Demographic and clinical characteristics of study population

Characteristics		Frequency (%)
Age(years)	<50	69(57.5)
	51-65	35(29.2)
	>65	16(13.3)
Gender	Male	79(65.83)
	Female	41(34.17)
Occupation	Employed	93(77.5)
	Unemployed	27(22.5)
Location	Rural	77(64.2)
	Urban	43(35.9)
Smoking	yes	40(33.3)
	No	80(66.7)
Alcohol use	yes	40(33.3)
	No	80(66.7)
Comorbidity	yes	26(21.7)
	No	94(78.3)

The proportion of patients who experienced ADRs based on demographic, clinical characteristics. Female, employment level, urban area and alcoholic were shown to have a significant relationship with the development of ADRs ($P < 0.005$) as in **Table 2**.

Table 2 Risk factors for ADRs from Antitubercular FDC medication.

Demography	Patients With ADR(N=43) Frequency (%)	Patients Without ADR(N =77) Frequency (%)	P-value
Age (years)			0.175^c
<50	29(67.44)	40(51.94)	
51-65	11(25.58)	24(31.16)	
>65	3(6.97)	13(16.88)	
Sex			**0.0033^c
Male	21(48.83)	58(75.32)	
Female	22(51.16)	19(24.67)	
Employment Status			**0.000793^c
Employed	38(88.37)	48(62.33)	
Unemployed	5(11.63)	22(28.57)	
Location			**0.00001^c
Rural	15(34.88)	62(80.5)	
Urban	28(65.1)	15(34.88)	
Smoking			0.3460^c
yes	12(27.90)	28(36.36)	
No	31(72.09)	49(63.63)	
Alcohol use			**0.178252^c
yes	11(25.58)	29(37.66)	
No	32(74.41)	48(62.33)	
Comorbidity			0.9124^c
yes	11(25.58)	15(19.48)	
No	32(74.41)	62(80.51)	

^c Chi-squared test- **p-value<0.05 is significant

Analysing by System wise distribution, gastrointestinal disorders were the most frequent ADR category, affecting 21 patients (17.5%). Skin and subcutaneous disorders were the second most common, affecting 16 patients (19.76%). Nervous system disorders were reported by 6 patients (6.97%). Less frequent side effects included joint pain 2(1.66%) and visual disturbance in 1(0.8%) as shown in **Table 3**.

Table 3: System wise distribution of adverse drug reactions reported

Adverse Drug Reactions	No of cases (n=43)	Percentage (%)
1. Gastrointestinal system (Epigastric pain, nausea and vomiting)	21	17.5
2. Dermatological system (Pruritis and rashes)	16	13.33
3. Nervous system (Peripheral neuritis, and dizziness)	3	2.5
4. Joint pain	2	1.66
5. Visual disturbance (optic neuritis)	1	0.83
Total	43	35.83

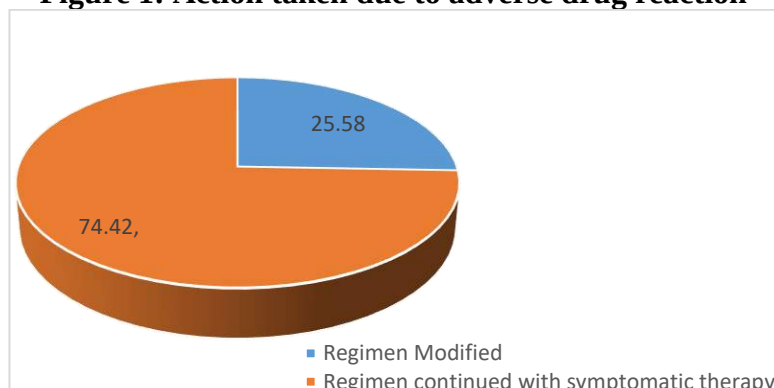
The number of ADRs were more during intensive phase when compared to continuous phase as shown in **Table 4**.

Table 4: Adverse drug reactions and phase of treatment

Adverse Drug Reactions	Intensive Phase N(%)	Maintainance Phase N(%)
1. Gastrointestinal system (Epigastric pain, nausea and vomiting)	18	3
2. Dermatological system (Pruritis and rashes)	16	0
3. Nervous system (Peripheral neuritis, and dizziness)	1	2
4. Joint pain	1	1
5. Visual disturbance (optic neuritis)	0	1

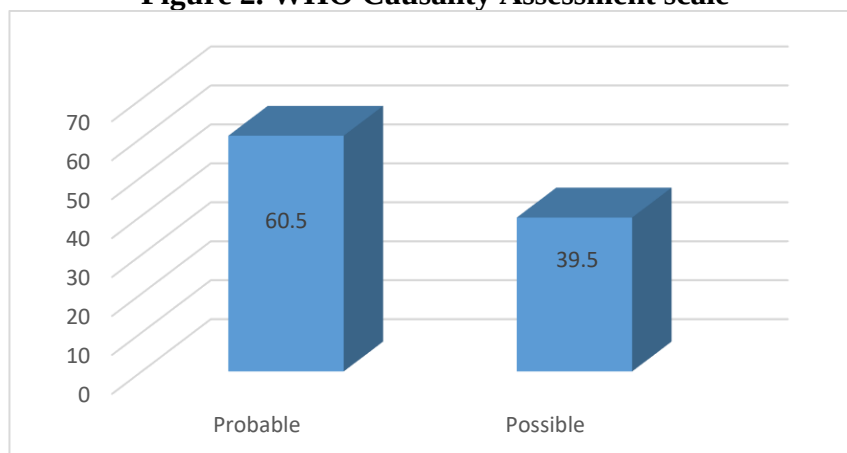
The treatment plan was modified due to ADRs in about 25.58% of cases, while the remaining 74.42% continued with symptomatic therapy shown in **Figure 1**.

Figure 1: Action taken due to adverse drug reaction



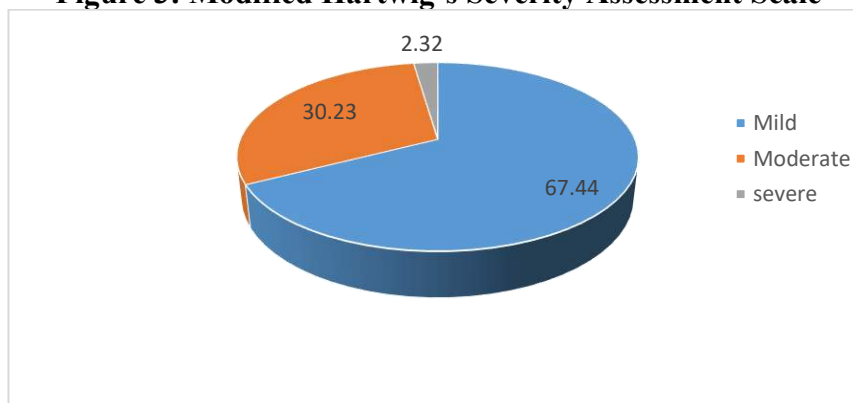
Causality assessment was done using WHO scale. The percentage of the probable and possible adverse effects was 60.5 and 39.5 respectively (**Figure 2**).

Figure 2. WHO Causality Assessment scale



The severity of adverse drug reactions was assessed using the Modified Hartwig and Siegel Scale. Out of the 120 patients evaluated, 67.44% were categorized as mild, requiring no changes in medication. Additionally, 30.23% fell into the moderate category, and only 2.32% needed intensive medical care, belonging to the severe class as in **figure 3**.

Figure 3: Modified Hartwig's Severity Assessment Scale



Discussion

There are many publications on ADRs to anti-tubercular medication. However very few have reported ADRs to FDCs. There is need to be explained in detail as all of medications are consumed at a given time and hence ADRs. The bioavailability of each drugs is unknown in the formulation. The current regimen also is based on body weight range and not individualized per kg body weight. Therefore there is likelihood of over dosage.

Our study aimed to identify and analyse the ADRs associated with the daily use of combination medications (FDC) in the NTEP's treatment plan. The percentage of ADRs among patients with pulmonary tuberculosis at our hospital throughout the research period was found to be 35.83% (Table 2). This is comparable to earlier studies that found a similar rate of 36.17%.¹²

Our study revealed that among various patient demographic characteristics only females, employed individuals, those residing in urban areas, and alcoholic patients exhibited a statistically significant association with an increased risk of developing ADRs. Females were more susceptible to ADRs with a rate of 51.16%, which aligns with study by Cheah et al.¹³ This increased risk in females could be attributed to hormonal fluctuations, particularly during pregnancy and menstruation. Additionally, potential interactions between anti-tuberculosis medications and birth control pills might further contribute to a higher incidence of ADRs in this group.^{14, 15} These results point to the necessity of extra safety measures, medication counselling, and closer observation in cases where anti-TB drugs are prescribed to female patients. Individuals living in urban areas and those who are employed report more ADRs compared to their rural or unemployed counterparts. This could be due to greater access to healthcare information and resources. This increased access might lead them to be more aware of potential side effects and therefore report them more frequently. However, other studies haven't shown the same significant difference.⁵ Our findings align with those of Kurniawati et al., who observed a higher prevalence of ADRs in individuals with a history of alcohol consumption compared to those without.¹⁶ Alcohol can interact with anti-TB medications and increase the risk of ADRs.

The Gastrointestinal (GI) symptom were the most common ADRs, with nausea, epigastric pain, and vomiting. This finding aligns with a prior study by Kiran et al. (26.7%) highlighting the known GI intolerance associated with first-line ATT drugs.⁶ Dermatological adverse effects, including purities (itching) and rashes, emerged as the second most common category of reported ADRs, accounting for 37.2% of all cases.⁶ Among these, maculopapular rash was the most frequently observed.¹⁶ This study identified a higher prevalence of ADRs during the intensive treatment phase, similar to previous research where a peak was observed within the first two months of anti-TB therapy.¹⁷ This knowledge emphasizes the importance of early detection and intervention for ADRs. Consequently, healthcare professionals should actively counsel patients about the potential for ADRs during the intensive phase, specifically focusing on the mentioned signs and symptoms (nausea, vomiting, rashes, etc.). Furthermore, implementing routine monitoring practices during this critical phase is crucial for the timely identification and management of ADRs.

Our study found that the majority (60.5%) of reported ADRs fell under the "probable" category according to the World Health Organization (WHO) causality scale.⁶

ADRs may cause patients to stop the drug, hospitalization, or occasionally even death. A modified Hartwig-Siegel scale was employed to evaluate the severity of the reaction that had occurred. 67.4% of ADRs were minor, and only one patient needed critical care, which was similar to the Maqusood M et al. study.¹⁸

A limitation of this study is the relatively small sample size. While our findings suggest potential associations between certain factors and adverse drug reactions, the generalizability of these results to the broader population may be limited.

Conclusion

While ATT-related ADRs are frequent, their potential to lead to treatment interruption and drug resistance necessitates proactive measures. Early detection and management of these reactions, coupled with patient counselling on lifestyle adjustments and potential ADRs, can significantly improve adherence and treatment success. This multi-pronged approach holds the key to minimizing the impact of ADRs and ensuring optimal outcomes for patients undergoing TB treatment

References

1. Manju R, Maheshwari YN, Ramya JE, Krishnamoorthy K. Adverse drug reaction monitoring of antitubercular drugs during intensive phase at tertiary care medical college hospital: A prospective study. *National Journal of Physiology, Pharmacy and Pharmacology*. 2020;10(11):976-980.
2. Ministry of Health and Family Welfare, Government of India. INDIA TB REPORT. 2022. Available from: <https://tbcindia.gov.in/WriteReadData/IndiaTBReport2022/TBAnnauReport2022.pdf>
3. Singh et al., the overall prevalence of ADRs with first-line anti-TB drugs varied from 8.4% to 83.5% (6) Singh A, Prasad R, Balasubramanian V, Gupta N, Gupta P. Prevalence of adverse drug reaction with first-line drugs among patients treated for pulmonary tuberculosis. *Clinical Epidemiology and Global Health*. 2015;3:S80–S90.
4. Hanumaiah V, Ranganath DD, Kakkuppi N. Assessment of adherence to anti tuberculosis medication for successful implementation of revised national tuberculosis programme at a tertiary care hospital, Shimoga: Across-sectional observational study. *International Journal of Basic & Clinical Pharmacology*. 2019;8(11).
5. Cheah MF, Zainal H, Hyder Ali IA. Evaluation of adverse reactions induced by anti-tuberculosis drugs in Hospital Pulau Pinang. *Malays J Med Sci*. 2018;25(5):103–114.
6. Kiran M, Nagabushan H. Adverse Drug Reactions Monitoring in Patients on Antitubercular Treatment in Tertiary Care Hospital, Mandya. *Biomedical & Pharmacology Journal*. 2021;14(2).
7. World Health Organisation. Pharmacovigilance in Tuberculosis care. 2013. Available from https://www.who.int/medicines/publications/PharmacoTB_web_v3.pdf.
8. Jameson JL, Fauci AS, Kasper DL, Hauser SL, Longo DL, Loscalzo J. *Harrison's Principles of Internal Medicine*. 20th ed. New York: McGraw-Hill Education/Medical; 2018.
9. Jawetz M. *Medical Microbiology*. 23rd ed. New York. McGrawHill Medical; 2004.
10. The Use of the WHO UMC System for Standardised Case Causality Assessment. Available from: <http://www.WHOUMC.org/graphics/4409.pdf>.
11. Hartwig S, Siegel J, Schneider P. Preventability and Severity Assessment in Reporting Adverse Drug Reactions. *Am J Hosp Pharm*. 1992;49: 2229-2232.
12. Mate, Kapil , et al. "Adverse Drug Reactions to a Daily Fixed-Dose Combination Based Antituberculosis Treatment Regime in India's National Tuberculosis Elimination Programme: A Prospective Cohort Study." *Journal of Clinical and Diagnostic Research*. 2022;16(8):14–19.
13. Cheah MF, Zainal H, Hyder Ali IA. Evaluation of adverse reactions induced by anti-tuberculosis drugs in Hospital Pulau Pinang. *Malays J Med Sci*. 2018;25(5):103–114
14. Sinha K, Marak IT, Singh W. Adverse drug reactions in tuberculosis patients due to directly observed treatment strategy therapy: experience at an outpatient clinic of a teaching hospital in the city of Imphal, Manipur, India. *The Journal of Association of Chest Physicians*. 2013;1(2):50.
15. Damasceno GS, Guaraldo L, Engstrom EM, Theme Filha MM, Souza-Santos R, Vasconcelos AG, et al. Adverse reactions to anti-tuberculosis drugs in Manguinhos, Rio de Janeiro, Brazil. *Clinics*. 2013;68(3):329–337.
16. Anand AC, Seth AK, Paul M, Puri P. Risk Factors of Hepatotoxicity During Anti-tuberculosis Treatment. *Med J Armed Forces India*. 2006;62(1):45–49.
17. Kurniawati F, Sulaiman SAS, Gillani SW. Adverse drug reactions of primary anti-tuberculosis drugs among tuberculosis patients treated in chest clinic. *International Journal of Pharmacy and Life Sciences*. 2012;3(1):1331–1338.

18. Maqusood M, Khan F A, Swaroop A. A Study on Incidence of Adverse Drug Reaction of AntiTubercular Drugs in New Cases of Pulmonary Tuberculosis in a Tertiary Care Teaching Hospital. Int J Med Res Prof. 2016;2(3):53-56.



Risk Assessment for Obstructive Sleep Apnea in End Stage Renal Disease Patients Undergoing Maintenance Hemodialysis

¹Dr Puneet K Nagendra, ²Dr Shiva Murthy N, ³Dr Avinash Ravikumar,

⁴Dr Vyshak Uddur Surendra, ⁵Dr Suryanarayana HV

¹ Associate Professor, ² Professor, ³ Assistant Professor, ⁴ Associate Professor, ⁵ Professor
¹ Department of Respiratory Medicine, CDSIMER. ² Department of Pharmacology CDSIMER. ³ Department of Pulmonary Medicine, AIMS. ⁴ Department of Respiratory Medicine, Yenepoya Medical College. ⁵ Jain Institute of Pulmonary and Sleep Medicine, BMJH.

¹Dayananda Sagar University, Ramanagara, India. ²Dayananda Sagar University, Ramanagara, India.

³Adichunchanagiri University, Mandya, India. ⁴Yenepoya Deemed to be University, Mangalore, India.

⁵ Bhagwan Mahaveer Jain Hospital, Bangalore, India.

ABSTRACT

Background: Obstructive Sleep Apnea (OSA) is prevalent among patients with End Stage Renal Disease (ESRD) undergoing maintenance hemodialysis (MHD). OSA exacerbates cardiovascular risk and negatively impacts quality of life in these patients. This study aims to assess the prevalence and risk factors of OSA in ESRD patients undergoing MHD in a southern region of India. **Methods:** This exploratory observational cross-sectional study included 64 ESRD patients undergoing MHD. Participants were assessed using a customized case record form (CRF) collecting demographic data, medical history, presenting symptoms, and clinical examination findings. OSA risk was evaluated using the STOP-BANG questionnaire. Statistical analysis involved linear regression to explore associations between STOP-BANG scores and various patient parameters. **Results:** Of the 64 patients (59.38% male, 40.63% female), 70.31% were over 40 years old. High OSA risk (STOP-BANG score ≥ 5) was identified in 17.19% of males and 3.13% of females. Common presenting symptoms included tiredness (56.25%), difficulty in falling asleep (54.68%), and frequent awakenings (46.87%). Hypertension (82.81%), diabetes mellitus (32.81%), and obesity (25.00%) were prevalent comorbidities. Linear regression revealed significant correlations between STOP-BANG scores and age, neck circumference, and height. **Conclusion:** The study highlights a substantial risk of OSA among ESRD patients on MHD, emphasizing the need for routine OSA screening and management in this population to mitigate cardiovascular risks and improve patient outcomes. Future research should focus on intervention strategies and longitudinal outcomes of OSA management in ESRD patients.

Index Terms - ESRD, Hemodialysis, STOP-BANG, OSA, Screening

INTRODUCTION

Sleep apnea occurs when the upper respiratory tract experiences interruptions lasting longer than 10 seconds during sleep. Obstructive Sleep Apnea (OSA) leads to recurrent arousals from sleep, oxygen desaturations, daytime sleepiness, fatigue, and cognitive impairment. This can have an adverse impact on quality of life. OSA is a common medical disorder affecting between 9% and 38% of the global adult population and from India, the prevalence of OSA in the general adult population ranges from 3.7% to 21%.¹ Accumulating data suggests a bidirectional relationship between OSA and CKD. That is, CKD likely confers an increased risk of OSA, and OSA may in turn increase the risk of renal injury.² According to studies, hemodialysis patients have a 10 times higher prevalence of sleep apnea than healthy individuals. According to estimates, sleep apnea is seen in 50–70% of maintenance hemodialysis (MHD) patients.³ OSA disrupts sleep, leading to daytime symptoms, such as excessive daytime sleepiness. In the meantime, repeated oxygen saturation drops increase

oxidative stress and stimulate the sympathetic system, leading to hypertension and an increased cardiovascular risk. Diagnosing OSA is therefore important in the management of End Stage Renal Disease (ESRD) patients undergoing MHD with high cardiovascular morbidity and mortality since it is a treatable condition.⁴

NEED OF THE STUDY

Given the significance of sleep apnea and the high rates of cardiovascular disease and complications in ESRD patients, in addition to the limitations of prior studies on the prevalence of this disease and its risk factors in ESRD patients in India, the current study aimed to ‘assess for the presence of risk factors of sleep apnea in ESRD patients undergoing hemodialysis.’

RESEARCH METHODOLOGY

The study was an exploratory, observational, cross-sectional study. After obtaining approval from the Institutional Ethics Committee (IEC approval number BMJH/DNB043/79/2016/02), the study was conducted from June 2015 to May 2016. All the adult patients above 18 years with ESRD undergoing MHD were considered for inclusion in the study. Patients who were critically ill, elderly, and not willing to give consent to participate in the study were excluded. The procedures were explained in simple terms and a consent form with details of procedure incorporated was given to the study participants. After obtaining consent, patients who presented to the study center for MHD and met the inclusion/exclusion criteria were subjected to history and examination as per a customized case record form (CRF) developed for the study.

In the present study, CRF had two parts for data collection. The first part included demographic parameters such as age, sex, weight in kilogram, height in centimeter, and body mass index (BMI). In addition, it included history of presenting complaints, most common habits before going to sleep, and relevant clinical examination findings. Presenting symptoms such as tiredness/easy fatigability, difficulty in falling asleep, frequent awakenings, problems in re-initiating sleep, early awakenings, impaired memory/concentration, loud snoring, excessive daytime sleepiness during reading/talking/watching television/driving/meetings, loss of libido, nightmares/panic attacks, un-refreshed sleep, morning headache, sleep walking/talk/eating, choking, sleep attacks (irresistible sleep), enuresis, sleep paralysis, abnormal leg movements, automatisms, and road traffic accident; Co-morbid conditions such as hypertension, diabetes mellitus, short neck, obesity, micrognathia, retrognathia, COPD, ischemic heart disease, hyperthyroidism, use of sleeping pills, cerebrovascular accidents, duration of ESRD in years, and frequency of dialysis per week.⁵

The second part of the questionnaire was a risk assessment of OSA using the STOP-BANG questionnaire. STOP-BANG questionnaire is a valid and effective screening tool for OSA in different populations and has a very strong identification ability. This questionnaire consists of eight items, including snoring, tiredness, observed apnea, hypertension, BMI ≥ 35 kg/m², age ≥ 50 years, neck circumference > 40 cm, and male gender. Responses were graded as “Yes (Score 1)” for the presence of risk factors and “No (Score 0)” for absence. The patients were classified as those with STOP-BANG scores ≥ 3 as being at risk for OSA. The results of STOP-BANG scoring and clinical examination that were performed were recorded in the study CRF and considered for analysis.⁶ In addition, details of activities two hours before sleeping such as watching television, using mobile, coffee, smoking, computer, reading, and use of alcohol were also collected and presented in the form of a table along with other risk factors.

STATISTICAL ANALYSIS

The values were expressed in frequency, proportions, mean, and standard deviation (SD) as appropriate. Linear regression analysis of individual parameters with STOP-BANG score was done using Graph Pad InStat 3 statistical software. $p \leq 0.05$ at a 95% confidence interval was considered significant. Linear regression analysis output is presented as *R-value*, Slope, and 95% confidence interval from to values. The parameters such as Neck circumference, Age, Height, Weight, BMI, Sleep Latency, Duration of ESRD, Frequency of Hemodialysis, and Sleep duration in hours were considered for correlation analysis with STOP-BANG score and same is presented in the form of figures (Fig No. 01). MS Word and MS Excel were used to generate tables as necessary.

RESULTS AND DISCUSSION

DEMOGRAPHIC PARAMETERS

In the present study, sixty-four (64) ESRD patients who were on MHD were considered for analysis. Both male (N = 38, 59.37%) and female (N = 26, 40.63%) patients were included in the study. The majority (70.31%) of patients were aged more than 40 years. These patients underwent HD at least 1 time per week to a maximum of 3 times per week. The duration of ESRD ranged from 0.1 years to 22 years. Other demographic parameters details are given in **Table No. 1**.

Table No. 1: Demographic profile of ESRD patients on MHD

Parameter	Sub parameter	N=64 (%)	Mean $\pm$ SD	Comments/Inference
Age in Years and Gender	20-29 Yrs.	10 (15.63)	24.3 $\pm$ 1.94	
	30-39 Yrs.	9 (14.06)	34.11 $\pm$ 3.25	
	40-49 Yrs.	13 (20.31)	43.76 $\pm$ 2.45	
	50-59 Yrs.	17 (26.56)	54.29 $\pm$ 2.8	
	60-69 Yrs.	13 (20.31)	63.15 $\pm$ 2.26	
	70-79 Yrs.	02 (03.13)	72 $\pm$ 0	
	Male	38 (59.38)	46.02 $\pm$ 15.88	Unpaired t-test. Comparison of age of Males Vs Females: p=0.5185 (not significant, t = 0.6494, df = 64)
	Female	26 (40.63)	48.38 $\pm$ 11.46	
ESRD duration in years	-	64 (100.00)	5.56 $\pm$ 4.47	Min=0.1, Max=22, Median=4
Hemodialysis frequency per week	-	64 (100.00)	2.29 $\pm$ 0.49	Min=1, Max=3, Median=2
Body Metabolic Index	-	64 (100.00)	23.88 $\pm$ 5.21	Min=15.8, Max=39.0, Median=23.4
Weight in Kg	-	64 (100.00)	60.87 $\pm$ 13.81	Min=30, Max=103, Median=60.25
Height in cm	-	64 (100.00)	160.56 $\pm$ 9.56	Min=138, Max=188, Median=161.5
STOP BANG Score: RISK OF OSA Low- 0 to 2 Intermediate- 3to4 High- >5	Male	$\geq$ 5	11 (17.19%)	17.19% of male ESRD patients have the risk of OSA
		<5	27 (42.19%)	
	Female	$\geq$ 5	02 (03.13)	03.13% of female ESRD patients have risk of OSA
		<5	24 (37.50)	

SYMPTOMS OF PATIENTS

The most common presenting symptoms were tiredness/fatigability (56.25%), difficulty in falling asleep (54.68%), frequent awakenings (46.87%), problems in re-initiation of sleep (45.31%), early awakenings (29.68%), etc. The frequency of presentation of other symptoms has been enumerated in **Table No. 2**.

Table No. 2: Symptoms at Presentation of ESRD and OSA patients undergoing MHD

Sl No.	Symptoms	No of ESRD patients N=64 (%)	At risk OSA patients, N=13 (%)
1.	Tiredness/fatigability	36 (56.25)	12 (92.30)
2.	Difficulty in falling asleep	35 (54.68)	10 (76.92)
3.	Frequent awakenings	30 (46.87)	13 (100.00)
4.	The problem in re-initiating sleep	29 (45.31)	13 (100.00)
5.	Early awakenings	25 (39.06)	09 (69.23)
6.	Impaired memory/concentration	19 (29.68)	07 (53.84)
7.	Loud snoring	17 (26.56)	07 (53.84)
8.	Excessive daytime sleepiness	12 (18.75)	06 (46.15)
9.	During reading/talking/watching tv/driving/meetings	11 (17.18)	04 (30.76)
10.	Loss of libido	08 (12.50)	04 (30.76)
11.	Nightmares/panic attacks	07 (10.93)	02 (15.38)
12.	Unrefreshed sleep	06 (09.37)	02 (15.38)
13.	Morning headache	04 (06.25)	00 (00.00)
14.	Sleep walking/talk/eating	03 (04.68)	00 (00.00)
15.	Choking	02 (03.12)	02 (15.38)
16.	Sleep attacks (irresistible sleep)	01 (01.56)	01 (7.69)
Note: None of the patients presented with enuresis, sleep paralysis, abnormal leg movements, automatisms, and road traffic accident.			

RISK FACTORS FOR OSA IN ESRD PATIENTS

A higher proportion of patients had hypertension (82.81%), diabetes mellitus (32.81%), Short neck (31.25%), Obesity (25.00%), Micrognathia (25.00%), and Retrognathia (25.00%) as co-morbid conditions. Watching television (42.19%), and use of Mobile (9.38%) were the most common activities that were prevalent two hours before sleep. Details of other risk factors and habits noted in the present study are listed in Table No. 3.

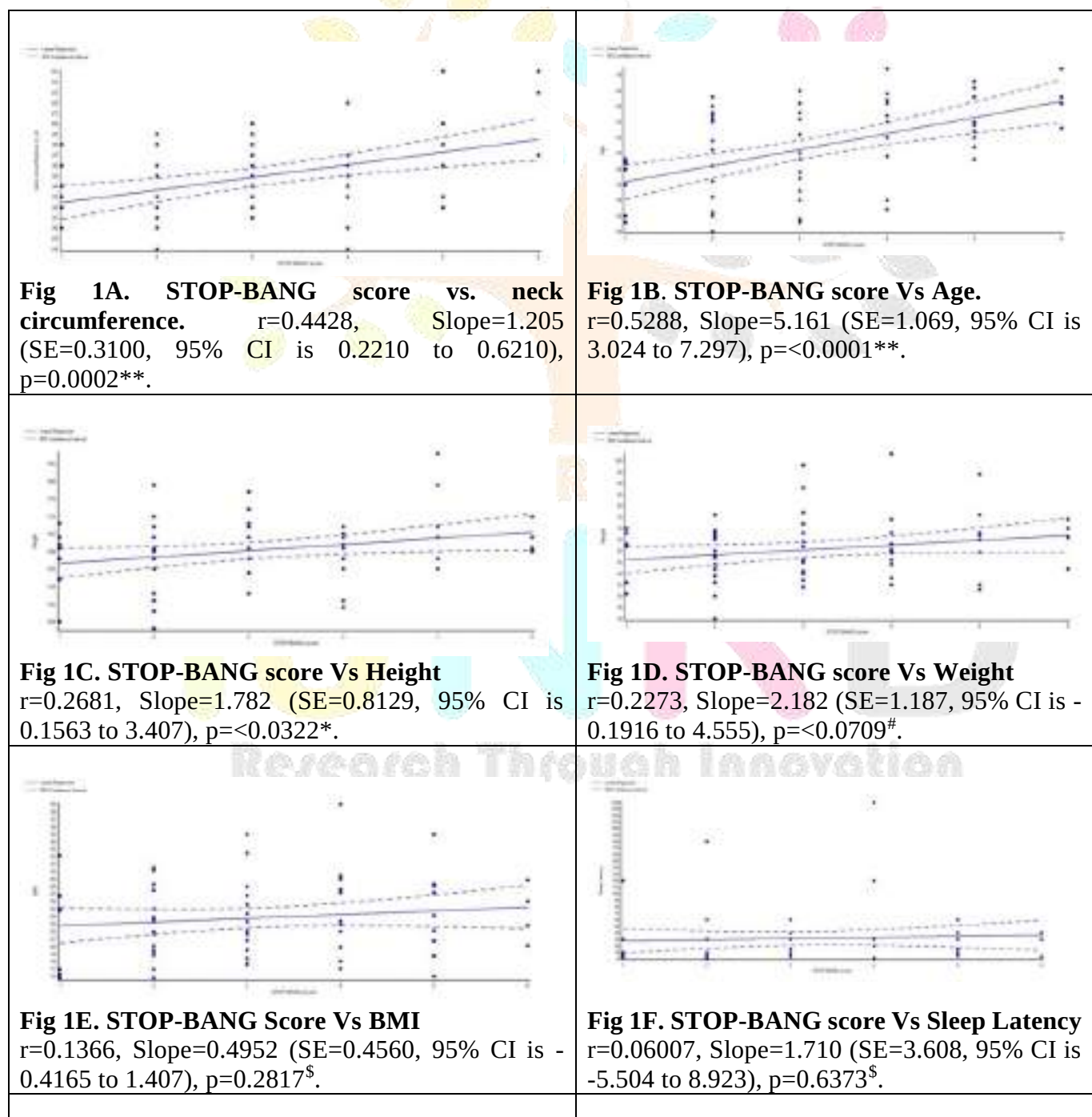
Table No. 3: Risk factors that were prevalent in ESRD patients undergoing MHD

Sl No.	Risk Factors		ESRD patients N=64 (%)	At risk OSA patients N=13 (%)
1.	Co-morbid conditions	Hypertension	53 (82.81%)	12 (92.30)
2.		Diabetes mellitus	21 (32.81%)	06 (46.15)
3.		Short neck	20 (31.25%)	05 (38.46)
4.		Obesity	16 (25.00%)	04 (30.76)
5.		Micrognathia	16 (25.00%)	05 (38.46)
6.		Retrognathia	16 (25.00%)	05 (38.46)
7.		COPD	4 (6.25%)	02 (15.38)
8.		Ischemic heart disease	3 (4.69%)	02 (15.38)
9.		Hyperthyroidism	3 (4.69%)	00 (00.00)
10.		Use of sleeping pills	1 (1.56%)	01 (7.69)
11.		Cerebro-vascular accidents	1 (1.56%)	01 (7.69)
12.	Activities 2 hours before sleep	Watching TV	27 (42.19%)	03 (23.07)
13.		Use of Mobile	6 (9.38%)	02 (15.38)
14.		Coffee	5 (7.81%)	01 (7.69)
15.		Smoking	3 (4.69%)	02 (15.38)
16.		Computer	3 (4.69%)	00 (00.00)
17.		Reading	2 (3.13%)	00 (00.00)
18.		Use of Alcohol	1 (1.56%)	01 (7.69)

Analysis of association of risk factors with ESRD using STOP BANG score:

Linear regression analysis of individual parameters (having continuous data) with STOP-BANG score suggested that: Considered significant and low positive correlation inferred with height ($r=0.2681$, Slope=1.782 (SE=0.8129, 95% CI is 0.1563 to 3.407), $p<0.0322$) of patients; Considered not quite significant and very low correlation inferred with weight ($r=0.2273$, Slope=2.182 (SE=1.187, 95% CI is -0.1916 to 4.555), $p<0.0709$); Considered not significant and very low correlation inferred with Sleep Latency ($r=0.06007$, Slope=1.710 (SE=3.608, 95% CI is -5.504 to 8.923), $p=0.6373$); Considered not significant and very low negative correlation inferred with duration of ESRD disease ($r= -0.1248$, Slope= -0.3880 (SE=0.3928, 95% CI is -1.171 to 0.3953), $p=0.3259$), frequency of hemodialysis ($r= -0.04398$, slope= -0.01509 (SE=0.04354, 95% CI is -0.1021 to 0.07195), $p=0.7300$) and sleep duration in hours ($r= -0.1472$, Slope= -0.1610 (SE=0.1374, 95% CI is -0.4357 to 0.1137), $p=0.2457$). (See Figure No. 1 A to I).

Figure No 1. Linear regression analysis of various parameters to find the association of risk factors with ESRD using STOP-BANG score analysis.



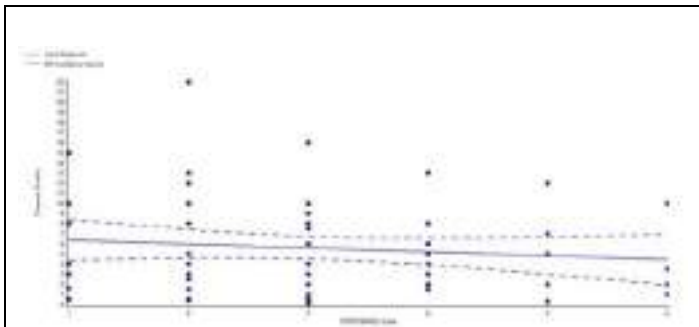


Fig 1G. STOP-BANG score Vs Duration of ESRD disease. $r = -0.1248$, Slope = -0.3880 (SE=0.3928, 95% CI is -1.171 to 0.3953), $p=0.3259^@$.

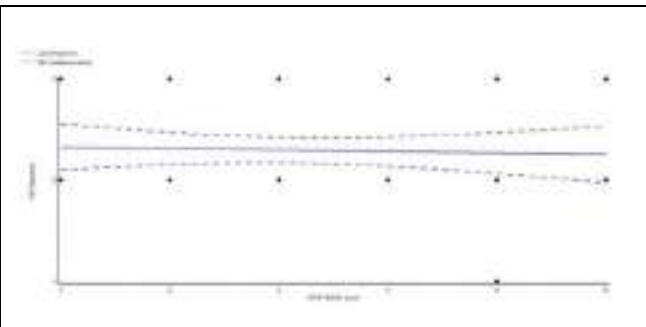
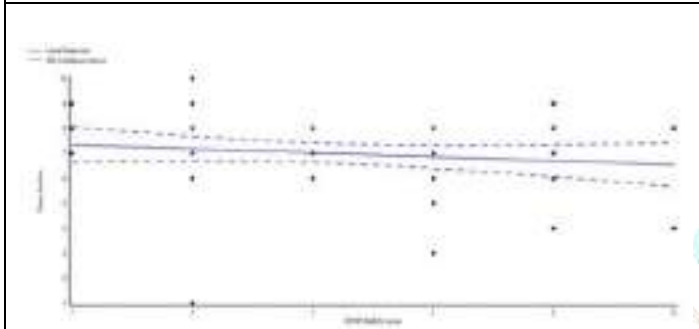


Fig 1H. STOP-BANG score Vs Frequency of Hemodialysis. $r = -0.04398$, Slope = -0.01509 (SE=0.04354, 95% CI is -0.1021 to 0.07195), $p=0.7300^@$.



Note:

$n=64$, $df=63$, r = correlation coefficient

**considered extremely significant and moderately positive correlation inferred.

*considered significant and low positive correlation inferred.

considered not quite significant and very low correlation inferred.

\$ considered not significant and very low correlation inferred.

@ considered not significant and very low negative correlation inferred.

End-stage renal disease (ESRD) patients have a higher risk of morbidity and require time-intensive care. It is an important chronic disease globally which can affect the quality of life and survival of the patient significantly. It affects a variety of populations throughout the world. Understanding the demographic factors, clinical features, and plausible risk factors can help us to identify the disease early and take preventive measures. Early detection and optimal management can improve patient outcomes. However, due to lower access to care, reactive treatment instead of proactive measures, can affect adversely. As reported by Gupta R et al¹⁸ early detection, improved education level, and treatment of diabetes, hypertension, glomerulonephritis, and cystic kidney disease resulted in reduced ESRD. It was observed that Hypertension (N=53, 82.81%), Diabetes mellitus (N=21, 32.81%), Short neck (N=20, 31.25%), Obesity (N=16, 25.00%), and Micrognathia (N=16, 25.00%) were the common co-morbidities that were prevalent in the patients that were included in this study. These findings again recommend similar measures to detect and treat these diseases in early adulthood to prevent CKD and ESRD.

Similar data was provided by Singh P et al.¹⁹ Causality of renal failure due to hypertension, diabetes mellitus, and renal calculi are explained by various authors. As per researchers, uncontrolled hypertension causes long-term damage to the blood vessels that supply the kidney. This affects the kidneys by reduction of oxygen and blood supply leading to failure of their function. Prolonged high serum glucose can result in damage and clogging of renal blood vessels affecting kidney function. Ureteral obstruction, hydronephrosis, and repeated infections due to renal calculi result in damage to the kidney. Prolonged obstruction in severe cases, can even lead to kidney failure. Therefore, chronic diseases were considered inconsequential as a causal factor for ESRD.

In our study, a good number of patients (N=36, 56.25%) were aged more than 45 years. In addition, there were a higher number of male patients (N=38, 59.37%) compared to female (N=26, 40.63%) patients suffering from ESRD. These findings were similar to the results published by Singh P et al¹⁹. As per their report, the most common age group for ESRD presentation was 46-60 years (52.1%). This may be due to the similar (Southeast Asian) populations were included in both studies. The results of the present study suggest the presence of sleep apnea in ESRD patients undergoing maintenance hemodialysis and investigate the effective factors in the occurrence of sleep apnea in these patients. The results showed that overall 20.31 % (n=13) of

patients had risk of obstructive sleep apnea (OSA). Out of which 17.19 % (n=11) was for males and 3.13% (n=2) for females.

A study by Forni Ogna et al., which aimed to determine the prevalence of sleep apnea and introduce a diagnostic approach for hemodialysis patients in Switzerland, showed that the prevalence of moderate to severe sleep apnea in ESRD patients was 56%.⁴ Moreover, a study by Ghanei Geshlagh et al. showed that 41.7% of hemodialysis patients had sleep apnea in Iran.⁷ Also, a study by Sabry et al. which aimed to determine the prevalence of sleep disorders in hemodialysis patients in Saudi Arabia showed that 31.8% of patients had these abnormalities.⁸

In contrast, some other studies reported a very high prevalence of sleep apnea in ESRD patients; a study by Huang et al. showed that 80% of ESRD patients had moderate or severe sleep apnea.⁹ Also, another study investigated the prevalence of sleep disorders in hemodialysis patients in Iran and showed that the total prevalence of sleep disorders was 75% in these patients.¹⁰ Overall, the prevalence of sleep apnea is high in ESRD patients, and the observed difference in the prevalence rates of different studies may be due to differences in the sample size, screening tools, diagnostic tools for measuring sleep apnea, and genetics.¹¹ The main cause of the high prevalence of sleep apnea in ESRD patients is unknown. However, some studies have shown that uremic toxins, metabolic acidosis, chronic hypoxemia, amino-acid metabolism abnormalities, and hormone imbalance are associated with the occurrence of sleep apnea in ESRD patients. Given the high prevalence of sleep apnea in ESRD patients, its negative impact on the mental health and adaptability of patients, and its role in the increased cardiovascular morbidity and mortality of patients, it is essential to design and implement regular screening programs for the detection of sleep apnea in ESRD patients.^{12,13}

Moreover, in the present study, the age of ESRD patients was showing a positive correlation. This finding is consistent with the results of previous studies, as they suggested older age as a risk factor for sleep apnea. This discrepancy may be attributed to the small sample size of our study. However, changes in the quantity and quality of sleep and the increased risk of sleep apnea in the elderly were observed, which may be due to the poor performance of muscles holding the open airway in the elderly.¹⁴

STOP-BANG scoring system is a widely accepted risk assessment method for OSA. It considers eight parameters such as snoring, tiredness, observed apnea, blood pressure, BMI, age, neck circumference, and gender. In our study, we observed a positive significant correlation with parameters such as age and neck circumference. In addition, a significant positive correlation was observed with height and weight parameters independently. However, BMI did not show any significant correlation with the STOP-BANG score. This may be attributed to lower mean BMI (23.88 ± 5.21) noted in our population undergoing MHD. The findings of the present study showed that BMI had a very low correlation with the occurrence of sleep apnea in CKD patients, which is not in line with similar studies in this area. A study by Sadeghniiat-Haghighi et al., which aimed to determine the reliability and validity of the Persian version of the STOP-BANG questionnaire in a sleep clinic population (n=603), demonstrated a significant association between BMI and sleep apnea. Two other studies by Lurie and Moroni et al. showed a linear association between the increase in BMI and AHI. Also, previous studies have shown that a weight loss of 10% in obese patients could reduce AHI by 27%. Considering the important role of BMI and overweight in the development of sleep apnea, attention to this risk factor in the preventive and control programs of sleep apnea seems necessary.¹⁵

Sleep latency, duration of ESRD, and frequency of hemodialysis showed very low and insignificant correlation. Whereas sleep duration in hours showed a very low and insignificant negative correlation.¹⁶ Consistent with previous studies,⁸ our study found that only 23.19% of MHD patients met 5–7 ideal CVH metrics, less than half of the general Chinese population. Traditional risk factors for cardiovascular disease such as hypertension, diabetes, obesity, and lack of exercise are more common in MHD patients, while dialysis-related factors such as anemia, inflammation, oxidative stress, and fluid overload also increase the incidence of CVD events. However, the results of our study showed that despite regular visits to hospitals, MHD patients have a higher risk of cardiovascular disease than the general population and they are not well-controlled. Cardiovascular disease is the most common complication and the leading cause of death in MHD patients, so more attention should be paid to the prevention and control of CVD in HD patients.¹⁷ One of the

limitations of this study is its cross-sectional design. Also, the small sample size (n=64) and the use of the STOP-BANG questionnaire rather than polysomnography, as the gold standard for OSA detection.

CONCLUSION

Poor sleep quality is common among dialysis patients and is associated with lower health-related quality of life. If OSA is one of the more prevalent sleep disorders within the dialysis patient population, perhaps screening for OSA ought to become a routine portion of case management of these patients. Early detection of sleep apnea in ESRD patients along with control of major risk factors associated with the disease prevents the occurrence of complications while undergoing maintenance hemodialysis allowing for better health-related outcomes in individual patients.

REFERENCES

1. Tejas Menon Suri, Tamoghna Ghosh, Saurabh Mittal, Vijay Hadda, Karan Madan, Anant Mohan. Systematic review and meta-analysis of the prevalence of obstructive sleep apnea in Indian adults. *Sleep Medicine Reviews*. 2023; 71:101829.
2. Abuyassin B, Sharma K, Ayas NT, Laher I. Obstructive Sleep Apnea and Kidney Disease: A Potential Bidirectional Relationship? *J Clin Sleep Med*. 2015 Aug 15;11(8):915-24.
3. Moradzadeh M, Mirmohammadkhani M, Tamadon MR, Mansori K, Malek F. Prevalence of Sleep Apnea and its Associated Factors in Chronic Kidney Disease Patients. *Tanaffos*. 2021 Feb;20(2):116-125.
4. Forni Ognà V, Ognà A, Pruijm M, Bassi I, Zuercher E, Halabi G, et al. Prevalence and Diagnostic Approach to Sleep Apnea in Hemodialysis Patients: A Population Study. *Biomed Res Int* 2015; 2015:103686.
5. Iliescu EA, Coe H, McMurray MH, et al. Quality of sleep and health-related quality of life in hemodialysis patients. *Nephrol Dial Transplant*. 2003; 18:126-132.
6. Patel D, Tsang J, Saripella A, Nagappa M, Islam S, Englesakis M Et al. Validation of the STOP questionnaire as a screening tool for OSA among different populations: a systematic review and meta-regression analysis. *J Clin Sleep Med*. 2021.
7. Ghanei Geshlagh R, Hemmati Maslakkpak M, Ghoci S. Sleep apnea and metabolic syndrome in hemodialysis patients. *Studies in Medical Sciences* 2011;22(4):339-45.
8. Sabry AA, Abo-Zenah H, Wafa E, Mahmoud K, El-Dahshan K, Hassan A, et al. sleep disorders in hemodialysis patients. *Saudi J Kidney Dis Transpl* 2010;21(2):300-5.
9. Huang HC, Walters G, Talaulikar G, Figurski D, Carroll A, Hurwitz M, et al. Sleep apnea prevalence in chronic kidney disease - association with total body water and symptoms. *BMC Nephrol* 2017;18(1):125.
10. Astanegi S, Omidvarborna M, Nourmohammadi B. Prevalence of sleep disorder in hemodialysis patients referred to Dialysis Center of Emam Reza hospital affiliated to Kermanshah University of Medical science. *J Clin Res Paramed Sci* 2012;1(1): e82170.
11. Unruh M, Miskulin D, Yan G, Hays RD, Benz R, Kusek JW, et al. Racial differences in health-related quality of life among hemodialysis patients. *Kidney Int* 2004;65(4):1482-91.
12. Kagawa S, Fukumori T. Sleep apnea syndrome in dialysis patients. *Nihon Rinsho* 2004;62 Suppl 6:411-5.
13. Lin CH, Perger E, Lyons OD. Obstructive sleep apnea and chronic kidney disease. *Curr Opin Pulm Med* 2018;24(6):549-554.

14. Edwards BA, O'Driscoll DM, Ali A, Jordan AS, Trinder J, Malhotra A. Aging and sleep: physiology and pathophysiology. *Semin Respir Crit Care Med* 2010;31(5):618-33.
15. Han C, Liu F, Yang X, Chen J, Li J, Cao J, et al. Ideal cardiovascular health and incidence of atherosclerotic cardiovascular disease among Chinese adults: The China-PAR project. *Sci China LifeSci.* 2018;61(5):504–14.
16. Song, YH., Cai, GY., Xiao, YF. *et al.* Risk factors for mortality in elderly hemodialysis patients: a systematic review and meta-analysis. *BMC Nephrol* 21, 377. 2020.
17. Dahnann M, Assabri AM, Khader YS. Risk Factors for End-Stage Renal Failure Among Patients on Hemodialysis in Aljomhory Hospital, Sa'adah Governorate, Yemen: Hospital-Based Case-Control Study. *JMIR Public Health Surveill.* 2019 Sep 25;5(3): e14215.
18. Gupta R, Woo K, Yi JA. Epidemiology of end-stage kidney disease. *Semin Vasc Surg.* 2021 Mar;34(1):71-78.
19. Singh P, Faisal AR, Sheikh AU, Alam MM, Faizan M, Neupane P, Uzair M, Acharya A, Saeed A, Akhtar FN. An Evaluation of Socio-Demographic and Risk Factor Profile in End-Stage Renal Disease Patients: A Cross-Sectional Assessment. *Cureus.* 2021 Jul 13;13(7): e16353.



Optic Neuritis Induced By Ethambutol

Uppada Vibha¹, Dr. Anusha S J² Dr. Puneet K Nagendra³,
Thrishala Guruprakash⁴

¹(Phase III MBBS Student, CDSIMER, India)

²(Assistant Professor, Department Of Pharmacology, CDSIMER, India)

³(Associate Professor, Department Of Respiratory Medicine, CDSIMER, India)

⁴(Phase III MBBS Student, CDSIMER, India)

Abstract:

Ethambutol (EMB) is one of the drugs in primary treatment of tuberculosis. EMB rarely induces ocular toxicity which is either dose-dependent or duration-dependent effect and is often reversible on therapy discontinuation. The toxicity has been reported at 4 to 12 months of the initiation of the therapy.[1] Here we report a case of 44year old female patient presented with the diminution of vision in both the eyes after 11 months of initiation of treatment. Following a series of eye examinations, the patient was diagnosed with EMB induced ocular toxicity and hence the drug was discontinued. The patient started recovering after the medicine was discontinued. This case study helps people comprehend the clinical presentation and treatment of ethambutol induced optic neuritis.

Keywords: Ethambutol, Optic neuritis, Tuberculosis

Date of Submission: 26-11-2023

Date of Acceptance: 06-12-2023

I. Introduction

Tuberculosis is one of the major global health burdens. It is more prevalent in India, about 316 per 1 lakh population.[5] The primary anti-tubercular treatment for extra pulmonary tuberculosis includes rifampin, isoniazid, pyrazinamide and ethambutol.

Ethambutol is a bacteriostatic antimicrobial used as primary treatment against tuberculosis. However, it can cause adverse effects such as visual disturbances, liver problems, and allergies. Ethambutol-induced optic neuropathy (EON) is a well-known consequence of ethambutol use, the severity of which varies with dose. EON is characterized clinically by painless loss of central vision and cecentral scotomas in the visual field. The prevalence of EON in various nations is close to 1%.[2]

The precise mechanism of action of ethambutol is unknown; however, it has been proposed that it acts as a chelating agent, disrupting one of several metal-containing enzyme systems in mycobacteria nucleic acid structures.[3] Ethambutol caused lesions in the optic chiasm and optic nerves in early animal trials.[4] Reversibility of optic neuritis has been regarded as dose- and duration-related, and reversible upon therapeutic withdrawal.

Unfortunately, patient education and quick drug discontinuation may not always improve the final vision outcome. Because the toxicity appears to be unpredictable, the medicine is to be used with caution.

II. Case Presentation

A 44-year-old female weighing 67kg was diagnosed with extra pulmonary tuberculosis. She presented to our centre 11 months back complaining of swelling in the right side of the neck which was diagnosed to be cervical lymphadenopathy due to extrapulmonary tuberculosis. After performing necessary investigations, she was started on anti-tubercular treatment with 5 tablets fixed dose combination (FDC) comprising total of isoniazid(375mg), rifampicin (750mg), pyrazinamide(2000mg) and ethambutol(1375mg) in a day.

The recommended dosages of the drugs in the FDC according to the weight of the patient include isoniazid(335mg), rifampicin (670mg), pyrazinamide(1340mg), ethambutol (1005mg).

After 11 months of treatment the patient presented with blurring of vision for both far and near, the onset of which was a month ago. On examination her visual acuity was counting fingers (CF) at 3m and improved with pinhole to 6/60 in both the eyes, intraocular pressure (IOP) was 18mm of Hg.

On follow-up after 20 days, the visual acuity was CF 3m in the right eye and CF 1m in the left eye with no improvement with pinhole in both the eyes. Color vision was impaired in both the eyes. Visual field test shows subtotal visual field loss. On distant direct ophthalmoscopy, the optic disc of both eyes was pale. Considering the possibility of EMB-induced optic neuritis, the patient was advised for cessation of ethambutol and given individual drugs of the continuation phase that includes isoniazid 300mg and rifampicin 650mg. She was started

with steroids along with Tablet methylprednisolone 50mg and pantoprazole 40mg. The patient was then lost to follow up and presented after 2 months. Her visual acuity was tested and found to be 6/60 in the right eye and CF at 3m in the left eye that improved with pinhole to 6/60. Near vision was N12 in the right eye and N18 in the left eye. Color vision was 1/17 in both eyes. Optical Coherence Tomography (OCT) was advised. The results showed pale optic disc and the rest was within normal limits. Visual field test shows subtotal visual field loss. Prescribed Tablet Neurobion forte along with steroids. Her vision was gradually improving as seen in figure 1a and 1b to 2a and 2b.

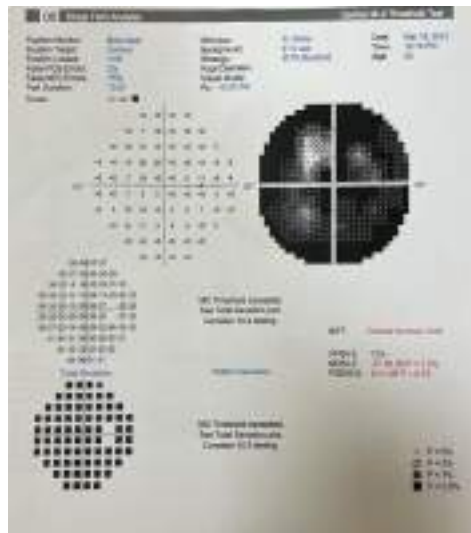


Figure 1a

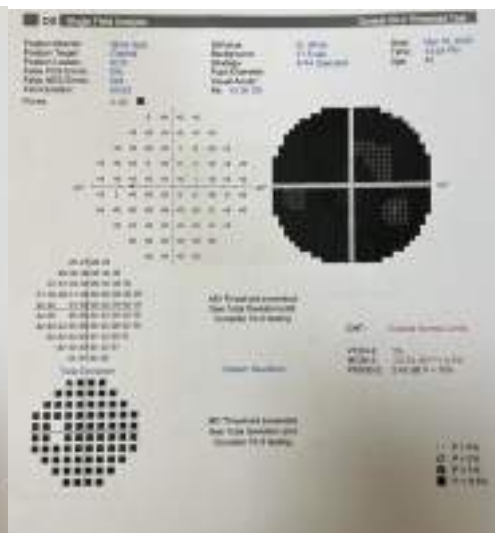


Figure 1b

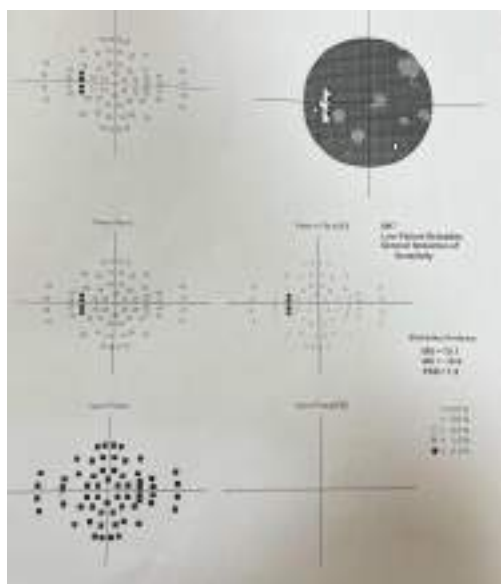


Figure 2a

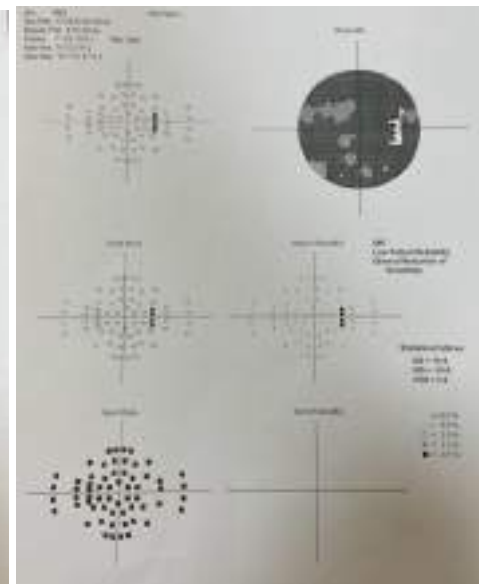


Figure 2b

III. Discussion

Ethambutol (EMB) is the primary anti tubercular treatment for extra pulmonary tuberculosis. The ocular toxicity induced from ethambutol is not usually common at standard doses used in the anti-tubercular treatment. Optic neuritis is the most serious adverse effect of EMB. It is reversible, but some studies indicate that it is irreversible.[4] Symptoms of ethambutol toxicity are usually seen between four and twelve months after starting EMB and are dose dependent.[1] On examination, central scotoma is common with the loss of color vision. The only treatment which has proven beneficial in EMB induced optic neuropathy is cessation of the drug. Mostly resolves in few months after discontinuing the drug. Isoniazid which is frequently administered with EMB can also cause ocular toxicity. If visual impairment persists even after the cessation of EMB, the discontinuation of INH is to be considered. Before treating, renal function test, history of eye diseases and record of visual acuity is

preferable. In a resource limited setting, routine visual acuity tests, and color vision tests is always preferable in specially the high-risk patients like the ones with comorbidities to avoid adverse effects due to EMB toxicity. This happens with awareness of the treating physician. There is a need for patient awareness about the importance of adverse drug reactions for seeking medical advice on priority.

IV. Conclusion

EMB, though being the primary anti- tubercular drug has the potential to cause serious ocular adverse effects that are dose and/or duration dependent leading to permanent vision loss. Early detection of EMB induced optic neuritis is important, the physicians should be aware of this potential sight- threatening adverse effect and its management.[1] There is a need to educate the patients about adverse drug effects and regular visual acuity tests for early toxicity detection. If there is no improvement in vision even after the withdrawal of EMB, cessation of isoniazid must be considered.

References

- [1]. Rahul V, Deeksha S. A Rare Case Of Ethambutol Induced Optic Neuritis In A Peripheral Health Institute Of Northern India. International Journal Of Science & Healthcare Research. 2021; 6(2): 14-16.
- [2]. Lee EJ, Kim SJ, Choung HK, Et Al. Incidence And Clinical Features Of Ethambutol-Induced Optic Neuropathy In Korea. J Neuroophthalmol 2008; 28:269–77.
- [3]. Kahana LM. Toxic Ocular Effects Of Ethambutol. Can Med Assoc J. 1987;137: 213-6.
- [4]. Russo PA, Chaglasian MA. Toxic Optic Neuropathy Associated With Ethambutol: Implications For Current Therapy. J Am Optom Assoc. 1994;65(5):332-8.
- [5]. <https://www.downtoearth.org.in/Health>



A REAL WORLD SAFETY STUDY ON DAPAGLIFOZIN, A PRELIMINARY ACTIVE SURVEILLANCE IN A TERTIARY CARE SETTING

Dr.Padmaja Shetty K^{1*}, Dr.Pratibha Nadig², Dr. Prashanth Kumar M³, Ms. Tanya Tanaaz⁴, Ms. Shruthi Hari⁵, Ms. Ananya⁶

^{1*} Assistant Professor, Department of Pharmacology, Dr Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, padmajaalva@gmail.com
Contact no- 9448862850

² Professor & HOD, Department Of Pharmacology, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, Dayananda Sagar University, pratibha.nadig@gmail.com
Contact no- 9901961964

³ Professor & HOD, Department Of Physiology, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, Dayananda Sagar University, drprashanthkumar@gmail.com
Contact no- 9448015663

⁴ Pharm D student, College of Pharmaceutical Sciences, Dayanada Sagar University

⁵ Pharm D student, College of Pharmaceutical Sciences, Dayanada Sagar University

⁶ II MBBS Student, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, Dayananda Sagar University

***Corresponding author:** Dr Padmaja Shetty K.

Assistant Professor, Department of Pharmacology, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, Dayananda Sagar University, E-mail: padmajaalva@gmail.com, padmajashetty.cdsimer@dsu.edu.in, Contact no- 9448862850

Abstract:

Background: Dapagliflozin, a popular SGLT 2 inhibitor is frequently used as a single or add on therapy in type 2 diabetes mellitus. With its efficacy established through extensive clinical trials, our study aims to collect preliminary safety data on dapagliflozin through active surveillance.

Material and Methods: The safety profile of dapagliflozin was evaluated in 100 patients aged > 18 years either on mono or add on dapagliflozin treatment for a duration of > 2 weeks. The safety data was collected on CRF after obtaining consent for a duration of 4 months from April 2022- July 2022 at a tertiary care hospital. The primary outcome was the proportion and frequency of AEs, causality and severity assessment of AEs. Secondary outcome delineated the association between sociodemographic and dapagliflozin characteristics with safety data.

Result: On analysis of safety data of 100 patients, mean age was 57.65 ± 12.23 years with male preponderance (57%) with average BMI – 27.75 ± 2.42 . About 39% adverse events were reported, of which the most common AEs were increased fatiguability (28.2%)(unexpected), hypoglycemia (17.9%), dapa specific adverse events such as genital tract infections (12.8%) and UTI (12.8%), gastro intestinal adverse events (~10-17%) and backpain- 9.09%. With 93% on add on therapy,

higher dose(10mg) and duration of administration (218.7 days) were significantly associated with adverse events.

Conclusion: Widespread clinical application of dapagliflozin among diabetics/nondiabetics have been associated with the need for vigilance on the safety data. The real life dapagliflozin safety data collected here contribute to the global incidence and watchlist.

Keywords: dapagliflozin, Adverse events, hypoglycemia, genital tract infections, UTI, Indian population

Introduction:

Sodium glucose transporter 2 (SGLT2) inhibitors initially introduced as oral hypoglycemic agents were later also found to exhibit reduction in sympathetic activity, oxidative stress, cardioprotection, renoprotection, weight loss and lowering of blood pressure. Their unique insulin independent mechanism of action targeted the high capacity sodium glucose transporters located in the early portion of proximal convoluted tubules of the kidney leading to glycosuria. This property has been used in order to attain euglycemic control either alone or in combination regimen.^{1,2,3}

Of the several FDA approved SGLT2 inhibitors, dapagliflozin was the first in the class antidiabetic agents.^{4,5} Dapagliflozin is used either in monotherapy or in combination with other antidiabetic medications/insulin at any stage of type 2 diabetes mellitus.⁵ Dapagliflozin is used at a dose of 5mg to a maximum of 10mg/ day for adequate glycemic control. Several randomized controlled trials have shown noninferiority of dapagliflozin in comparison to other antidiabetic agents. The therapeutic role of dapagliflozin has been expanded to many other non diabetic conditions as well.⁶

Several randomized controlled trials have studied the efficacy and provided a comprehensive list of adverse events profile of dapagliflozin. Dapagliflozin in single/dual/ triple therapy has shown greater glycemic control with respect to HbA1c levels and weight reduction.⁷

The increasing popularity of SGLT2 inhibitors for various indications also draws our attention towards safety data. The most common adverse events reported are hypoglycemia, genital tract infections, urinary tract infections, backache, dryness of mouth, gastrointestinal adverse events such as nausea, vomiting, constipation.^{5,8,9}

Despite the safety and efficacy of dapagliflozin proved through RCTs, real world data/observational studies have shown varying incidence and severity of adverse events such as urinary tract infections, genital tract infections and more serious adverse events such as Fournier's gangrene, ulcers/ non healing wounds.⁵ Hence this preliminary real world safety surveillance aims to determine the frequency, association and severity of dapagliflozin safety data among Indian diabetic population where its usage has risen substantially.

Materials and methods:

Review of outpatient and ward case sheet prescription by the clinical pharmacists, 130 patients on dapagliflozin were screened for the study, of which 18 patients did not agree to participate in the study and 12 patients did not meet the study criteria.

The study size of 100 diabetic patients met the study criteria of >18 years of age, both gender, on dapagliflozin for >2 weeks, either alone or in combination at a dose of 5mg or 10mg. Study was conducted from April 2022- July 2022 at a tertiary care setting after obtaining written informed consent. Type-2 diabetic patients who were on dapagliflozin for more than 2 weeks but had to discontinue treatment were also included in the study. Patients with contraindications to dapagliflozin such as hypersensitivity reactions, stopped dapagliflozin within 2 weeks, patients on dapagliflozin for conditions other than type 2 diabetes, pregnant women were excluded from the study.

For this active surveillance, the CRF for direct patient interviews was designed to include sociodemographic, clinical, medication related data and a set of 12 adverse drug reactions of

dapagliflozin as listed on FDA-PI, SmPC and other real time clinical studies. For telephonic interviews a set of 10 validated questionnaires comprising of the above 12 ADRs were included.

The study was designed and conducted in accordance with the Declaration of Helsinki, Good Clinical Practice guidelines and was conducted after obtaining institutional ethics committee approval (CDSIMER/MR/0019/IEC/2021). The adverse events thus collected were assessed for frequency, severity, duration, causality, seriousness of reactions and association of risk factors with ADRs.

The primary outcomes included the proportion, frequency and types of AEs reported. Causality and severity assessment of adverse events(AE) and association of AE with sociodemographic, clinical and dapagliflozin characteristics were included as secondary outcomes.

WHO causality assessment score was used to measure the relationship between dapagliflozin and AEs as definite=3, probable=2, possible=1 and unlikely=0 while Hartwig's severity score classified the severity of AEs as mild=1, moderate=2 and severe=3.

Statistical analysis: A preliminary sample size of 100 was calculated for this study derived from previous real time data. Descriptive and inferential statistical analysis has been carried out in the present study. Continuous measurements are presented as mean $\pm$ SD and categorical measurements are presented in number/percentages (%).

A multivariate logistic regression was performed to assess the relation between adverse event and the explanatory variables: gender, age, address, employment status, BMI, education, socioeconomic status and comorbidities. Data were checked for multicollinearity with the Belsley-Kuh-Welsch technique. Heteroskedasticity and normality of residuals were assessed respectively by the Breusch-Pagan test and the Shapiro-Wilk test. A p-value < 0.05 was considered statistically significant. Statistical analysis was performed with Microsoft Excel and the Statistical Package for Social Sciences (SPSS) version 27.

Result:

Patient demographic and clinical characteristics:

Patient demographics and clinical characteristics details are as shown in table 1. The study included patients aged 57.65 ± 12.23 years with male preponderance(57%). Clinical evaluation showed patients with BMI 27.75 ± 2.42 and systolic blood pressure was 128.27 ± 13.3 mm Hg and diastolic blood pressure : 80.22 ± 9.9 mm Hg.

Table 1: Sociodemographic and clinical characteristics (n=100)

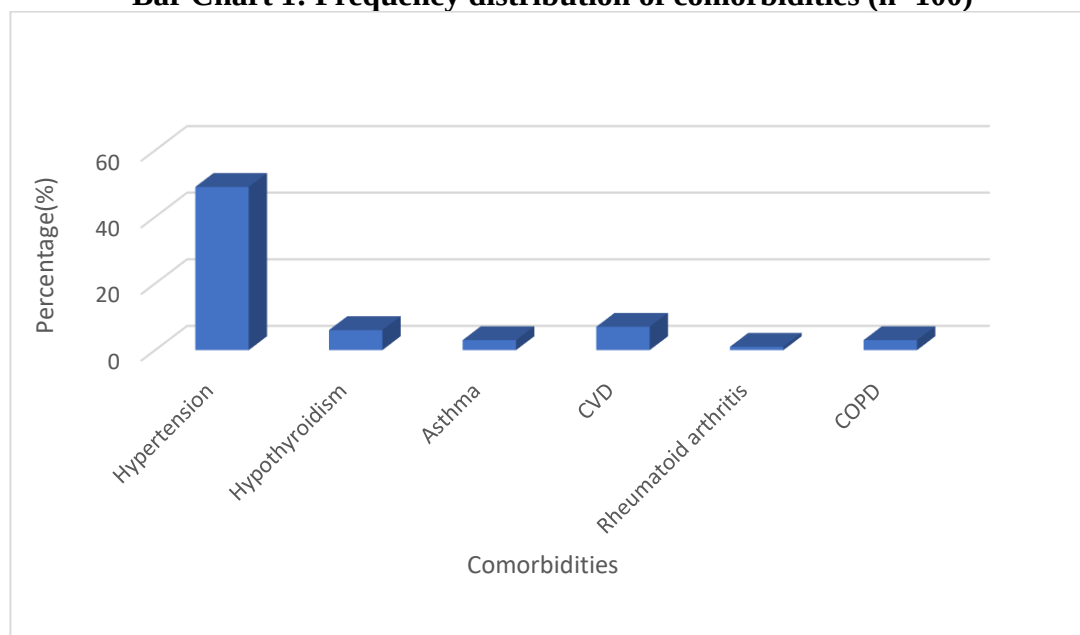
Sociodemographic & clinical characteristics	%
Age in Years	
• 18-30	5.0
• 31-45	16.0
• 46-65	56.0
• Above 65	23.0
Gender	
• Male	57.0
• Female	43.0
BMI	
• <25	77
• >25	23
Address	
• Rural	55.0
• Urban	45.0
Education	
• Educated	76
• Uneducated	24
Socioeconomic status	
• Upper middle	33.0

• Lower middle	37.0
• Upper lower	30.0
Employment status	
• Employed	45
• Unemployed	55
Blood pressure	
• <120/80 (Normal)	63.0
• 120-139/80-89 (Prehypertension)	23.0
• 140-159/90-99(Stage 1 HTN)	12.0
• >160/100 (Stage 2 HTN)	2.0
Presence of Comorbidities	55

At the time of enrolment in the study, laboratory examination showed FBS -150.5±49.12mg/dl, PPBS- 250.94±92.04 mg/dl with mean HbA1C as 9.56±2.29 % and serum creatinine levels-0.88 ±0.21mg/dl.

Among the study population with comorbidities (55%) (Bar Chart 1) the most common comorbidities observed were hypertension (49%), coronary heart disease (7%), asthma (3%), COPD (3%), rheumatoid arthritis (1%) and hypothyroidism (6%).

Bar Chart 1: Frequency distribution of comorbidities (n=100)



Dapagliflozin use and concomitant medications :

Considering the dapagliflozin related characteristics : 7% were taking dapa as single drug while 66% were on 10mg dose, 93% were add on therapy. Most of the patients (57%) included in this study have been on dapagliflozin for an average duration of 218.7 days (Table 2).

Table 2: Real Time Dapagliflozin utilisation characteristics(n=100)

Dapagliflozin characteristics	%
Dapa(single/ combi)	
• Single	7.0
• Adds on	93.0
Combination	
• No	2.0
• Single	6.0
• 2 drugs	29.0
• 3 drugs	61.0
• > 3	2.0

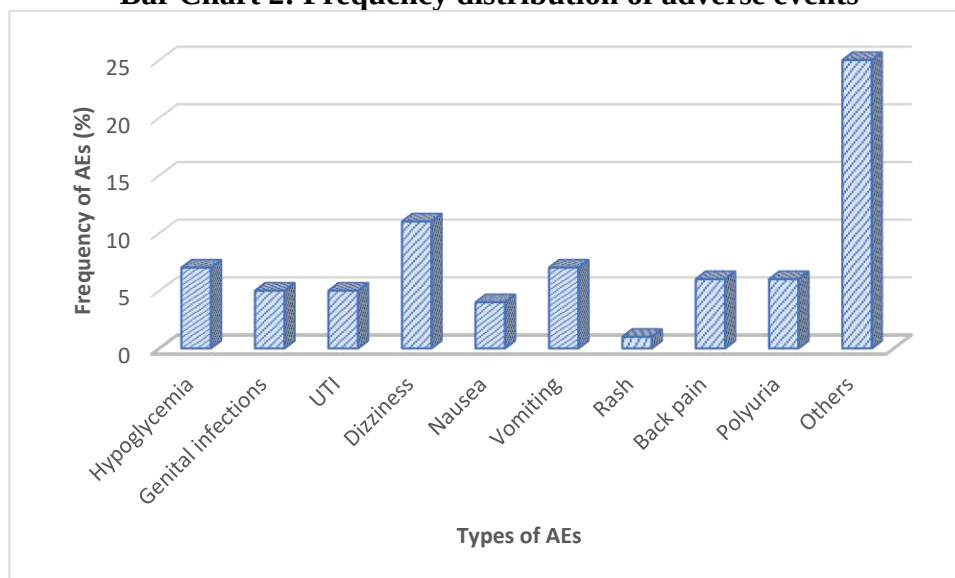
Dapa dose	
• 5mg	34.0
• 10mg	66.0
Duration	
• 1-6 months	57.0
• 7-12 months	21.0
• 1-2 yr	16.0
• 2-5 year	6.0
Personal history	
• No	89.0
• Smoking	4.0
• Alcohol	6.0
• Tobacco	1.0
Concomitant medications	
• No	44.0
• Yes	56.0

Around 56% of patients were on concomitant medications, of which 69.6% were on antihypertensive medications, 35.7% were on anticoagulants and antiplatelets drugs, 46.4% were on other medications such as statins, thyronorm, alprazolam, salbutamol, ambroxol, formoterol and budesonide, clopidogrel, thyronorm, antibiotic doxycycline, Vitamin B supplements, hematinics etc.

Adverse events(AE) profile among patients:

The frequency of AEs reported among patients is as shown in Bar Chart 2. 39% of patients on dapagliflozin presented with AEs. The most common AEs reported for dapagliflozin were fatiguability (28.2%) (unexpected), hypoglycemia (17.9%), dizziness(28.2%), polyuria (15.38%), backpain (9.09%), genital infections (12.8%), urinary tract infection (12.8%), nausea (10.2%), vomiting (17.9%), rash (2.56%), constipation (7.69%)(unexpected), dryness of mouth (5.12%), headache (2.56%)(unexpected), weight loss(2.56%), sleeplessness (2.56%)(unexpected), palpitations (2.56%)(unexpected), pain abdomen (5.12%), loss of appetite (2.56%)(unexpected), wound/ulcer (2.56%), chills (2.56%) and chest pain (2.56%)(unexpected).

Bar Chart 2: Frequency distribution of adverse events



Treatment was not changed for 29% of AEs reported, while in 12% cases, treatment with the suspected drug was withheld, but no treatment was given to manage AE. In 6% AEs, treatment with suspected drug was withheld/ discontinued and other treatment was given to manage AEs.

Causality assessment by WHO Probability Scale showed that 57% had possible and 22% had probable relationship to AEs. As per Hartwig's severity score assessment, 63% of AEs were mild while 16% were moderate. There were no serious AE(SAEs) reported.

Association of sociodemographic factors and clinical characteristics with AEs:

As shown in Table 3, multivariate analysis showed that lower BMI (OR=0.8, [0.64 ; 1.0], $p=0.046$) was associated with higher rates of adverse events while the socioeconomic status, employment status, education, gender, age, address and presence of comorbidities were not associated with the AEs incidences.

Table 3: Association between demographic variables & rate of adverse events:

	Odds Ratio	p-Value
Rate of adverse events	293.2 [0.686 ; 125252.96]	0.066
Age		
Risk for each 1-unit increase	0.999 [0.958 ; 1.04]	0.958
Address		
Reference: rural	1.1 [0.368 ; 3.31]	0.861
Employment status	0.793 [0.222 ; 2.83]	0.72
BMI		
Risk for each 1-unit increase	0.799 [0.641 ; 0.996]	0.046 *
Education	0.902[0.251;3.24]	0.875
Socioeconomic status		
Reference: lower middle	1.14 [0.36 ; 3.62]	0.821
	0.506 [0.155 ; 1.65]	0.259
Comorbidities	2.06 [0.799 ; 5.31]	0.135
Gender		
Reference: M	0.994 [0.277 ; 3.57]	0.993

* $p<0.05$ ** $p<0.01$ *** $p<0.001$ **** $p<0.0001$

In multivariate analysis (Table 4), > 1 year duration of administration of dapagliflozin (OR=4.66, [1.58 ; 13.75], $p=0.0053$) and concomitant medications (OR=0.32, [0.13 ; 0.81], $p=0.016$) were associated with higher rates of AE.

Table 4: Association of dapagliflozin data to rate of AEs

	Odds Ratio	p-Value
Intercept	0.873 [0.47 ; 1.62]	0.668
Dapa dose		

	Odds Ratio	p-Value
Reference: 10mg	0.532 [0.202 ; 1.4]	0.202
Duration		
Reference: <1 year	4.66 [1.58 ; 13.75]	0.00527 **
Concomittant medications		
Reference: Yes	0.321 [0.127 ; 0.809]	0.016 *

* p<0.05** p<0.01*** p<0.001**** p<0.0001

Multilogistic regression analysis showed that the most common AEs like hypoglycemia, UTI , GI disturbances showed a positive trend of incidence towards duration of dapagliflozin administration while fatiguability was significantly associated with higher dose of dapagliflozin (10mg)(p<0.05).

Discussion:

Amongst the various SGLT2 inhibitors, dapagliflozin has been one of the commonly used antidiabetic agents in Indian population at a dose of 5mg/10mg/day. In the recent days, its use has also been expanded towards management of heart failure, chronic kidney disease, myocardial infarction, fatty liver diseases, weight loss, dyslipidemia.^{10,11,12}

Sociodemographic and clinical characteristics observed in study by Jung-Fu Chen et al was similar to that observed in our study including mean age (57.65±12.23yrs), male preponderance (57%) with BMI (27.75 ± 2.42)(p<0.05). More than half of our study population had comorbidities(55%), most common being hypertension(49%) similar to the study.¹³

In this study the real time dapagliflozin utilisation showed majority of study population on multiple antidiabetic medications while 66% were on highest dapagliflozin dose/day for effective blood glucose control. This was also associated with 56% of study population on concomitant medications to improve morbidity and mortality status. AE frequency of our study was similar to the study done by Brooks A.M et al where single and multidose phase I studies reported 21% and 37% of AEs while safety data analysis from phase II/III studies done by Serge Jabbour showed ≥1 AEs in 60% of cases.^{14,15}

Most common AEs reported in this study were classified as expected such as dapagliflozin specific adverse events such as urinary tract infections (UTI)(12.8%), genital tract infections(GTI)(12.8%), hypoglycemia(17.9%), gastrointestinal tract infections such as nausea, vomiting, pain abdomen, weight loss and unexpected AEs included increased fatiguability, palpitation, loss of appetite, chest pain. The expected AEs reported is similar to review article by Sohita Dhillon¹⁶ and research study done by Guo L¹⁷ et al, where hypoglycemia was ~14% while genital and urinary tract infections were ~5%. While the clinical practice experience study done by Anitha A P et al showed hypoglycemia, GTI, UTI, hypotension, increased risk of breast and bladder cancer and increased uric acid levels.¹⁸ DECLARE TIMI 58 clinical trial and study by Martha K Nicholson showed higher frequency of genital tract infections among women (13.2 %) which is similar to our study.¹⁹

Questionnaire based surveillance focused on the subjective AEs which included the increased incidence unexpected events such as increased fatiguability, constipation, loss of appetite, weight loss, palpitation, chest pain. These AEs affected the routine activity, medication adherence among the patients. Focusing on subjective AEs are important to identify and report AEs as well as provide timely assistance to help patients adhere to treatment.²⁰

Increased rate of dapa specific adverse events such as hypoglycemia, UTI and genital tract infections were significantly (p<0.05) associated with factors such as increased duration (>1 yr) and higher dose (10mg) of dapagliflozin administration, concomitant medications and increased BMI (>25). More than half of the study population showed mild AEs and possible relationship with

dapagliflozin. Study by Amit Varshney²¹ has shown good safety profile of dapagliflozin when administered in Indian population.

Despite absence of SAEs, our study has shown that 6% of AE cases discontinued treatment similar to study by jabbour at al.¹⁵ The most common adverse events reported in our study which resulted in discontinuation of treatment were increased fatiguability, hypoglycemia and genital tract infections which affected their quality of life.²²

The study focused on active surveillance to collect AEs through direct patient interviews which significantly showed association with reasons for discontinuation of treatment. Dapagliflozin related AEs reported can be added to the global watchlist. However, the study also presents with the limitation of a smaller sample size and was confined to a smaller geographical distribution. Hence more detailed multicentric study should be carried out to track the safety profile of SGLT2 inhibitors due to its increasing popularity,

Conclusion: Safety data in this preliminary study on real time dapagliflozin utilisation has shown incidence similar to global reporting. The increased incidence of unexpected adverse events which had serious implication on patient's day to day activity and medication adherence needs more surveillance on field.

References:

1. Nelinson DS, Sosa JM, Chilton RJ. SGLT2 inhibitors: a narrative review of efficacy and safety. *J Osteopath Med*. 2021 Feb 1;121(2):229-239. doi: 10.1515/jom-2020-0153. PMID: 33567084.
2. Fadiran O, Nwabuo C. The Evolution of Sodium-Glucose Co-Transporter-2 Inhibitors in Heart Failure. *Cureus*. 2021 Nov 8;13(11):e19379. doi: 10.7759/cureus.19379. PMID: 34925982; PMCID: PMC8654149.
3. Jaehyun Lim, Soong Kwak, You-Jung Choi et al. Differing Efficacy of Dapagliflozin Versus Empagliflozin on the Risk of Incident Atrial Fibrillation in Patients With Type 2 Diabetes: A Real-World Observation Using a Nationwide, Population-Based Cohort. *Journal of the American Heart Association* Vol. 13, No. 3. e030552 <https://doi.org/10.1161/JAHA.123.030552>
4. Padda IS, Mahtani AU, Parmar M. Sodium-Glucose Transport Protein 2 (SGLT2) Inhibitors. [Updated 2023 Jun 3]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK576405/>
5. Saeed MA, Narendran P. Dapagliflozin for the treatment of type 2 diabetes: a review of the literature. *Drug Des Devel Ther*. 2014 Dec 10;8:2493-505. doi: 10.2147/DDDT.S50963. PMID: 25525338; PMCID: PMC4267514.
6. Hsia DS, Grove O, Cefalu WT. An update on sodium-glucose co-transporter-2 inhibitors for the treatment of diabetes mellitus. *Curr Opin Endocrinol Diabetes Obes*. 2017 Feb;24(1):73-79. doi: 10.1097/MED.0000000000000311. PMID: 27898586; PMCID: PMC6028052.
7. Sahay, R.K., Giri, R., Shembalkar, J.V. et al. Fixed-Dose Combination of Dapagliflozin + Sitagliptin + Metformin in Patients with Type 2 Diabetes Poorly Controlled with Metformin: Phase 3, Randomized Comparison with Dual Combinations. *Adv Ther* 40, 3227–3246 (2023). <https://doi.org/10.1007/s12325-023-02523-z>
8. Filippatos TD, Liberopoulos EN, Elisaf MS. Dapagliflozin in patients with type 2 diabetes mellitus. *Ther Adv Endocrinol Metab*. 2015 Feb;6(1):29-41. doi: 10.1177/2042018814558243. PMID: 25678954; PMCID: PMC4321869.
9. Fda.gov. [cited 2024 Feb 12]. Available from: https://www.accessdata.fda.gov/drugsatfda_docs/label/2020/202293s020lbl.pdf
10. Zargar AH, Trailokya AA, Ghag S et al. Current Role of Dapagliflozin in Clinical Practice. *J Assoc Physicians India*. 2021 Sep;69(9):11-12. PMID: 34585897.
11. Gupta M, Rao S, Manek G et al. The Role of Dapagliflozin in the Management of Heart Failure: An Update on the Emerging Evidence. *Ther Clin Risk Manag*. 2021 Aug 12;17:823-830. doi: 10.2147/TCRM.S275076. PMID: 34408424; PMCID: PMC8367215.
12. Bailey CJ, Gross JL, Hennicken D et al. Dapagliflozin add-on to metformin in type 2 diabetes inadequately controlled with metformin: a randomized, double-blind, placebo-controlled 102-

- week trial. BMC Med. 2013 Feb 20;11:43. doi: 10.1186/1741-7015-11-43. Erratum in: BMC Med. 2013;11:193. PMID: 23425012; PMCID: PMC3606470.
13. Chen JF, Peng YS, Chen CS, et al. Use and effectiveness of dapagliflozin in patients with type 2 diabetes mellitus: a multicenter retrospective study in Taiwan. Peerj. 2020 ;8:e9998. DOI: 10.7717/peerj.9998. PMID: 33240585; PMCID: PMC7678460.
14. Brooks AM, Thacker SM. Dapagliflozin for the treatment of type 2 diabetes. Ann Pharmacother. 2009 Jul;43(7):1286-93. doi: 10.1345/aph.1M212. Epub 2009 Jul 7. PMID: 19584379.
15. Jabbour S, Seufert J, Scheen A et al. Dapagliflozin in patients with type 2 diabetes mellitus: A pooled analysis of safety data from phase IIb/III clinical trials. Diabetes Obes Metab. 2018 Mar;20(3):620-628. doi: 10.1111/dom.13124. Epub 2017 Oct 26. PMID: 28950419; PMCID: PMC5836959.
16. Dhillon S. Dapagliflozin: A Review in Type 2 Diabetes. Drugs. 2019 Jul;79(10):1135-1146. doi: 10.1007/s40265-019-01148-3. Erratum in: Drugs. 2019 Dec;79(18):2013. PMID: 31236801; PMCID: PMC6879440.
17. Guo L, Wang J, Li L et al. A multicentre, prospective, non-interventional study evaluating the safety of dapagliflozin in patients with type 2 diabetes in routine clinical practice in China (DONATE). BMC Med. 2023 Jun 14;21(1):212. doi: 10.1186/s12916-023-02906-7. PMID: 37316847; PMCID: PMC10268430.
18. Anitha AP, Balasubramanian S, Ramalingam AG at al. An exploration of the experience of dapagliflozin in clinical practice. Future Sci OA. 2022 Nov 1;8(8):FSO816. doi: 10.2144/fsoa-2022-0038. PMID: 36457541; PMCID: PMC9704035).
19. Martha K Nicholson, Randa Ghazal Asswad & John PH Wilding(2021). Dapagliflozin for the treatment of type 2 diabetes mellitus – an update, Expert Opinion on Pharmacotherapy, 22:17, 2303-2310, DOI: 10.1080/14656566.2021.1953471
20. Liu L, Suo T, Shen Y, Geng C,et al. Clinicians versus patients subjective adverse events assessment: based on patient-reported outcomes version of the common terminology criteria for adverse events (PRO-CTCAE). Qual Life Res. 2020 Nov;29(11):3009-3015. doi: 10.1007/s11136-020-02558-7. Epub 2020 Jun 20. PMID: 32564293.
21. Varshney A, Rawat R. Comparison of safety and efficacy of dapagliflozin and empagliflozin in type 2 diabetes mellitus patients in India. Rev Assoc Med Bras (1992). 2023 Aug 14;69(8):e20230090. doi: 10.1590/1806-9282.20230090. PMID: 37585983; PMCID: PMC10427181.
22. Cahn A, Raz I, Bonaca M, Mosenzon O et al. Safety of dapagliflozin in a broad population of patients with type 2 diabetes: Analyses from the DECLARE-TIMI 58 study. Diabetes Obes Metab. 2020 Aug;22(8):1357-1368. doi: 10.1111/dom.14041. Epub 2020 Apr 27. PMID: 32239659.

Assessment of NCD risk using Community Based Assessment Checklist among population in urban field practice area, Manikeswari-Kalaburagi Karnataka.

¹Dr Pavan S Kalasker, ²Dr Ullasini Kolhar, ³Dr Brunda N K, ⁴Saifan H Nadaf, ⁵Dr Shivanand

Abstract: **Background:** Non-communicable diseases (NCD) like cardiovascular diseases, diabetes mellitus, cancer and chronic pulmonary obstructive diseases have become major public health challenges, increasing at rapid pace and responsible for 70% of premature deaths in India. It is necessary to develop cost effective, easily usable screening tool to identify high risk individuals in the population. Community Based Assessment Checklist (CBAC) is one such tool employed by health workers in primary health centres. Aim of our study was to estimate the NCD risk and find associated variables among adult population of Manikeshwari, an urban field practice area of Gulbarga Institute of Medical science, Kalaburagi (GIMS) using CBAC as the screening tool. **Materials & Methods:** This was a descriptive, community based cross-sectional study conducted among 300 randomly selected adult participants with age 30 years conducted in urban field practice area Gulbarga institute of medical sciences, Kalaburagi, Karnataka. CBAC (community-based assessment checklist) was used to screen subjects and assign risk score to individuals. **Result:** 34% of subjects were found to be having NCD risk score of 4 and above, indicating close follow up as they were at increased risk of developing NCD. Age, gender, education, blood pressure and BMI were found to be statistically significant association with NCD risk score.

Keywords: NCD risk score, CBAC (Community Based Assessment Checklist)

AFFILIATIONS

¹Assistant Professor,
Department of Community
Medicine, GIMS
Kalaburagi.

²Assistant Professor,
Department of General
Medicine, GIMS
Kalaburagi.

³Associate Professor,
Department of Community
Medicine, CDSIMER
Dayananda Sagar
University Ramnagara.

⁴Phase III Part -I MBBS
student, GIMS Kalaburagi.

⁵Associate Professor,
Department of Community
Medicine, Mahadevappa
Rampure Medical College
Kalaburagi Karnataka.

CORRESPONDING AUTHOR

Dr Shivanand

drshivanand2u@gmail.com

INTRODUCTION

As India moves into the epidemiological and demographic transition, we are faced with an increasing burden of non-communicable diseases. One of the goals of the newly developed Sustainable Development Goals is the reduction of premature mortality. ⁽¹⁾ Non-Communicable Diseases (NCDs) like Cardiovascular diseases, Diabetes, Cancer and Chronic Obstructive Pulmonary Diseases have become major public health challenges, which contribute to high morbidity and mortality in India. People of all age groups, regions and countries are affected by NCDs. These conditions are often associated with older age groups, but evidence shows that 17 million NCD deaths occur before the age of 70 years. Of these premature deaths, 86% are estimated to occur in low- and middle-income countries. Children, adults and the elderly are all vulnerable to the risk factors contributing to NCDs, whether from unhealthy diets, physical inactivity, exposure to tobacco smoke or the harmful use of alcohol or air pollution. ⁽²⁾ The four common NCDs (Cardiovascular diseases, Cancer, Diabetes and Chronic respiratory diseases) are estimated to account for over 57% of the total mortality in the age group of 30-59 years, thereby adversely impacting social and economic development. ⁽³⁾

These diseases are driven by forces that include rapid unplanned urbanization, globalization of unhealthy lifestyles and population ageing. Unhealthy diets and a lack of physical activity may show up in people as raised blood pressure, increased blood glucose, elevated blood lipids and obesity. These are called metabolic risk factors and can lead to cardiovascular disease, the leading NCD in terms of premature deaths. ⁽²⁾

Article Title: Assessment of NCD risk using Community Based Assessment Checklist among population in urban field practice area, Manikeshwari- Kalaburagi Karnataka

As a signatory to the Global Action Plan for the Prevention and Control of Noncommunicable Diseases (NCD), India is now mandated to halt the rise of diabetes by 2025 and reduce the prevalence of hypertension by 25% between 2010 and 2025. To achieve these targets, the Government of India has launched a National Multisectoral Action Plan for the Prevention and Control of NCDs and a dedicated program for the National Prevention and Control of Cancer, Diabetes, Cardiovascular Disease and Stroke (NPCDCS).⁽⁴⁾ Series of measures have taken by MoHFW (Ministry of Health and Family Welfare) beginning from NTCP (National Tobacco Control Programme) in 2007 and launch of NPCDCS (National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular diseases and stroke) in 2010 to population-based screening in 2016 for effective control of these diseases.

In our country due to low levels of health awareness and significant information asymmetry that exists, screening for diseases where there are no obvious symptoms is perceived to be an unnecessary process, particularly so, amongst the poor, for whom a day's visit to the secondary or tertiary facility for screening, might mean the loss of a day's wages.⁽⁵⁾ Management of NCDs includes detecting, screening and treating these diseases, and providing access to palliative care for people in need. High impact essential NCD interventions can be delivered through a primary health care approach to strengthen early detection and timely treatment.⁽²⁾

Population based screening will also serve the purpose of increasing awareness in the community about NCDs/ risk factors and the need for periodic screening. It also enables an understanding of better health and avoidance of risk factors in the general community.⁽²⁾ Community Based Assessment checklist (CBAC) is a simple and effective method for assessing non communicable diseases and assigning risk score to individual. India being vast and diverse country, CBAC is the cost-effective approach as it can be used with minimum training by health worker.

There is paucity of studies and further exploration on usage of CBAC as screening tool needs to be undertaken. There is a need for intensive population based screening and early detection of individuals with NCD risk factors. Hence, this study is an attempt to know the load in the community and further strength population-based screening which are currently undertaken at primary health care level. The objectives of study are to estimate NCD risk using Community Based Assessment Checklist (CBAC) among adult population.

METHODOLOGY

A descriptive, community based, cross sectional study was conducted at Manikeshwari, which is urban field practice area of department of community medicine, Gulbarga Institute of Medical Sciences, Kalaburagi (GIMS), Karnataka. Study was conducted for a period of 3 months among adult population with more than 30 years of age and those individuals who are known case of hypertension, diabetes mellitus, stroke, or cardiovascular disease and pregnant women were excluded from study. According to NFHS 5, the prevalence of overall hypertension in Karnataka is 25%, and using formula $n = z^2 pq/d^2$, sample size was found to be 300.⁽¹²⁾

Data collection method: There are 7 wards in UHTC Manikeshwari with 66353 with 17561 houses. Required sample size was divided among 7 wards according population proportion to size. From each ward, houses were selected by systematic random sampling and eligible subjects were included in the study. Participants were interviewed and examined after obtaining verbal consent. Data was collected by semi structured questionnaire which contained socio-demographic details, Community Based Assessment Checklist. Anthropometric Measurements and blood pressure was recorded as a part of routine general physical examination.

Study Tool: Community Based Assessment Checklist (CBAC) is used by health workers in PHC for screening of NCDs like Hypertension, Diabetes and Cardiovascular diseases. It is simple questionnaire which is intended to capture details related to age, family history for any of the NCDs, waist circumference, and risky behaviours such as physical inactivity, use of/or exposure to tobacco and alcohol use. Each question has allotted score and if total score of individual subjects is 4 and above indicates high risk for developing NCDs and need for further evaluation and follow up.

Statistical Analysis: Data was entered in MS Excel 2019 version and presented in percentages and proportions; Chi square test was applied wherever required to find association between subjects with high risk CBAC score and various other variables.

RESULTS

Out of total 300 subjects, highest number of subjects belonged to age group 31-40 years, 65% were females and around 40% had illiterate. Majority (46%) of subjects reported housewife as their occupation and 70.3% were belonging to nuclear families. [Table 1]

Table 1- Distribution of Study Participants according to socio-demographic variables							
		Male		Female		Total	
		No.	%	No.	%	No.	%
Age groups	31 to 40	36	34.3	88	45.1	124	41.3
	41 to 50	28	26.7	48	24.6	76	25.3
	51 to 60	21	20.0	42	21.5	63	21.0
	61 to 70	9	8.6	14	7.2	23	7.7
	71 and above	11	10.5	3	1.5	14	4.7
Literacy status	Illiterate	22	21.0	96	49.2	118	39.3
	Primary School	9	8.6	16	8.2	25	8.3
	Middle School	29	27.6	45	23.1	74	24.7
	Preuniversity	15	14.3	12	6.2	27	9.0
	Graduate	23	21.9	22	11.3	45	15.0
	Post Graduate	7	6.7	4	2.1	11	3.7
Occupational status	Labourer	25.0	23.8	25.0	12.8	50.0	16.7
	Private	53.0	50.5	24.0	12.3	77.0	25.7
	Government	20.0	19.0	6.0	3.1	26.0	8.7
	Housewife	0.0	0.0	138.0	70.8	138.0	46.0
	Farmer	7.0	6.7	2.0	1.0	9.0	3.0
Type of family	Joint	33.0	31.4	56.0	28.7	89	29.7
	Nuclear	72.0	68.6	139.0	71.3	211	70.3
Socio-economic status	Upper	15.0	14.3	20.0	10.3	35.0	11.7
	Upper Middle	21.0	20.0	30.0	15.4	51.0	17.0
	Middle	20.0	19.0	56.0	28.7	76.0	25.3
	Lower Middle	36.0	34.3	47.0	24.1	83.0	27.7
	Lower	13.0	12.4	42.0	21.5	55.0	18.3
	Total	105	100.0	195	100.0	300	100.0

Table 2-Association of NCD risk score with variables									
	NCD Risk Score	3 and below		4 and above		Total		Chi Square Value	P value
		No.	%	No.	%	No.	%		
Gender	Male	61	58.1	44.0	41.9	105	100	4.49	0.03*
	Female	137	70.3	58.0	29.7	195	100		
Age group	31 to 40	115	92.7	9	7.3	124	100	82.8	<0.001*
	41 to 50	47	61.8	29	38.2	76	100		
	51 to 60	19	30.2	44	69.8	63	100		
	>61	17	73.9	20	87.0	23	100		
Educational Status	Illiterate	64	54.2	54	45.8	118	100	15.42	<0.001*
	School	67	56.8	32	27.1	99	100		
	Pre-university and above	67	56.8	16	13.6	83	100		
Occupational Status	Labourer	31	63.3	18	36.7	49	100	2.2	0.69
	Private	49	63.6	28	36.4	77	100		
	Government	20	76.9	6	23.1	26	100		
	Housewife	93	66.9	46	33.1	139	100		
	Farmer	5	55.6	4	44.4	9	100		
Socio-Economic Status	Upper	26	74.3	9	25.7	35	100	3.1	0.54
	Upper Middle	31	60.8	20	39.2	51	100		
	Middle	54	71.1	22	28.9	76	100		
	Lower Middle	52	62.7	31	37.3	83	100		
	Lower	35	63.6	20	36.4	55	100		

Article Title: Assessment of NCD risk using Community Based Assessment Checklist among population in urban field practice area, Manikeswari- Kalaburagi Karnataka

Type of Family	Joint	57	64.0	32	36.0	89	100	0.21	0.64
	Nuclear	141	66.8	70	33.2	211	100		
Blood Pressure	Normal	91	75.2	30	24.8	121	100	13.67	0.001*
	High Normal	71	67.0	35	33.0	106	100		
	Hypertension	36	49.3	37	50.7	73	100		
BMI	Underweight	24	82.8	5	17.2	29	100	20.45	<0.001*
	Normal	92	73.0	34	27.0	126	100		
	Overweight	61	64.9	33	35.1	94	100		
	Obesity	21	41.2	30	58.8	51	100		
	Total	198	66.0	102	34.0	300	100		

NCD risk score of 4 and above was significantly high in male subjects. NCD risk increased with increase in age and was more common in illiterate group. No statistically significant association was found between high NCD risk score and occupation, socio-economic status and type of family. Based on their blood pressure, study participants were divided into three categories, normal, high normal and hypertension, among 300 participants, 73 (24.3%) were detected to have hypertension, 106 (35.3%) were high normal blood pressure and 121 (40.4%) having normal blood pressure. Study participants with “hypertension” category were having high NCD risk score of 50.7%, followed by those in 33% in “high normal” category and least was in “normal” category with 24.8%. High NCD risk score was increasing with increase in blood pressure. This association was statistically highly significant. Based on Body Mass Index, study participants were divided into different categories. NCD Risk score was highest in obese category (58.8%) followed by those in overweight category (35.1%), normal (27%) and least in underweight (17.2%). NCD risk score was increasing with increase in body mass index. This association was statistically highly significantly. [Table 2]

DISCUSSION

This study is conducted in urban slum area of Kalaburagi district, which is situated in northern part Karnataka, with aim to estimate non-communicable disease risk using CBAC (community-based assessment checklist).

Most of the participants (65%) in this study are females and among them 70.7% identified housewife as their occupation. Almost all the participants were belonging to Hindu religion. 41.3% of study sample consisted of younger population in the age group of 30 to 40 years and non-formal education constituted 40% of population.

Validity of CBAC as the screening tool has been tested by Vinoth Kumar Kalidoss et al in Kerala and reported sensitivity and specificity to be 85.7% and 53.7% respectively. Score of 4 and above increased sensitivity to 98%. However, Gupta et al found sensitivity and specificity to be 65.4% and 52.4% and reported lesser predictive value for diabetes and hypertension as compared to IDRS score.

Among the 300 randomly selected study participants in this study, 102 had risk score of 4 and above, which is 34% of sample. These study subjects are at high risk of developing non-communicable diseases like hypertension, diabetes mellitus, cardiovascular diseases and cancer, hence have to be screened more frequently and referred to higher center. Kaur et al reported much higher risk score 57.7% as compared to our study, in rural Haryana. Choudhry N et al also reported very high-risk score. (24% at CBAC >4, 48% at CBAC =4). However, Jaacks et al conducted study with higher sample of 11,322 in rural Punjab reported CBAC score ≥ 4 to be 14.4%. Preet et al conducting similar study in medical camp in Delhi noted 24% of study sample were having risk score 4 and above. Gupta et al in hospital-based study found 29.3% of sample to have high risk score. Variation in different numbers in scoring can be due to rural-urban variation, hospital-field variation, gender composition variation and self-reporting nature of screening tool. There are six parameters in CBAC scoring regarding age, smoking, alcohol consumption, waist circumference, physical activity and family history of NCDs. Among these, five are self-reporting parameters and one parameter waist circumference can be verified. Hence investigator has to rely on the answers given by subjects to be correct.

CBAC risk score was significantly higher in males (41.9%) compared to females (29.7%) in this study. Kaur et al also reported similar finding. High CBAC risk score increased consistently with increase in age group of subjects. Jaacks et al also reported similar finding in their study. In our study, literacy status of subjects was significantly associated with high CBAC risk score. Illiterate, schooling and pre-university and above subjects had 45.8%, 27.1% and 13.6% respectively. Hence with increase in literacy level consistent decrease in risk scores. This may be attributed to subjects becoming more aware of their health with increase in literacy status. Jaacks et al reported similar finding, 50.2%, 29.4% and 20.4% of subjects in high risk with non-formal education, primary and middle schooling and high school and above education respectively.

Article Title: Assessment of NCD risk using Community Based Assessment Checklist among population in urban field practice area, Manikeswari- Kalaburagi Karnataka

In present study, occupation, socio-economic status and type of family did not have significant association with high risk. However, Jaacks et al reported employment and income to have significant association with high-risk score.

On measurement of blood pressure, hypertension, high normal and normal subjects had 50.7%, 33% and 24.8% respectively. 46% of hypertensive subjects were in high-risk group as compared to 26% in low-risk group as noted by Jaacks et al.

With increase in BMI of subjects, CBAC risk score also increased consistently. Similar findings were found by Komal Preet et al, BMI of 25 and above had more risk of high scores.

CONCLUSION

In our study, with CBAC as screening tool, 34% of study subjects have risk score of 4 and above. Increased age and male gender have significantly higher score. Higher literacy status is associated with significantly lower CBAC score. Occupation and socio-economic status did not show any association with CBAC score. Higher blood pressure and increased BMI are significantly associated with higher CBAC score.

Acknowledgments: We would like to express our gratitude to all the study population who participated in this study and interns who has supported in the study.

Funding: ICMR STS Project Funding.

Conflict of interest: None declared.

Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Ministry Of health and Family Welfare, Government of India. National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular diseases and Stroke (NPCDCS): https://main.mohfw.gov.in/Major-Programmes/_non-communicable-diseases-injury-trauma/_Non-Communicable-Disease-II/National-Programme-for-Prevention-and-Control-of-Cancer-Diabetes-Cardiovascular-diseases-and-Stroke-NPCDCS. [Accessed on 20/12/2022]
2. World Health Organisation. Noncommunicable diseases. Available from URL: <https://www.who.int/en/news-room/fact-sheets/detail/noncommunicable-diseases> [Accessed on 16-02-2024]
3. National Multisectoral Action Plan for Prevention and Control of Non-communicable diseases. Ministry of Health and Family Welfare, Government of India. Available from URL [https://main.mohfw.gov.in/sites/default/files/National Multisectoral Action Plan NMAP Prevention and Control of Common NCDs 2017-22.pdf](https://main.mohfw.gov.in/sites/default/files/National%20Multisectoral%20Action%20Plan%20NMAP%20Prevention%20and%20Control%20of%20Common%20NCDs%202017-22.pdf) [Accessed on 16-02-2024]
4. Jaacks LM, Awasthi A, Bhupathiraju S, Kumar S, Gupta S, Sonawane V. A community-based noncommunicable disease prevention intervention in Punjab, India: Baseline characteristics of 11,322 adults. *Indian J Community Med* 2022; 47:23-9
5. Ministry Of health and Family Welfare, Government of India. NCD Module for Medical Officers -WHO/OMS: Extranet Systems Available from URL: https://extranet.who.int/ncdccs/Data/IND_D1_NCD%20Module%20For%20Medical%20Officers%20-%20Population%20based%20screening.pdf. [Accessed on 1/1/2023].
6. Kaur P, Jaswal P, Sarin J. Predicting risk for Non-Communicable Disease (NCDs) using Community Based Assessment Checklist (CBAC) form among Adults of Haryana. *Annals of R.S.C.B.* 2021;25(6):17623-30
7. Preet K, Kaur S, Kaur N, Singh D. Prevalence and risk factors of non -communicable disease among population attending medical camp organized by Ayush Healthcare in Bakhtawarpur, Delhi. *International Journal of Advance Research, Ideas and Innovations in Technology*. 2019;5(5):136-41
8. Choudhary N, Sangara S, Narangyal A. Risk assessment for non- communicable diseases among out patients visiting urban health centre in Jammu region: A cross sectional study. *International Journal of Advanced Community Medicine*. 2020; 3(1): 109-111
9. Kalidoss VK, Aravindakshan R, Kakkar R, Satyanarayanan S, Chelimela D, Naidu NK. A Study to Assess the Validity of Community based Assessment Checklist – The Standard Non-Communicable Diseases Screening Tool of Frontline Health Workers. *Kerala Medical Journal*. 2021;14(1):3-6
10. Gupta M et al. Recalibrating the Non-Communicable Diseases risk prediction tools for the rural population of Western India. *BMC Public Health*. (2022) 22:376. Available from URL: <https://doi.org/10.1186/s12889-022-12783-z>

Article Title: Assessment of NCD risk using Community Based Assessment Checklist among population in urban field practice area, Manikeswari- Kalaburagi Karnataka

11. Sandhu S, Singh MM, Chauhan R, Mazta SR, Prashar A. Risk factor profile for non-communicable diseases in public institutions of Shimla, Himachal Pradesh, India. Int J Community Med Public Health 2016; 3:3063-7`
12. Ministry Of health and Family Welfare, Government of India. Available from URL: <https://main.mohfw.gov.in/basicpage-14>. [Accessed on 20/12/2022].

Original research article

COMPARATIVE STUDY BETWEEN LOW PRESSURE AND STANDARD PRESSURE PNEUMOPERITONEUM IN LAPAROSCOPIC CHOLECYSTECTOMY ON ALANINE TRANSAMINASE

¹Dr. Sharath Kumar M, ²Sharath Chandra Tejas, ³Praveen G

^{1, 2, 3}Assistant Professor, Department of General Surgery, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research (CDSIMER), Karnataka, India

Corresponding Author:

Praveen G

Abstract

This study is a randomized control trial conducted in CSI Holdsworth Memorial Hospital, Mysore. Study was initiated after taking clearance from Scientific and Ethical committee. Study population consists of 60 patients requiring Laparoscopic Cholecystectomy for benign gall bladder disease. They were divided into two groups, Group-A and Group-B each group consisting of 30 patients. Pre-operative Alanine transaminase (ALT) level was measured in both the groups. Group-A was operated using Low pressure pneumoperitoneum (8-12 mmHg), Group-B was operated using Standard pressure pneumoperitoneum (12-15 mmHg) and duration of the procedure was also noted. Post-operative 24th hour Alanine transaminase (ALT) level was measured. Changes in ALT level in both the groups were compared and reasons for alteration in Liver enzymes were studied.

Keywords: Pneumoperitoneum, laparoscopic, cholecystectomy, alanine transaminase

Introduction

Modern surgery has evolved to be technically sophisticated and complex. During the past several decades, numerous individuals cultivated and promoted the access for laparoscopy. The big development in the field of laparoscopy was made by invention of computer chip television camera. This scientific modernization implement the means to program a magnified picture of the operation field on to the monitor, facilitating performance of complex laparoscopic procedures, better results with least damage ^[1].

Laparoscopy provides access to the peritoneal cavity for diagnosis and for many surgical interventions that were previously possible only by laparotomy ^[2]. Some of diseases which were not dealt due to fear of damage to surrounding structures during access are presently been treated easily with laparoscopic surgery ^[1].

Pneumoperitoneum is a crucial factor in laparoscopy. Insufflation with it, helps to maximize the working space in a limited contained cavity. Method of insufflation is usually intra peritoneal, wherein the abdominal wall gets elevated and the viscera gets

suppressed^[3].

Carbon dioxide (CO₂) is the preferred gas for establishing a pneumoperitoneum, and this method of creating pneumoperitoneum using CO₂ is referred to as capnoperitoneum. Although the mainstay for cholecystectomy is laparoscopy, it also has its own limiting factors. It produces elevated intra-abdominal pressure (IAP) and continuous compression on intra-abdominal organs with elevation of diaphragm, which might potentially influence the hepatic, pulmonary and renal functions^[4].

Physiological changes due to pneumoperitoneum depend on amount of intra-abdominal pressure used intraoperatively and time taken to complete the surgery^[5]. Pneumoperitoneum created with CO₂ for Laparoscopic cholecystectomy in head up position leads to greater risk of decrease in cardiac output and hence affecting hepatic perfusion^[5, 8].

The intra-abdominal pressure of 12-14 mmHg of carbon dioxide (CO₂) traditionally used in laparoscopic surgery is higher than normal pressure values of the portal system (7-10 mmHg). This pneumoperitoneum value could therefore reduce portal flow and cause physiological alterations in liver function^[5]. By using a pressure less than traditional pressure, there may be chances of visceral injury and prolonged time of procedure due to reduced operating space.

Despite other studies ideal pressure is not given for creating pneumoperitoneum in laparoscopic cholecystectomy considering alteration of liver function and injury to biliary structure. This study is to determine the reasons for elevation of liver function parameter at different insufflation pressure and to determine the best pressure for laparoscopic procedure considering patient safety and post-operative wellbeing.

Aim and Objectives

Aim

To correlate the effect of pressure and duration of intra-operative carbon dioxide pneumoperitoneum on the hepatic enzyme Alanine transaminase, in Laparoscopic cholecystectomy.

Objective

To identify possible reasons for changes in liver enzymes in relation to insufflation pressure, duration of procedure in patients undergoing Laparoscopic cholecystectomy.

Materials and Methods

Study site

The study was conducted in the department of general surgery, of CSI Holdsworth Memorial Hospital, located in Mysore of Karnataka state. This hospital is a multi-disciplinary hospital with exclusive beds allotted to surgical patients.

Study design

This study was a prospective double blinded randomized control trial.

Study population

The study population constituted of patients presenting to department of General surgery of CSI Holdsworth Memorial Hospital for Laparoscopic cholecystectomy. The

study participants who fulfilled inclusion criteria were included in the study.

Inclusion criteria

1. Patients undergoing laparoscopic cholecystectomy procedures in, CSI Holdsworth Memorial Hospital, Mysore.
2. Age more than 18year.

Exclusion criteria

- Patients with coexisting liver disease, long term use of hepatotoxic drug and those who undergo ERCP within one week preoperatively.
- Patients with intraoperative, bile duct injury, obstruction, infection, leakage and high grade fever during surgery.
- Age less than 18year.
- Pregnancy, lactation.

Study duration

The total study duration was from October 2018 to May 2020.

Sample size determination

Sample size was calculated based on previous study of alteration in liver function tests following laparoscopic procedure.

We have considered, Prevalence -18%

Precision -10%

Confidence level -95%

Type 1 error - 0.05

The formula to this study for sample size calculation is

$$N = [Z^2 P (1-P)] / d^2$$

Where, n = sample size

Z = statistical level of confidence (2)

D = precision

$$N = [2^2 \times 0.18(1-0.18)] / (0.1)^2$$

$$N = 59$$

Total 60 number of patients will be selected for the study after application of inclusion and exclusion criteria and enrolled after taking informed and written consent. These patients will be divided into two equal group containing 30 subjects in each group.

Conduction of study**Randomization and blinding**

Randomization used was a block randomization, so that every sampling unit got an equal chance of being included in it. Randomization of each patients was done into two groups one of which underwent Laparoscopic cholecystectomy at low pressure 10-12 mmHg and other group underwent Laparoscopic cholecystectomy at standard pressure 12-15 mmHg. Randomization was done using codes obtained from www.randomization.com using randomly permuted blocks with random block sizes

and allocation ratio of 1:1. Blinding followed in the present study was a double blinding technique, neither the study participant nor the investigator knows about which patient gets operated at what pressure.

Sampling method

Once a patient General surgery department, CSI Holdsworth Memorial Hospital fulfils the above mentioned inclusion and exclusion criteria allocation to groups as per randomization to the current study was done. Patients were explained about the purpose of study verbally and in form of written patient information sheet in a language of their understanding ensuring strict confidentiality. Written informed consent were taken prior to undertaking for surgery. Following Helsinki declaration, they were given option not to participate in study if they wish to or opt out anytime from study (detailed sheets included in Annexure).

Patients were assigned a random number generated through a computer software and will be grouped as A and B. Group A - Patients undergoing Laparoscopic cholecystectomy at Low pressure pneumoperitoneum 8-12 mmHg. Group B - Patients undergoing Laparoscopic cholecystectomy at Standard pressure pneumoperitoneum 12-15 mmHg. All patients underwent surgery were measured pre-operative ALT and post operatively after 24 hr again ALT was measured. Level of ALT in both group were measured and tabulated. Only ALT was measured which is more specific for liver. Other routine pre-operative blood investigations like complete blood count, blood grouping and typing, bleeding time, clotting time, renal functional test, HIV, HBsAg, HCV, ECG were done.

Parameters included in the study

Primary outcome of interest was measuring changes in ALT and duration of the surgery and adverse effect associated in both the group.

Ethical consideration

The study, approved by ethical committee, was undertaken in Surgical department at CSI Holdsworth memorial hospital, Mysore.

1. Respondents participated in the survey voluntarily after giving informed consent in their language of understanding and was fully informed in presence of a senior specialist, about the aims and objectives of the study and associated possibility of any complications along with amount of risk of its incidence as supported by current literature, before participants in it.
2. The questionnaire did not contain any degrading, discriminating or any other unacceptable language that could be offensive to any members of the sample group.
3. The privacy of the research participants, anonymity of individuals and organisations participants in the research and adequate level of confidentiality of the research data will be ensured. The data obtained in the study and photograph, if taken will be published in the journal.
4. Falsification, fabrication and misinterpretation of data, deception or exaggeration about the aims and objectives of the research, as well as representation of primary data findings in a biased way will be avoided.
5. The researchers participating in the study don't have any affiliations in any forms

whatsoever to any institution, company or agency. There are not any known possible conflicts of interest.

6. Complete freedom to individuals to participate and to withdraw from research at any time without penalty or loss of benefits to which the subject would otherwise be entitled.

Consent of the study participants

Printed consent form was given to the participants if she could read, or it was to read out to him the presence of another person, after which the participant was asked to sign (or place thumb impression) on the form (Annexure IV). The confidentiality of the study participants was maintained at all points of the study.

Statistical analysis

Summary statistics was done by means of proportions for categorical/binary variables and mean, median, Standard deviation, Inter Quartile Range (IQR) for continuous variables.

Inferential statistics was done by using Chi square test/fisher exact test, Independent t test, and Mann Whitney test.

All the statistical methods were done using SPSS 21.0 version for windows. $p < 0.05$ was considered statistically significant.

Chi square test/fisher exact test are used comparing two or more independent proportions. Fisher exact is used when the number of expected numbers in $>25\%$ cells is <5 .

Independent t test was used to compare means between independent groups/mutually exclusive groups.

Mann Whitney test was used to compare the continuous variable which is not normally distributed/ ordinal variables between two independent group

Results

Total patients studied were 60 among which 24 were male and 36 were female. 17 and 19 females are operated at low and standard pressure respectively. 13 and 11 males are operated at low and standard pressure respectively.

Table 1: Sex distribution in study population

		Pressure			
		Low		Standard	
		Count	Column N %	Count	Column N %
Sex	Female	17	56.7%	19	63.3%
	Male	13	43.3%	11	36.7%

P=0.6, chi square test

The groups were similar with respect to gender as it is statistically insignificant.

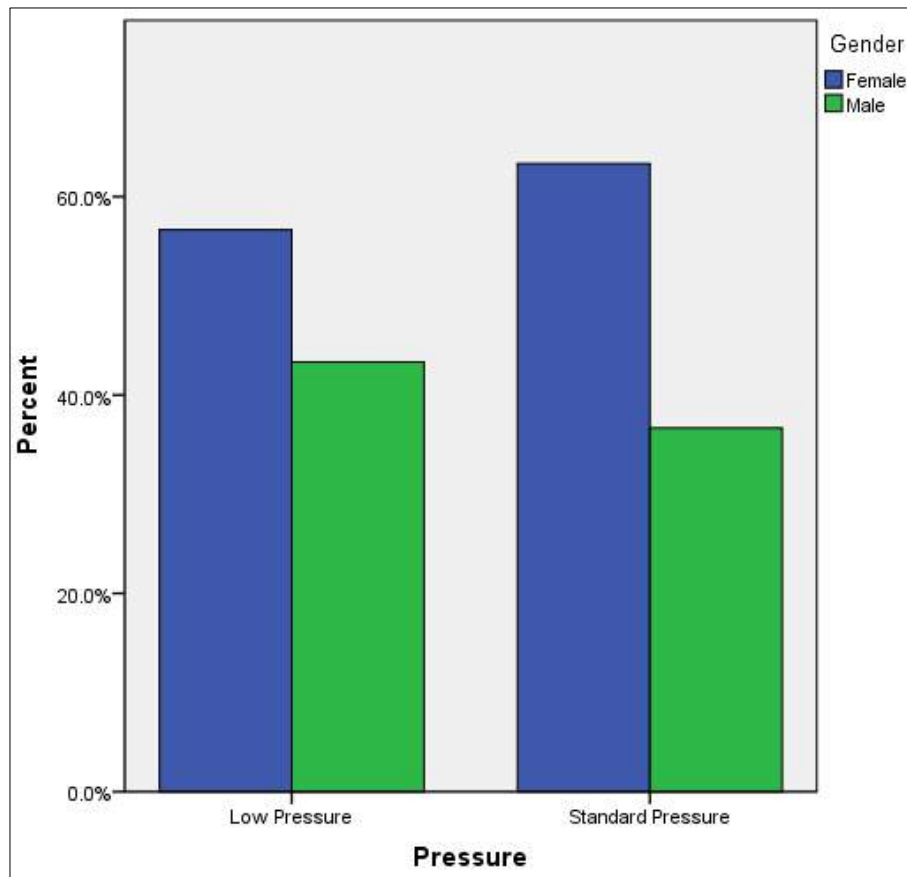


Fig 1: Bar chart showing sex distribution in study population

The population operated at low pressure is 43.87 ± 12.73 years and standard pressure is 44.93 ± 11.81 years.

Table 2: Age distribution in study population

	Pressure			
	Low		Standard	
	Mean	SD	Mean	SD
Age	43.87	12.73	44.93	11.81

P=0.7, independent t test

There was no statistically significant difference in age between the two groups

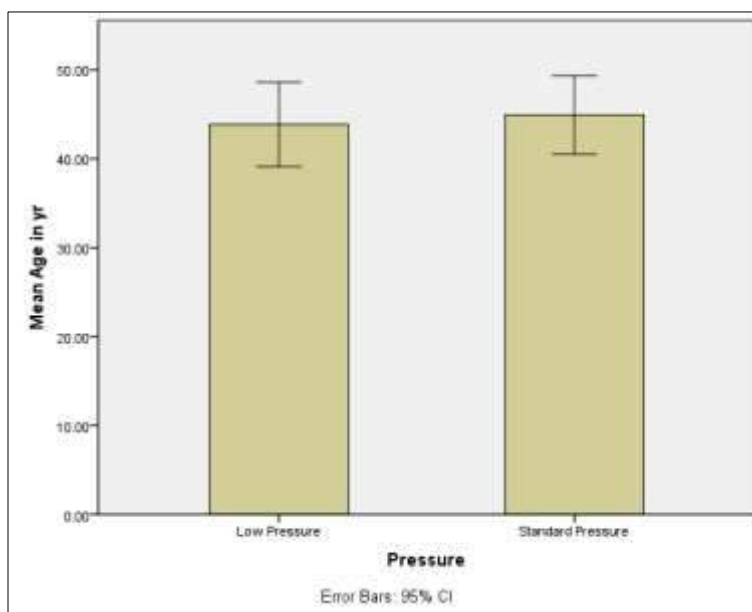


Fig 2: Age wise distribution in study population

There are 5 subjects in both low and standard pressure group were below 30 years of age. 9 and 5 were between 31 to 40 years, 11 and 14 were between 41 to 50 years, 5 and 6 were above 51 years respectively.

Table 3: Comparison of age between low and standard pressure group

		Pressure			
		Low		Standard	
		Count	Column N %	Count	Column N %
Age groups	<30 yr.	5	16.7%	5	16.7%
	31-40 yr.	9	30.0%	5	16.7%
	41-50 yr.	11	36.7%	14	46.7%
	>51 yr.	5	16.7%	6	20.0%

P=0.66, chi square test

There was no statistically significant difference in age groups between the two groups. In other words age was similar in both groups and groups are comparable w r t age groups.

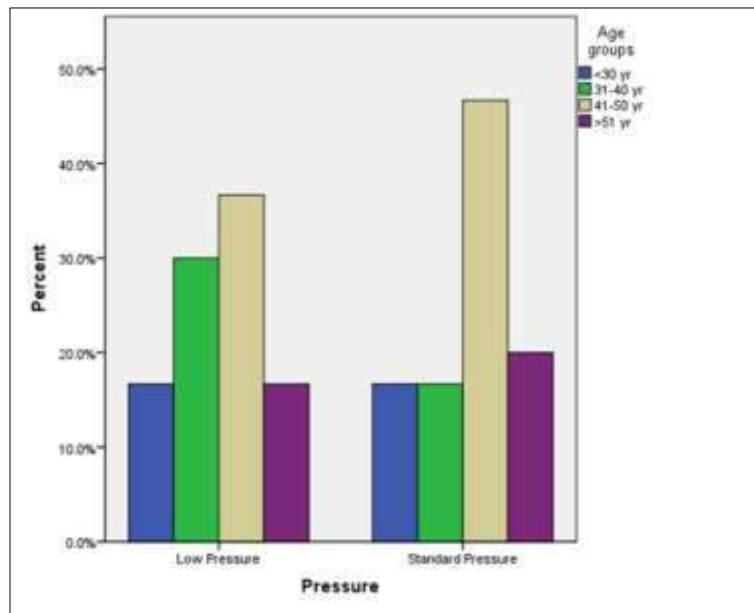


Fig 3: Different age distribution in each group

Duration of laparoscopic cholecystectomy using low pressure pneumoperitoneum is 91 ± 13.09 minutes and using standard pressure pneumoperitoneum is 86.17 ± 10.96 minutes.

Table 4: Duration of procedure in both group

	Pressure			
	Low		Standard	
	Mean	SD	Mean	SD
Duration in minutes	91.00	13.09	86.17	10.96

P=0.12

Independent t test

There was no statistically significant difference in duration of surgery between the two groups.

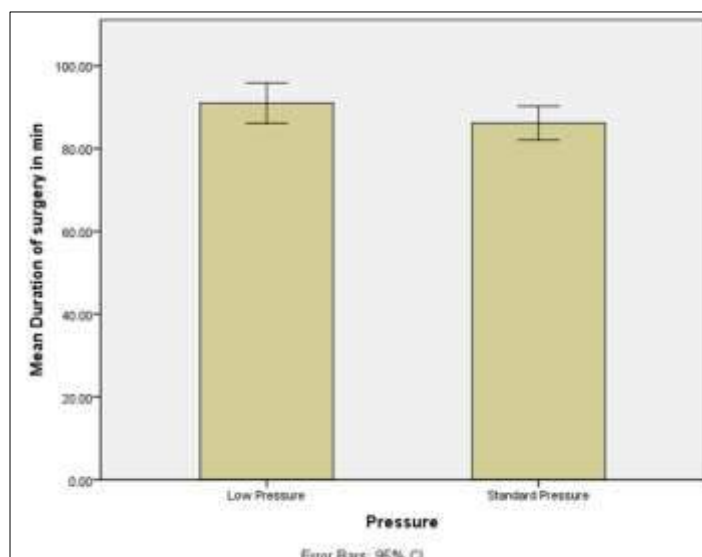


Fig 4: Graph showing duration of procedure in Low and Standard pressure pneumoperitoneum

The pneumoperitoneum pressure used for low pressure group is 11.8 ± 0.7 mmHg and for standard pressure is 15 ± 0 mmHg

Table 5: Pressure difference in both groups

	Pressure			
	Low		Standard	
	Mean	SD	Mean	SD
Pressure in mmHg	11.8	0.7	15.0	.0

$p < 0.0001$, independent t test

There was statistically significant difference in pressure between two groups. Standard pressure group had 3.2 mm of Hg higher compared to low pressure group.

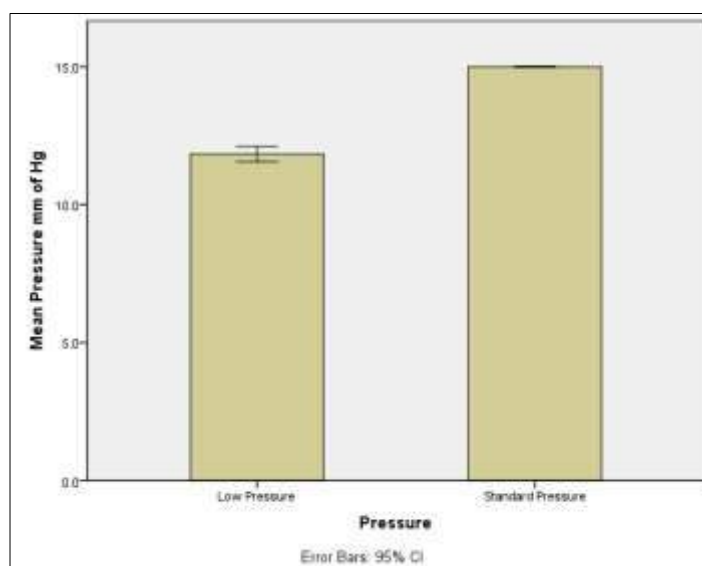


Fig 5: Graph showing pressure difference in both group

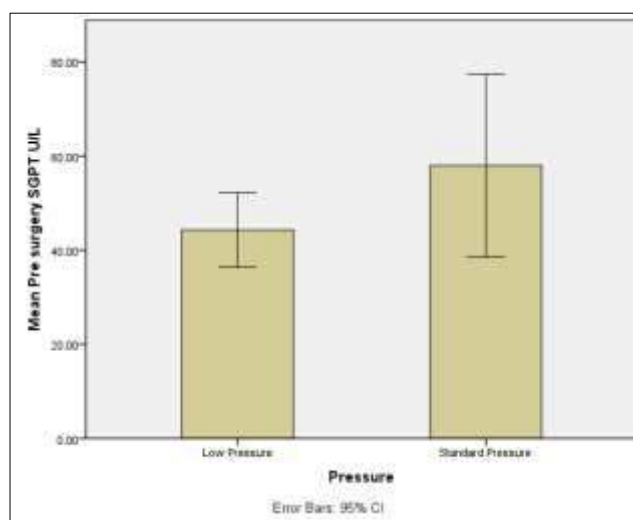
The pre-operative Alanine transaminase (ALT/SGPT) value are 44.27 ± 21.14 units/liter in low pressure and 57.97 ± 21.14 units/liter in standard pressure pneumoperitoneum group.

Table 6: Comparison of pre-operative ALT (SGPT) in both group

	Pressure			
	Low		Standard	
	Mean	SD	Mean	SD
Pre-operative ALT U/ltr	44.27	21.14	57.97	52.00

P=0.2, Independent t test

There was no statistically significant difference in pre surgery ALT in both groups. The pre surgery ALT was similar in both groups.

**Fig 6:** Pre-operative ALT (SGPT) in both groups

The elevation of ALT (SGPT) in first post-operative day is 56.23 ± 23.33 Unit/liter in low pressure and 77.67 ± 51.38 Unit/liter in standard pressure pneumoperitoneum.

Table 7: Post-operative elevation in ALT (SGPT) in both groups

	Pressure			
	Low		Standard	
	Mean	SD	Mean	SD
@24HR SGPT U/l	56.23	23.33	77.67	51.38

P=0.04, independent t test

There was statistically significant higher ALT (SGPT) level in standard pressure group; however this increase of nearly 20 U/L is not clinically significant. (Table 7).

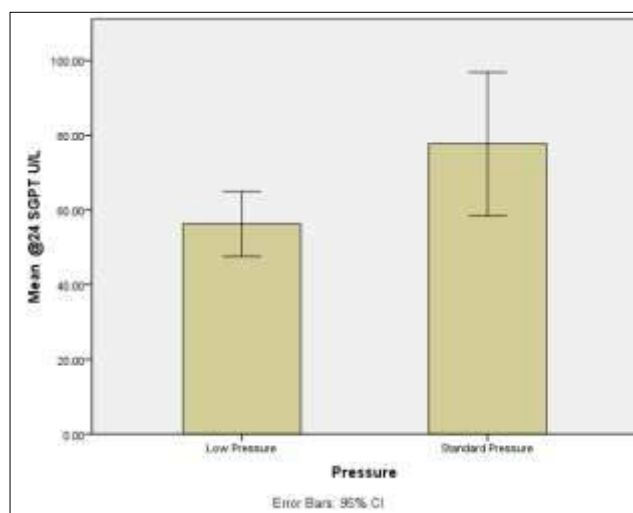


Fig 7: Graph showing first post-operative day changes in ALT (SGPT) in both groups

Table 8: Comparison of elevation in ALT/SGPT in low and standard pressure pneumoperitoneum group

	Pressure									
	Low					Standard				
	Mean	SD	Median	Q1	Q3	Mean	SD	Median	Q1	Q3
Increase of SGPT U/L	11.97	10.55	8.00	6.00	16.00	19.70	30.56	21.50	6.00	39.00

P=0.021, Mann Whitney test

The low pressure group had lesser increase [8, 6-16] compared to standard pressure [21.5, 6-39], as shown in the table 8. This difference in increase of SGPT was statistically significant, but not clinically relevant.

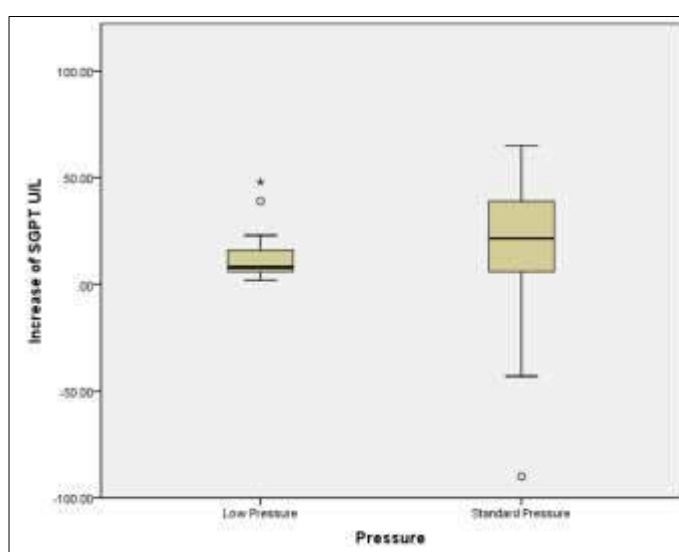


Fig 8: Graph showing elevation in ALT (SGPT) in low and standard pressure pneumoperitoneum group

Percentage increase in ALT (SGPT) in low pressure group is 20.10, 10.26, 42.59 Unit/liter and in standard pressure pneumoperitoneum is 44.12, 9.88, 105 Unit/liter.

Table 9: Percentage increase in ALT (SGPT) in both groups

	Pressure					
	Low Pressure			Standard Pressure		
	Median	Q1	Q3	Median	Q1	Q3
% Increase of SGPT U/L	20.10	10.26	42.59	44.12	9.88	105.00

P=0.2, Mann Whitney test

The difference in percentage increase of ALT (SGPT) is statistically insignificant before removing the outliers.

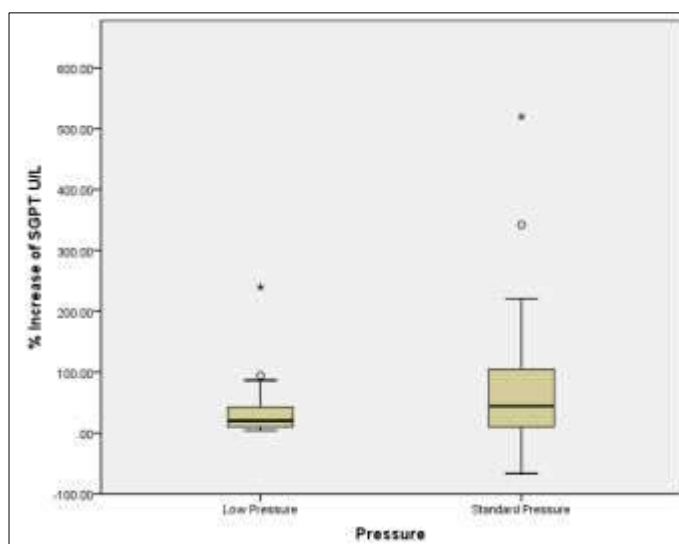


Fig 9: Percentage increase in ALT (SGPT) in both group before removing the outliers
Percentage increase in ALT (SGPT) in low pressure pneumoperitoneum is 19.51, 10.26, 40 and in standard pressure pneumoperitoneum is 27.27, 8.70, 84.62.

Table 10: Percentage increase in ALT (SGPT) in both group after removing the outliers

	Pressure					
	Low Pressure			Standard Pressure		
	Median	Q1	Q3	Median	Q1	Q3
% Increase of SGPT U/L	19.51	10.26	40.00	27.27	8.70	84.62

P=0.4, Mann Whitney test

The difference in percentage increase of ALT (SGPT) is statistically insignificant after removing the outliers.

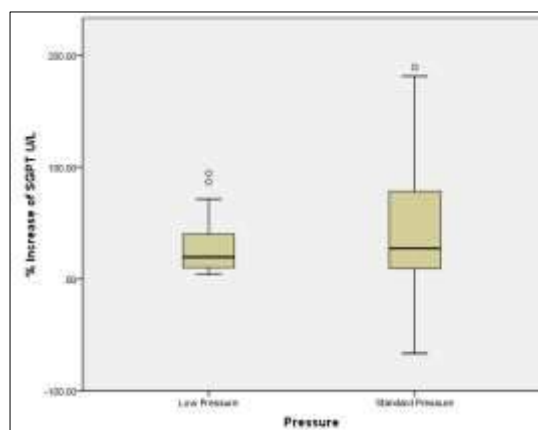


Fig 10: Percentage increase in ALT (SGPT) in both group after removing the outliers.

Out of 30 subjects in low pressure group only 2 subjects experienced shoulder tip pain and out of 30 subjects in standard pressure pneumoperitoneum group 7 subjects experienced shoulder tip pain.

Table 11: Shoulder tip pain experienced by subjects in low and standard pressure group

		Pressure			
		Low		Standard	
		Count	Column N %	Count	Column N %
Shoulder Tip Pain	NO	28	93.3%	23	76.7%
	YES	2	6.7%	7	23.3%

P=0.07, chi square test

The shoulder tip pain was low (2, 6.7%) in low pressure group compared to standard pressure group (7, 23.3%). However this difference was not statistically significant. This non significance may be due to lower sample size.

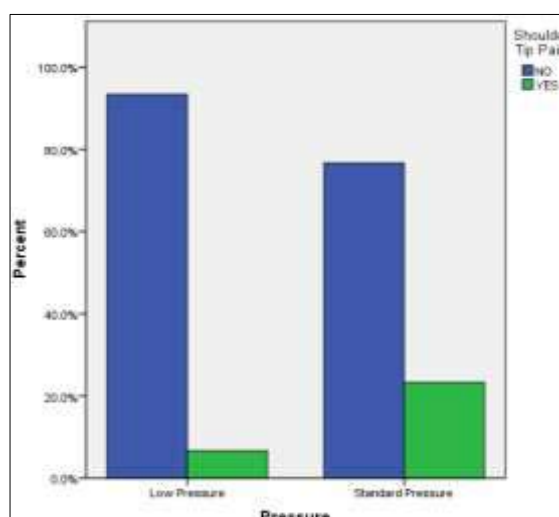


Fig 11: Bar graph showing shoulder tip pain in subjects underwent laparoscopic

cholecystectomy in low and standard pressure pneumoperitoneum

Discussion

The present study was done to correlate the effect of pressure and duration of Carbon dioxide pneumoperitoneum on liver enzyme and to study the reasons for changes in liver enzyme in relation to different insufflation pressure of pneumoperitoneum and duration of procedure, in patient undergoing Laparoscopic cholecystectomy. There were two groups, group A operated at Low pressure pneumoperitoneum (8-12 mmHg) and group B operated at Standard pressure pneumoperitoneum (12-15 mmHg).

In our study, Alanine transaminase is measured to find the effect of pressure and duration of pneumoperitoneum on liver enzyme because it is more specific.

In this study we measured changes in ALT (Alanine transaminase) in both low pressure and standard pressure pneumoperitoneum group on first post-operative day. It showed transient elevation of ALT in both group. The elevation is more in standard pressure pneumoperitoneum group (77.67 ± 51.38 unit/liter) when compared to low pressure pneumoperitoneum (56.23 ± 23.23 unit/liter).

In our study, duration of the procedure was slightly more for Low pressure group (91 ± 13.09 minutes) when compare to Standard pressure group (86.17 ± 10.96 minutes) but it was statistically insignificant.

Thus elevation in liver enzymes during Laparoscopic cholecystectomy is not only dependent on pressure and duration of Carbon dioxide pneumoperitoneum. It depends on other factors also.

The first factor to be considered is carbon dioxide pneumoperitoneum itself. All the patients in our study were subjected to carbon dioxide pneumoperitoneum and they showed changes in post-operative serum liver enzymes level irrespective of the group.

Many studies, have unexplained changes in post-operative liver function in patients undergoing laparoscopic procedures. CO₂ pneumoperitoneum might be one of the main reasons for this change in serum liver enzymes, as this is the main difference between laparoscopic surgeries and open surgeries ^[2].

Lai H *et al.*, ^[6] stated that the elevated intra-abdominal pressure due to pneumoperitoneum may be responsible for the increase in liver enzymes after laparoscopic abdominal surgery.

According to a study *et al.*, intraperitoneal pressure used for laparoscopic procedures are higher than the pressure in the portal venous system which impedes portal circulation, in turn reduces portal flow up to 50%, hence causes depression of the hepatic reticular endothelial system which causes elevation of liver enzymes.

Morino M *et al.* ^[5] concluded that change in liver function tests is directly proportional to duration & pressure used for pneumoperitoneum.

P Rama Rao *et al.* ^[2] also stated that during laparoscopic surgery, there is an elevation and depression of intra abdominal pressure (IAP) in a short time, this sudden alteration of IAP could cause undulation of portal blood flow. This undulation in blood flow and re-irrigation of organs may give rise to ischemia and re-irrigation damage of tissues and organs, especially the Kupffer and endothelial cells of hepatic sinusoids by free radicals generated at the end of a laparoscopic procedure which results in elevation of liver enzymes.

Other unmeasured confounding factors may also be responsible for elevation of liver enzymes, such as extended liver traction in large laparoscopy procedure that lead to

hepatocyte damage, and the intraoperative “squeeze” pressure effect on the liver that free liver enzymes into the blood stream. The increased IAP also triggers Neurohumoral responses of the vasopressin renin–angiotensin–aldosterone system. Vasopressin and norepinephrine play a significant role in causing damage to the hepatic function^[2].

The local effect of prolonged use of diathermy to the liver surface in laparoscopic cholecystectomy and the spread of heat to liver parenchyma may alter hepatic enzymes^[2].

Thus our study findings supported by previous studies reported, we could conclude that

- The carbon dioxide pneumoperitoneum itself.
- Insufflation pressure of the carbon dioxide pneumoperitoneum both Low and Standard pressure which are more than normal portal pressure.
- The duration of carbon dioxide pneumoperitoneum.
- Surgical techniques used during dissection of gall bladder from liver bed.
- Prolonged use of diathermy.
- Other unmeasured confounding factors are responsible for elevation of liver enzymes.

Conclusion

On comparing values of ALT at different pressures and duration of procedure, the study showed pneumoperitoneum pressure affects on the function of the liver. The changes in ALT is not significant on comparing low and standard pressure pneumoperitoneum. Hence both Low and Standard pressure pneumoperitoneum causes elevation of ALT, that is any insufflation pressure more than normal portal pressure causes alteration in liver function. The elevation of ALT is transient and none of the subjects showed features of hepatic dysfunction.

References

1. Syed Ibrahim AM. Evaluation of the Effects of Laparoscopic Surgeries on Hepatic Enzymes; Journal of Dental and Medical Sciences (IOSR-JDMS) 2279-0861. 2017 Aug;16(8):22-28.
2. Rama Rao P, Rao PR, Kongara S, Snigdha Y, Kalyan KA. Study of Alterations in Liver Function Tests Following Laparoscopic Surgery;IOSR Journal of Dental and Medical Sciences (IOSR-JDMS); 2279-0861. 2017 Mar;16(3):48-54.
3. Gautham G, Anand C, Pajanivel R. Effects of capnoperitoneum for laparoscopy on liver, renal and pulmonary functions: A prospective observational study. International Surgery Journal. 2017 May 24;4(6):1903-7
4. Morino M, Giraudo G, Festa V. Alterations in hepatic function during laparoscopic surgery. Surgical endoscopy. 1998 Jul 1;12(7):968-972.
5. Rana ML, Bansal AS, Singh NJ, Swain N. Study in change in liver enzymes after laproscopic cholecystectomy: a retrospective study. Journal of evolution of medical and dental sciences-JEMED. 2014 Dec 25;3(73):15411-15416.
6. Sharma A, Singal R, Mittal A, Grover AS, Zaman M. Effect of Duration of Surgery on Liver Enzymes after Cholecystectomy: Safety or Duration. Journal of Current

Surgery. 2018 Jan 9;7(4):53-57.

7. Lai H, Mo X, Yang Y, Xiao J, He K, Chen J, *et al.* Association between duration of carbon dioxide pneumoperitoneum during laparoscopic abdominal surgery and hepatic injury: a meta-analysis. PloS one. 2014 Aug 11;9(8):e104067.
8. Jakimowicz J, Stultiens G, Smulders F. Laparoscopic insufflation of the abdomen reduces portal venous flow. Surg. Endosc. 1998;12(2):129-132.

COMPARATIVE STUDY OF SYRINGE PRESSURE IRRIGATION OF NORMAL SALINE WITH AND WITHOUT POVIDONE IODINE IN PREVENTING SURGICAL SITE INFECTION

Authors

**Dr.Vishnuvardhan Poojari, Assistant professor, Department of
General surgery**

**Dr.Monica Devanand, Assistant professor, Department of General
surgery**

Dr.Gopal subbaiah, Professor, Department of General surgery

**Dr.Jeevan Kumar D V, Assistant professor, Department of General
surgery**

Dr. Naresh, Consultant neurosurgeon

INTRODUCTION

Surgical site infection (SSI), also known as surgical wound infection¹, is the most common surgical complication and is associated with prolonged hospital stays, high costs, morbidity, and mortality^{2,3}. At 3% in the US, SSI can range from 5% for clean surgeries to above 20% for emergency colon surgery in a dirty area.

11% of surgery patients in low- to middle-income nations are infected. SSI causes around 400000 extra hospital days in the US, costing 10 billion dollars annually. SSI patients have longer, more expensive hospital stays and a higher likelihood of ICU time. They also had 5 times the chance of readmission and 2 times the risk of mortality.

Within 30 days of surgery, surgical site infection can arise at any depth, from the surface to the deepest cavity that remains after organ dissection.

CDC defines SSI4 diagnosis criteria. It's divided:

- 1) Surgical site infection at the incision.
- 2) Deep incisional surgical site infection.
- 3) Infection at the surgery site.

To obtain useful data, hospital, outpatient, and post-discharge SSI surveillance must be effective 5, 6, 7.

Christou N V et al. revealed various risk variables, including poor host defenses and acute and chronic physiological derangement.

Albumin and age-related bacterial contamination at surgery predisposes to SSI (8).

In 2004, Leaper et al. found that study design, data collection, analysis, and reporting must be improved to reliably determine SSI baseline rates for cost-effective measure evaluation⁹.

Multiple studies have compared normal saline irrigation, pressure irrigation, pressure irrigation + povidone iodine, chlorhexidine, alcohol, and others, with inconsistent efficacy and cost effectiveness. Pressure irrigation may prevent SSI better than surgical incision irrigation, according to research. These preparations are routinely utilised during surgeries, but surgeons choose them based on lack of data on SSI prevention.

Thus, this study compared syringe pressure irrigation of normal saline and normal saline + povidone iodine to avoid surgical site infection.

Methods and materials

A tertiary care hospital's Department of General Surgery did this randomized control trial on emergency and elective laparotomies for peritoneal contamination. This 2-year study of 15–65-year-olds ran from October 2021 to October 2023.

Excluded patients were immunocompromised, took steroids or immunosuppressive drugs, had type II diabetes, or were allergic to piperacillin/iodine.

Randomised

Computer-generated randomization was used to divide the study population into two groups.

Group A: syringe-pressure normal saline irrigation patients.

Group B Syringe pressure irrigation with normal saline and povidone iodine

PROCEDURE:

The Shija Hospitals and Research Institute, Imphal Manipur Ethical and Scientific Committee approved the study. Selection criteria were used to evaluate peritonitis patients undergoing open laparotomy at Shija Hospitals and Research Institute's Department of General Surgery. Detailed medical history, physical exam, and investigations selected patients. The selected patients were informed about the study and interventions in their local language and gave signed informed consent.

Gender, age, and pertinent history were recorded on predesigned and pretested Performa. The results of a complete clinical examination were documented.

Laboratory tests included complete blood count, blood urea, and serum creatinine. Randomization determined patient assignment.

procedure.

Pre-operative

The abdomen was cleaned with 10% povidone iodine three times on the operating table. All study subjects received PIPERACILLIN+TAZOBACTAM (after skin test) and METRONIDAZOLE.

To eliminate bias, antibiotic dosage is adjusted by age and weight before skin incision. Our institution's antibiotic protocol determined these drugs.

During operation

First peritoneum and rectus sheath are closed with synthetic nonabsorbable nylon suture (ETHILON) loop in single layer during abdominal wall closure. Irrigating the subcutaneous tissue with the solution according to the group is next.

Group A: wound irrigated with 300 ml 0.9% normal saline using a 20 ml syringe and 19-gauge IV catheter.

Group B: wound irrigated with 40 ml of 10% povidone iodine and 120 ml of 0.9% normal saline in a 20-ml syringe with 19-gauge IV catheter.

After wound irrigation, suction removed all irrigated fluid, a fresh dry mop dried the wound, and skin stapler clips closed the wound.

Post-operative

Our hospital policy had patients take PIPERACILLIN+TAZOBACTAM and METRONIDAZOLE postoperatively. Pain management was provided by injectable systemic analgesics until the fifth post-operative day and oral analgesics until the eighth.

All study materials were sterilised according to our institute's protocols.

Post-op wound inspections occurred on days 3, 5, and 7. His vitals (pulse rate, temperature) and wound assessment (local erythema, edoema, and pain at surgical site) were recorded on the seventh post-operative day. Post-op total leucocyte count was performed on day 7. Ten days after surgery, skin clips were removed and wound was evaluated. Follow-up occurred in the second and fourth post-operative weeks. Follow-up vitals included temperature and wound examination for infection. Pus specimens from surgical site infection patients were cultured and sensitivity tested. S.S.I. was confirmed by two surgeons.

All participants received the patient information leaflet and informed consent form.

Definition of Wound Infection

Definition of wound infection:

Surface incisional SSI—Infection only affects skin and subcutaneous tissue.

Infection affects fascial and muscle layers in deep incisional SSI.

Organ/space SSI—Infection concerns any anatomy (organs and spaces) other than the incision that was opened or modified during surgery.

Statistical analysis

The collected data was reviewed for consistency and completeness before being entered and analysed by SPSS 21. Percentages, mean, standard deviation, and 95% confidence interval were shown. Analysis used Student's t-test. A P value of < 0.05 indicated statistical significance.



Figure 2: Clean wound without SSI.



Figure 3: superficial incisional SSI.



Figure 4: deep incisional SSI.



Figure 5: deep incisional SSI.

RESULTS

Average age in both the groups was comparable, and in both groups males are more than females. Additionally, there was no significant difference between hemoglobin concentrations was found between these two groups.

Blood urea level was 31.3 mg/dl in group A on average whereas it was 31.35 mg/dl on average in group B. No significant difference existed between these two groups considering blood urea levels.

Average duration of surgery in group A was 2 hours whereas duration was 2.2 hours in patients of group B. Hence, the average duration of surgery was comparable in both the groups.

There was decreased occurrence of erythema in patients of group B but that was statistically insignificant (p value = 0.3268). Similarly, there was decreased occurrence of local swelling at surgical site (on seventh postoperative day) in patients of group B but that was statistically insignificant (p value = 0.3268).

There was decreased occurrence of local pain in patients of group B but that was statistically insignificant (p value = 0.3268). So in our study for those patients who had local pain on seventh post-operative day (9.33% in group A and 3% in group B), oral analgesics was given for more post-operative days compared to other patients in the study. There was decreased

occurrence in patients of group B but that was statistically insignificant (p value = 0.3268)

Additionally, decreased occurrence of tachycardia in patients of group B but that was statistically insignificant (p value = 0.3268), with which was decreased occurrence in patients of group B but that was statistically insignificant (p value = 0.3268).

In group A who were irrigated with syringe pressure irrigation of normal saline SSI was found in seven patients out of which one was noted on 3rd post-operative day, four were on fifth day and two were on seventh post-operativeday.

In group B who were irrigated with normal saline + povidone iodine under syringe pressure SSI was found three patients of which two were noted on fifth post-operative day and one was on seventh post-operative day. So, in our study all the patients who had SSI noted in first week i.e. within seventh post-operative day.

Out of 7 patients who had SSI in group A (who were irrigated with syringe pressure irrigation of normal saline) 6 patients had superficial incisional SSI and one had deep incisional SSI. In group B (B who were irrigated with normal saline + povidone iodine under syringe pressure) out of 3 patients who was having SSI, two patients had superficial incisional SSI and one patient had deep incisional SSI. SSI was decreased in patients of group B i.e. Those who were syringe pressure irrigated with normal saline + povidone iodine compared to normal saline only but this difference was statistically insignificant (p value = 0.3268).

DISCUSSION

This study was designed to compare syringe pressure irrigation of normal saline and syringe pressure irrigation of normal saline + povidone iodine in prevention of surgical site infection, over follow up of 30 days after surgery.

A prospective analysis on 816 patients with wounds healed by using sterile gloves or clean non-sterile gloves indicated that there is no statistically significant difference in infection rate between the 2 groups (6.1% in the sterile gloves group versus 4.4% in the clean non-sterile gloves group) (14). This was the conclusion of a trial that was conducted on 816 patients. An earlier study by Ghafouri and colleagues (15) demonstrated that the use of clean gloves, as opposed to sterile ones, does not raise the risk of infection in contaminated uncomplicated wounds that are being healed in the emergency department rather than sterile gloves. In addition, Ruthman and colleagues demonstrated that there is not an increased risk of infection in laceration repairs that do not make use of caps or masks during the process of wound repair (16).

We have investigated the potential influence that the irrigation solution plays in lowering the overall infection rate. The results of another study conducted by Lammers et al on 33 highly infected acute traumatic wounds showed that soaking the wounds for 10 minutes in 1% povidone-

iodine has no advantage over soaking them in normal saline or doing nothing (the control group) in terms of the quantitative wound bacterial counts (17). We came to the conclusion that a Povidone-iodine solution with a concentration of 1% was not more effective than regular saline in lowering the infection rate in uncomplicated traumatic wounds that were treated in the emergency department. There are also further studies that recommend using regular tap water rather than normal saline for the treatment. For instance, in a review of clinical trials, the rates of infection in acute and chronic wounds that were irrigated with either normal saline or water were compared and contrasted. Tap water is associated with a lower rate of infection (than normal saline) in adults, but the rate of infection is similar in both groups of children in acute wounds. In chronic wounds, the relative risk of infection when irrigated with tap water is 0.16 compared with normal saline (18). This study showed that there is no statistically significant difference in infection rates when wounds are cleansed with tap water versus not purified at all. The findings of our research have been replicated in other research including non-traumatic wounds and ulcers of a more complex kind. For instance, Yavascan et al. demonstrated in their research that irrigating the exit-site of peritoneal dialysis catheter with normal saline can reduce the an infection rate of exit-site as effectively as povidone-iodine (19). Additionally, a review conducted by O'Meara et al. on venous leg ulcers demonstrated that the effectiveness of povidone-iodine and other anti-septic solutions (such as chlorhexidine,

CONCLUSION

This study concludes that there is no statistically significant difference in prevention of surgical site infection when patients were syringe pressure irrigated with normal saline when compared to those patients who were syringe pressure irrigated with normal saline + povidone iodine. Hence pressure irrigation with normal saline alone is a cost effective, easily available, easy to do and more economic alternative to syringe pressure irrigation with normal saline + povidone iodine. Also patients should be evaluated clinically and with biochemical investigations for early diagnosis of surgical site infection and its prompt treatment within period of 30 days of surgery.

REFERENCES

1. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992; a modification of CDC definitions of surgical wound infections. *Infection Control Hosp Epidemiol* 1992;20(5):271-274.
2. Astagneau P, Rioux C, Golliot F, Brucker G. Morbidity and mortality associated with surgical site infections: results from the 1997–1999 INCISO surveillance. *J Hosp Infect* 2001;48:267-274.
3. Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. *Infect Control Hosp Epidemiol* 1999;20:725-730.
4. Fanning C, Johnston BL, MacDonald S, LeFort-Jost S, Dockerty E. Postdischarge surgical

- site infection surveillance. *Can J Infect Control* 1995;10:75-79.
5. Nichols RL. Surgical wound infection. *Am J Med* 1991;91:54S-64S.
 6. Manian FA, Meyer L. Comprehensive surveillance of surgical wound infections in outpatient and inpatient surgery. *Infect Control Hosp Epidemiol* 1990;11:515-520.
 7. Raymond DP, Pelletier SJ, Crabtree TD, Schulman AM, Pruett TL, Sawyer RG. Surgical infection and the aging population. *Am Surg* 2001; 67:827-833.
 8. Christou NV, Nohr CW, Meakins JL. Assessing operative site infection in surgical patients. *Arch Surg* 1987;122:165-169
 9. Leaper DJ, van Goor H, Reilly J, Petrosillo N, Geiss HK, Torres AJ et al. Surgical site infection - a European perspective of incidence and economic burden. *Int Wound J* 2004;1:247-273.
 10. Watanabe A, Kohnoe S, Shimabukuro R, Yamanaka T, Iso Y, Baba H et al. Risk factors associated with surgical site infection in upper and lower gastrointestinal surgery. *Surg Today* 2008;38:404-412.
 11. Owens CD, Stoessel K. Surgical site infections: epidemiology, microbiology and prevention. *J Hosp Infect* 2008;70:3-10.
 12. Bagnall NM, Vig S, Trivedi P. Surgical-site infection. *Surg* 2009; 27:426-430.
 13. Cheadle WG. Risk Factors for Surgical Site Infection. *Surg Infect* 2006; 7:7-11.
 14. Digison MB. A Review of Anti-septic Agents for Pre-operative Skin Preparation. *Plast Surg Nurs* 2007;27:185-189.
 15. Ghafouri HB, Zoofaghari SJ, Kasnavieh MH, Ramim T, Modirian E. A pilot study on the repair of contaminated traumatic wounds in the emergency department using sterile versus non-sterile gloves. *Hong Kong J Emerg Med* 2014;21(3):148-152.
 16. Ruthman JC, Hendricksen D, Miller RF, et al. Effect of cap and mask on infection rates in wounds sutured in the emergency department. *Ill Med J* 1984;165:397-399.
 17. Lammers RL, Fourré M, Callahan ML, Boone T. Effect of povidone-iodine and saline soaking on bacterial counts in acute, traumatic, contaminated wounds. *Ann Emerg Med* 1990;19(6):709-14.
 18. Fernandez RS1, Griffiths R, Ussia C. Water for wound cleansing. *Int J Evid Based Healthc* 2007;5(3):305-23.
 19. Yavascan O, Anil M, Kara OD, Bal A, Akcan N, Senturk S, Unturk S, Aksu N. The comparison of exit-site care with normal saline and povidone-iodine in preventing exit-site infection and peritonitis in children on chronic peritoneal dialysis treatment. *Saudi J Kidney Dis Transpl.* 2011;22(5):931-4.
 20. O'Meara S, Al-Kurdi D, Ologun Y, Ovington LG, Martyn-St James M, Richardson R. Antibiotics and antiseptics for venous leg ulcers. *Cochrane Database Syst Rev.* 2014 10;1:CD003557.
 21. Storm-Versloot MN, Vos CG, Ubbink DT, Vermeulen H. Topical silver for preventing

- wound infection. Cochrane Database Syst Rev. 2010;17(3):CD006478.
22. Mueller TC, Loos M, Haller B, et al. Intra-operative wound irrigation to reduce surgical site infections after abdominal surgery: a systematic review and meta-analysis. *Langenbecks Arch Surg*. 2015;400(2):167-81.
 23. Sindelar WF, Mason GR. Efficacy of povidone-iodine irrigation in prevention of surgical wound infections. *Surg Forum* 1977;28:48-51.
 24. Sindelar WF, Mason GR. Intraperitoneal irrigation with povidone-iodine solution for the prevention of intra-abdominal abscesses in the bacterially contaminated abdomen. *Surg Gynecol Obstet* 1979;148:409-11.
 25. Singh A, Goyal HO, Kaur B, et al. Wound healing: some observations. *J Indian Med Assoc* 1988;86:81.
 26. Moore Z, Cowman S. A systematic review of wound cleansing for pressure ulcers. *J Clin Nurs*. 2008;17(15):1963-72

Fungal Sepsis in Tertiary Care NICU

Raksha S K¹, Prasad N A², Monika D³, Vishnuvardhan Poojari^{4*}

Abstract: Background: Fungal infections have emerged as a critical problem in neonatal intensive care units. The vast majority of fungal infections in neonates are due to *Candida* species, with a small number being due to *Malassezia*, *Aspergillus* and other rare fungi. *Candida* has become an increasingly significant neonatal pathogen to cause late onset sepsis and compete with bacteria as one of the leading causes of nosocomial infections. We conducted a prospective study for a period of 1 year to know the incidence and course of fungal sepsis in a tertiary care NICU. **Methods:** This prospective study was conducted in a Neonatal Intensive Care unit of a tertiary care hospital from December 2016 to December 2017. Neonates admitted to K R Hospital NICU suspected / already diagnosed to have fungal sepsis were studied. The hospital has 23 bedded NICU with an average of 400 to 500 admissions each year. Informed parental consent was taken. A standardized case report form was developed to collect data on demographic, clinical, diagnostic, treatment and outcome of all these cases. Neonates admitted to tertiary care NICU were screened for fungal sepsis using standardized proforma developed to collect data and followed up. **Results:** Out of 15 neonatal cases of fungal sepsis, 11 (73.3%) were females and 4 (26.7%) were males. In the observed study, 7 cases (46.7%) were between 27-32 wks, 3(20%) were between 33-36 wks and 5(33.3%) were above 37 wks of gestational age. In the present study, 5 neonates (33.3%) were below 1.5 kg, 5 neonates (33.3%) between 1.5 to 2.5 kg and remaining 5 neonates (33.3%) had birth weight between 2.5 to 3.5 kg. In the present study, 12 cases (80%) were outborn and remaining 3(20%) were inborn cases. Out of 15 cases, 8 cases (53.3%) had early onset fungal sepsis within seven days of hospitalization and remaining 7 cases (46.7%) developed late onset fungal sepsis (>7 days after hospitalization). **Conclusion:** Fungal sepsis is one of the emerging problem in NICU and high index of suspicion is necessary for early diagnosis and treatment and good outcome.

Keywords: Fungal sepsis, Tertiary care, NICU.

AFFILIATIONS

^{1,3}Assistant Professor,
Dept of Pediatrics, Dr.
Chandramma

Dayananda Sagar
Institute of Medical
Education and
Research,

Devarakaggalahalli,
Karnataka, India

²Consultant

Neonatologist,

Rangadore Memorial
hospital, Bangalore

⁴Assistant Professor,
Dept of Surgery, Dr.
Chandramma

Dayananda Sagar
Institute of Medical
Education and
Research,

Devarakaggalahalli
Karnataka, India

CORRESPONDING AUTHOR

Dr. Vishnuvardhan
poojari

INTRODUCTION

Fungal infections have emerged as a critical problem in neonatal intensive care units. The vast majority of fungal infections in neonates are due to *Candida* species, with a small number being due to *Malassezia*, *Aspergillus* and other rare fungi. *Candida* has become an increasingly significant neonatal pathogen to cause late onset sepsis and compete with bacteria as one of the leading causes of nosocomial infections.^{1,2,3}

This rise is attributed to extensive use of broad-spectrum antibiotics and advances in medical field which contributes to increase in susceptible population available for these opportunistic pathogens.

Preterm low birth weight babies are more vulnerable to acute fungal sepsis because of immature immune system, invasive interventions and prolonged use of antimicrobials that serve as risk factor for fungal colonization.

Candida species can spread through vertical transmission from maternal flora or horizontal transmission from hands of health care workers.

Reported incidence of Candida sepsis ranges from 1.6% to 9% in VLBW, 10% to 16% in ELBW neonates.

Mortality associated with Candida sepsis ranges between 40 to 60% which increases with decreasing gestational age.

One of the most important factors that contribute to poor outcome with fungal sepsis includes diagnostic delay and delayed initiation of antifungal therapy. If recognized early, effective antifungal therapy is possible with favorable outcome. Candidemia is not only associated with a significant morbidity and mortality but also extends the duration of hospital stay and increases the cost of medical care.

We therefore have done this study to explore our observational findings of 15 cases with fungal sepsis, to add in the better understanding of this life-threatening infection, recognizing factors that may escalate infant's risk of fungal infections and to help in recognizing early warning signs and symptoms of invasive fungal infections.

Hence this study was conducted To determine the incidence of fungal sepsis in Level III NICU, To describe the clinical course, diagnosis, treatment and outcome of fungal sepsis in Level III NICU.

MATERIAL AND METHODS:

This prospective study was conducted in a Neonatal Intensive Care unit of a tertiary care hospital from December 2016 to December 2017. Neonates admitted to K R Hospital NICU suspected / already diagnosed to have fungal sepsis were studied.

The hospital has 23 bedded NICU with an average of 400 to 500 admissions each year. Informed parental consent was taken. A standardized case report form was developed to collect data on demographic, clinical, diagnostic, treatment and outcome of all these cases.

Initial Investigations done:

- a) *Hematological*—Haemoglobin, Total count, Differential count, Platelet count, Prothrombin time, Serum Electrolytes, Serum creatinine, DNA PCR, Blood Culture for fungus, Urine for Candida.

Radiological—

- Chest X-ray PA view,
- Analysis of neonates with fungal sepsis was done for the following:
- Maternal risk factors
 - Gestational age
 - Birth weight
 - Age at time of diagnosis
 - Use of postnatal steroids
 - Duration of antimicrobial therapy
 - Duration of ventilation
 - Central line access / Duration
 - Total Parenteral Nutrition / Duration
 - Abnormal total count / thrombocytopenia
 - High CRP
 - Fluctuating blood sugar
 - Metabolic acidosis
 - For end organ dissemination
 - 2D Echo
 - Cranial ultrasound
 - Eye check up
 - Abdominal ultrasound
 - CSF analysis was done.

RESULTS:

This prospective study was conducted in KR Hospital NICU over period of 12 months between December 2016 to December 2017. There were 464 admissions in the unit in one year. Out of which, 15 neonates were diagnosed to have fungal sepsis. The incidence of fungal sepsis in the observed study was 3.23 %.

Out of 15 neonatal cases of fungal sepsis, 11 (73.3%) were females and 4 (26.7%) were males. In the observed study, 7 cases (46.7%) were between 27-32 wks, 3(20%) were between 33-36 wks and 5(33.3%) were above 37 wks of gestational age.

In the present study, 5 neonates (33.3%) were below 1.5 kg, 5 neonates (33.3%) between 1.5 to 2.5 kg and remaining 5 neonates (33.3%) had birth weight between 2.5 to 3.5 kg.

In the present study, 12 cases (80%) were out born and remaining 3(20%) were inborn cases.

Out of 15 cases, 8 cases (53.3%) had early onset fungal sepsis within seven days of hospitalization and remaining 7 cases (46.7%) developed late onset fungal sepsis (>7 days after hospitalization).

Table 1: Early/ late onset fungal sepsis

Early/ late	No. of patients	%
Early(<7days)	8	53.3
Late(>7 days)	7	46.7
Total	15	100.0

Table 2: Possible risk factors in 15 neonates with fungal sepsis

Risk factor	No of cases	Percentage
Birth weight	5	33.3%
Gestational age < 32 wks	7	46.7%
Mech. ventilation(>7 days)	8	53.3%
Broad spectrum antibiotics	5	33.3%
Use of multiple antibiotics	5	33.3%
Central venous catheters	4	26.7%
Parenteral nutrition	9	60%
Duration of stay(>21 days)	6	40%
Use of postnatal steroids	3	20%

In the present study, 5 neonates (33.3%) had birth weight of < 1500 gm and 7 neonates (46.7%) with gestational age of <32 wks. Parenteral nutrition (60%), prolonged hospital stay (40%) , prolonged mechanical ventilation (53.3%) , use of multiple antibiotics (33.3%) were other significant risk factors observed in this study.

Table 3: Source of Positive fungal culture

	No. of patients (n=15)	%
Blood C/S		
● Negative	7	46.7
● Positive	8	53.3

Urine		
• Negative	14	93.3
• Positive	1	6.7
DNAPCR		
• Negative	8	53.3
• Positive	4	26.7
CSF		
• Negative	13	86.7
• Positive	2	13.3

In the present study; out of 15 neonates diagnosed to have fungal sepsis: blood culture positivity was seen in 53.3%, urine for Candida positivity in 6.7%, DNA PCR positivity in 26.7% and CSF isolation of fungus was seen in 13.3 %.

Out of 15 cases, 3 cases had polymicrobial sepsis who were treated early in other hospitals with multiple broad spectrum antibiotics. All 3 neonates had associated Klebsiella sepsis.

Table 4: Clinical features in neonates with fungal sepsis

Clinical features	No. of patients (n=15)	%
Slow clinical deterioration	5	33.3
Change in skin colour	6	40.0
Abdomen distension with gastric aspirates	5	33.3
Apnoeic spells	4	26.7
Fever	4	26.7
Hypotension	5	33.3
Hyperglycemia	7	46.7

In this study, most of the neonates with fungal sepsis were noted to have hyperglycemia (46.7%). 6 neonates (40%) were noted to have change in skin colour. Abdominal distension with gastric aspirate was seen in 33.3%. 5 neonates (33.3%) had slow clinical deterioration. Fever and apnoeic spells were seen in 26.7% cases. In this study, raised CRP (66.7%) , Thrombocytopenia (53.3%) , anemia (46.7 %), and leucopenia (46.7%) were the significant laboratory findings observed.

Table 5: Outcome

Outcome	No. of patients	%
DAMA	3	20.0
Expired	3	20.0
Survived	9	60.0
Total	15	100.0

Out of 15 neonates with fungal sepsis in the observed study 9 neonates (60%) , 3 neonates (20%) expired and 3 neonates(20%) were discharged against medical advice.

Prophylactic antifungal therapy was not used in this study in view of possible emergence of resistant fungal species. All neonates with fungemia were treated initially with Amphotericin B for 2 - 6 weeks. Fungal therapy was continued for at least 2 weeks after last negative blood culture result. Amphotericin B was switched over to oral voriconazole for completion of therapy.

In the present study there was no evidence of end organ dissemination in heart, brain, eyes, hepatic and renal system.

DISCUSSION:

The incidence of candidemia during the study period was 3.23 % of all NICU admissions. Although the present study was limited to a one year period, it reports a high overall incidence of Candida infection. This may be attributed to routine screening in our NICU for fungal infection in predisposed low birth weight neonates receiving prolonged broad spectrum antibiotics. This is a tertiary care NICU; hence referred out born cases were more than inborn cases of fungal sepsis. In the present study 12 cases (80%) were out born and remaining 3(20%) were inborn cases of fungal sepsis.

Low incidence of fungal sepsis was noted by Eman F et al ⁴ (0.27%), Kim D H et al ⁵ (0.85%) and Kosoff et al ⁶ (1%) whereas study done by Wang et al ⁷ noted 5.7% and Singh K et al ⁸ demonstrated 22.8% rate of invasive fungal infection in preterm babies staying for more than one week in the NICU.

The mean gestational age was 33.8 wks and mean birth weight was 1625 gm. In the present study not only preterm and low birth weight neonates but term babies of >2500 gm weight also had fungal sepsis. Out of 5 term babies observed in this study who were diagnosed to have fungal sepsis, 3 had risk factor of vaginal candidiasis in the mother and other 2 neonates were Infant Of Diabetic Mother .1 neonate had received prolonged course of broad spectrum antibiotic with prolonged ventilation (>7 days) and 1 neonate with fungemia also underwent surgery for Imperforate Anus.

This observation was different from studies done by many others which showed preterm and low birth weight being the main risk factors for fungal sepsis. In the studies done by Saiman et al ⁹ , Wang et al ⁷ one of the significant risk factors for fungal sepsis was gestational age <32 weeks. In the study done by Romero M C et al ¹⁰, 12 newborns were preterm infants and 2 were term infants who required abdominal surgery.

Leibovitz E et al¹¹, did a retrospective study of 25 infants with systemic candidiasis during the period 1980-1989. Candidemia was associated with prolonged antibiotic therapy, parenteral nutrition and tracheal intubation. Lin HH et al¹² (1990) reviewed the cases of 43 patients with fungemia and examined the clinical significance of fungemia and the results of treatment. All episodes were nosocomial infections. Most patients had underlying diseases and predisposing factors. Intravascular catheters (100%), surgical procedures (46.5%), and total parenteral nutrition (41.9%) were the most common predisposing factors. The clinical manifestations were not characteristic and consisted of nonspecific signs of sepsis. The overall mortality rate was 79 %. They suggested that fungal infection should be considered early when a febrile patient at high risk doesn't improve with broad spectrum antibacterial therapy.

Khristina N Feja et al ¹³(2005) performed a matched case control study to determine risk factors for late onset Candidemia among infants in the NICU. They concluded that central venous catheter use, gastrointestinal pathology and previous bacterial blood stream infections were significant predictors of Candidemia. Mendiratta DK et al ¹⁴ (2006) done a study to determine colonization of Candida species in preterm babies and identify the risk factors. They concluded in their study that colonization of preterm's by Candida was a significant problem in NICU and the important risk factors observed in colonized infants were male sex, administration of steroids and antibiotics and vaginal colonization of mothers.

Narain S et al ¹⁵ (2002). In his study done at KEM Hospital Mumbai found that the factors that possibly led to Candidemia were broad spectrum antibiotics, low birth weight, prematurity and ventilator therapy. Central lines and parenteral nutrition were not common factors causing Candida sepsis.

Baradkar BP et al ¹⁶ done a study in 2008 which showed that commonest predisposing factors observed were antibiotic therapy(100%), prematurity(100%), low birth weight(100%), RDS(66.7%), patients on ventilator (66.7%),

patients on central line catheters (33.3%) and urinary catheters (50%). Clinical features were nonspecific and difficult to differentiate from bacterial sepsis.

In this study, most of the neonates with fungal sepsis were noted to have hyperglycemia (46.7%). 6 neonates (40%) were noted to have change in skin colour. Abdominal distension with gastric aspirate was seen in 33.3%. 5 neonates (33.3%) had slow clinical deterioration. Fever and apnoeic spells were seen in 26.7% cases.

Jill E Baley, et al¹⁷, in 1984 did a study of 10 clinically diagnosed cases of systemic fungal infections in VLBW infants. Prior to developing systemic fungal illness, these infants required prolonged total parenteral nutrition, central arterial or venous catheters, and multiple courses of broad spectrum antibiotics. The clinically diagnosed disseminated fungal infection was noted at a mean age of 33 days with one or more of the following: respiratory deterioration, abdominal distention guaic positive stools, carbohydrate intolerance, Candiduria, endophthalmitis, meningitis, erythematous rash, temperature instability and hypotension. These signs and symptoms were seen as chronic or were intermittent in clinical course.

David R Lagdon¹⁸ in his study of fungal infections in premature infants (1984) observed late onset carbohydrate intolerance and imply that fungal sepsis may precipitate hyperglycemia.

Claudia et al¹⁹, performed a prospective study published in 2005, of the clinical and epidemiological aspects of *Candida* species sepsis. 44 out of 128 neonatal intensive care patients with clinical sepsis and suspected fungal etiology were chosen randomly for the study. Infant's Blood, urine, GIT, oral and skin samples were cultured. 34 (77.27%) from 44 neonates presented critical clinical signs. The most common signs were abdominal distension (59.09%), Enterocolitis (54.55%), fever (54.55%), dehydration (52.27%), respiratory distress (52.27%), hypothermia (31.82%) and diarrhea (31.82%). They concluded that gastrointestinal involvement due to Candidemia is significant.

In this study, raised CRP (66.7%), Thrombocytopenia (53.3%), anemia (46.7%), and leucopenia (46.7%) were the significant laboratory findings observed.

Daniel K Benjamin et al in 2000²⁰ performed a retrospective review of all NICU patients with systemic candidiasis between 1995 and 1998 at Duke university medical centre to determine the epidemiology, risk factors, clinical presentation and outcomes for neonates with candidiasis.

They concluded that neonates infected with *Candida* species can often present with a clinical picture of slow deterioration. They also concluded that sustained decline in platelet count of 10% per day or more in a neonate on broad spectrum antibiotics for suspected sepsis may be indicative of fungemia.

S Torres et al²¹ performed a study published in 2007. They retrospectively reviewed the medical charts of 42 neonates with late onset sepsis with positive blood culture. The most reliable marker of *Candida* sepsis was thrombocytopenia which was found in 17.7% of the episodes of late onset sepsis. The incidence of thrombocytopenia was significantly higher in *Candida* sepsis than in bacterial sepsis (100% vs 5.9%). Only 2 patients with bacterial sepsis had thrombocytopenia and both cases were caused by gram negative bacteria. They concluded that thrombocytopenia is a highly specific marker of neonatal *Candida* sepsis. Analysis of platelet counts is a simple laboratory test that helps to guide, diagnosis and the use of early empirical therapy.

In the present study there was no evidence of End organ dissemination in neonates with fungal sepsis. However study by Noyola et al²² (2001) conducted a retrospective review of 86 neonates with Candidemia hospitalized from 1989 to 1999, to determine the incidence of ophthalmologic, renal and cardiac involvement. The objectives of the study were to determine the incidence of ophthalmologic, renal and cardiac involvement during Candidemia and to define potential predictors of their presence. Evaluation of eyes, kidneys and heart was performed.

Ophthalmologic, intra abdominal or cardiovascular involvement was documented in 20 (23.3%) of 86 Candidemia premature infants who underwent evaluation for candidiasis. The abnormality most frequently found was in the cardiovascular system. 6 infants had a thrombus in superior or inferior vena cava as the only abnormality. 2 had increased echogenicity of mitral valve and one of these also had a thrombus in the left innominate vein. Vegetations in left ventricle, vegetations in left atrium and echodense masses in both ventricles were observed in 1 infant each. On the basis of their findings they suggested that ophthalmologic, renal and cardiac evaluations are indicated in the neonates with Candidemia because their detection may influence therapy and outcome.

In this study prophylactic antifungal therapy were not given in view of development of possible resistant fungal strains. However several other studies recommend prophylactic antifungal therapy in ELBW, VLBW, preterm (<30 wks). A multicentre randomized controlled trial study is required to standardize the protocol for prophylactic antifungal therapy. The present study done showed overall outcome of 60% who survived and 20 % mortality. This statistics differs from other studies. Study done by Lin HH et al (1990) showed a mortality of 79%.

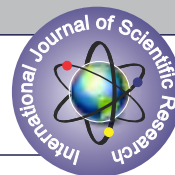
CONCLUSION:

Fungal sepsis represents an emerging and burning problem for late onset sepsis in NICU. Diagnosis of neonatal fungal sepsis begins with clinical suspicion in presence of multiple risk factors like prematurity, low birth weight, prolonged hospitalization, prolonged antibiotic therapy and invasive interventions. A positive culture for *Candida* species should prompt a complete end organ evaluation. Fungal sepsis is associated with high morbidity and mortality. Early diagnosis and appropriate antifungal therapy, combined with elimination of possible risk factors and evaluation for end organ damage may lower morbidity and mortality.

REFERENCES:

1. D K Benjamin Jr , Charles Poole, WJ.Steinbach, J L .Rowen , T J .Walsh. Neonatal Candidemia and End organ damage: Critical Appraisal Of the Literature Using Meta- analytic Techniques.Pediatrics.2003;112;634-640.
2. Jarvis WR .Epidemiology of Nosocomial Fungal infections, with emphasis on *Candida* species.Clin Infect Dis 1995;20:1526-30.
3. Centre for Disease control and prevention. National Nosocomial Infections surveillance (NNIS) report, Data summary from October 1986 –April 1996.Am J Infect Control 1996;24:380-8.
4. Kossof , Eric et al . Candidemia in neonatal intensive care unit : Trends during 15 years and clinical features of 111 cases:Ped Infect Dis J.17(6);504-8,June 1998.
5. Kim D H , Lee J A et al . Systemic candidiasis in neonatal intensive care unit:A 8 year experience.Department Of Pediatrics , College Of Medicine.Seoul National University, Seoul, Korea.
6. Eman F Badran , Jumana H Al Baramki et al . Epidemiology and clinical outcome of candidemia among Jordanian newborns over a 10 year period
7. Wang L W , Lin CH et al . Systemic fungal infection in very low birth weight infants.1996. Jul – Aug:37(4); 272-7.
8. Singh K , Chakrabarthi A , Narang A , Gopalan S , Yeast : Colonization and invasive fungal infection in preterm neonates in a tertiary care centre. Indian J Med Res 1999;110:169-173.
9. Saiman L , Ludington E et al . Risk factors for candidemia in neonatal intensive care patients.The national epidemiology of mycosis survey study group.Pediatr Infect Dis J(2000) 90;319-324
10. Romero Reyes MC , Fernandez F et al .Neonatal systemic candidiasis in the 90 s. An Esp Pediatr.1996.Mar :44(3);257-61.
11. Leibovitz E ,Amitai M et al 1992. Systemic candidial infections associated with use of peripheral venous catheters in neonates:A 9 year experience.Clin Infect Dis.1992;15(3);554.
12. Lin HH , Liu Y C et al . Fungemia :Analysis of 43 cases .J Formos Med Assoc.1990.Oct:89(10);863.
13. Christina N Feja , Fannu Wu et al . Risk factors for candidemia in critically ill infants :J Pediatr .2005 August: 147(2):156-61.
14. B K Mendiratti , V Rawat et al . *Candida* colonization in preterm babies admitted to NICU in rural setting :Indian J Medical Microbiology,2006,Vol 24 pg 263-67.
15. S Narain , J S Shastry et al. Neonatal systemic candidiasis in a tertiary care centre:Indian Journal Of Medical Microbiology,2003;21(1);56-58.
16. M Baradkar , M Mathur et al. *Candida Glabrata* – Emerging pathogen in Neonatal Sepsis:Tropical Medicine and Public Health Vol 1 2008 pg 5-8.
17. Baley J.E, T.M. Kliegman, and A.A. Fanaroff.1984.Disseminated fungal infections in very low birth weight infants: Clinical manifestations and epidemiology. Pediatrics.72:144-152.
18. David R Langdon ;Fungal infections in premature infants , Pediatrics.Vol 74 No3,1984.
19. Claudia H C , Sophia M E et al .Neonatal candidiasis in Venezuela:Clinical and epidemiological aspects:Microbiologia Vol47 No 1-2, Jan-Mar 2005 pg 11-20.

20. Benjamin D K Jr , Kelly Ross et al .When to suspect fungal infection in neonates : A clinical comparison of Candida Albicans and Candida Parapsilosis fungemia with coagulase negative Staphylococcus bacteremia.Pediatrics.2000;106;712-8.
21. S Torres Claveras , M Dupla Arenaz et al.Nosocomial Candida infections and thrombocytopenia in very low birth weight newborns.Pediatr (Barc)2007 Dec ;67(6):544-7.
22. Daniel E Noyola , Marisol Fernandez et al . Ophthalmologic ,visceral and cardiac involvement in neonates with candidemia.Clinical Infectious Diseases.2001;32;1018-23.



ACCURACY OF VIRTUAL COLONOSCOPY VERSUS CONVENTIONAL COLONOSCOPY IN DIAGNOSIS OF COLORECTAL PATHOLOGIES

General Surgery

Dr Lokesh M N

Professor Of Surgery, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, Dayananda Sagar University

Dr Anil Kumar K N*

Associate Professor Of Surgery, Dr Chandramma Dayananda Sagar Institute Of Medical Education and Research, Dayananda Sagar University *Corresponding Author

ABSTRACT

Background: Colorectal cancer is major health issue affecting population worldwide in recent years. Conventional colonoscopy is the gold standard investigation used for screening and diagnosis of CRC but associated with its own disadvantages in the form of pain, discomfort, abdominal distension and rarely perforation. Virtual colonoscopy is a recent radiological technique to evaluate the colon without morbidities of conventional colonoscopy. **Aims and Objectives:** To evaluate the sensitivity and specificity of contrast computed tomography in comparison with conventional colonoscopy. **Methodology:** Study was conducted from June 2022 to September 2023 on 76 patients. This is a prospective double blind study. Patients underwent virtual colonoscopy followed by conventional colonoscopy after informed consent. The conventional colonoscopy findings were regarded as gold standard and were compared with virtual colonoscopy in relation to location and type of the lesion. Histopathological findings were noted in patients in whom biopsy was performed. **Results:** Intraluminal findings of both the investigations were comparable except few incomplete evaluations in conventional colonoscopy secondary to obstructive growth or poor patient compliance. Virtual colonoscopy had additional advantages like fat stranding and enlarged lymph nodes but with a drawback of no tissue diagnosis. Virtual colonoscopy and conventional colonoscopy was successful in all patients. Sensitivity of the virtual colonoscopy was 100% with positive predictive value of 100% in comparison to conventional colonoscopy. Specificity could not be assessed as only positive cases on conventional colonoscopy were taken. **Conclusion:** Accuracy of Virtual colonoscopy is equivalent to conventional colonoscopy for screening and can be used as primary tool in assessing colorectal pathologies.

KEYWORDS

Virtual colonoscopy, conventional colonoscopy, colorectal cancer.

INTRODUCTION

Colorectal cancer is a major health issue affecting worldwide population in recent years. It is the third most common carcinoma and second most fatal cancer worldwide¹. Highest incidence is in Australia and Western Europe and least in Africa and South Central Asia. Within Asia incidence is high in all developed Asian countries and low in south Asian countries.

Screening is an important tool in the early diagnosis and treatment of colorectal cancer, but only few undergo regular screening with various reasons for non-compliance like discomfort, bowel preparation and cost as Conventional colonoscopy was the only screening tool available.

Conventional colonoscopy is the gold standard with high sensitivity and specificity² with advantage of biopsy and intervention, but associated with risk for perforation and cardiopulmonary events secondary to sedation. Cecal intubation is the main goal of conventional colonoscopy but completion rate is variable³ due to colon tortuosity, stricture or fecal matter. Virtual colonoscopy causes minimal discomfort and doesn't require sedation so it is better patient compliant, no risk for perforation, complete evaluation in obstructive lesions and staging is achieved in the same time, but its own disadvantages like no tissue biopsies⁴, low sensitivity for polyp less than 5mm and mucosal lesions, no scope for intervention, exposure to radiation.

Pilot studies in various centers are exploring the potential of helical CT and computer generated volumetric data analysis for detecting polyps and cancer. Evidence shows polyps or adenoma is the critical factor in colorectal cancer. A study on 1693 patients with 10 years follow-up period showed Polypectomy substantially reduces the incidence of colorectal cancer in the cohort compared with that expected in the general population⁵.

MATERIALS AND METHODS:

Study was done after the institutional Ethical clearance.

Source Of Data:

Study was conducted on 76 patients who underwent conventional colonoscopy and virtual colonoscopy with Spiral CT at endoscopy unit in tertiary care hospital from June 2022 to September 2023.

Inclusion Criteria:

All patients who had symptoms suggestive of colorectal disease and

who were in risk category.

Exclusion Criteria:

1. Patient who had previous colonic surgeries.
2. Patients who had incomplete bowel preparation.

Method Of Collection Data:

It is a prospective double blind study. Patients underwent virtual colonoscopy first followed by conventional colonoscopy. Findings of both are corroborated. Diagnosis was confirmed by histopathological examination. The finding in the conventional colonoscopy is regarded as gold standard.

Data Analysis:

All the baseline characteristics were analyzed as mean $\pm$ standard deviation (SD) for continuous variables and as a frequency (Percentage) for all variables. Chi square test was used where applicable.

RESULTS:

Study was conducted on 76 patients comprised of 42 males and 34 females (mean age 56 $\pm$ 12 years). Table 1 shows age distribution and table 2 shows gender distribution.

Table – 1

Age in years	No of patients	Percentage
30 – 40	12	15.8
41 – 50	18	23.7
51 – 60	22	28.9
61 – 70	20	26.4
>70	4	5.2
Total	76	100.0

Table – 2

Conventional colonoscopy diagnosis	Gender		Total
	Male	Female	
Suspicious for CA ascending colon	4(9.5%)	2(5.9%)	3(7.9%)
Suspicious for CA transverse colon	6(14.3%)	4(11.8%)	5(13.2%)
Suspicious for CA descending colon	4(9.5%)	6(17.6%)	5(13.2%)
Suspicious for CA sigmoid colon	2(4.8%)	4(11.8%)	3(7.9%)
Suspicious for CA rectum	26(61.9%)	16(47%)	21(55.2%)

Familial adenomatous polyposis	0(0%)	2(5.9%)	1(2.6%)
Total	42	34	76(100%)

Table-3

Virtual colonoscopy diagnosis	Gender		Total
	Male	Female	
Suspicious for CA ascending colon	4(9.5%)	2(5.9%)	3(7.9%)
Suspicious for CA transverse colon	6(14.3%)	4(11.8%)	5(13.2%)
Suspicious for CA descending colon	4(9.5%)	6(17.6%)	5(13.2%)
Suspicious for CA sigmoid colon	2(4.8%)	4(11.8%)	3(7.9%)
Suspicious for CA rectum	26(61.9%)	16(47%)	21(55.2%)
Familial adenomatous polyposis	0(0%)	2(5.9%)	1(2.6%)
Total	42	34	76(100%)

Table-4

Additional findings on virtual colonoscopy	No of patients
Fat stranding (Perirectal, Pericolonic, Mesenteric)	50
Lymph nodes (Perirectal, Mesenteric, Pericolonic, Illac)	42
Ascites	6
Pneumo - peritoneum	2
None	6

DISCUSSION:

There are evidence to prove regular screening markedly reduce the mortality from colorectal malignancy, but there still debate about the optimal screening tool. Fecal occult blood positive resulting in the diagnosis of colorectal cancer was 15 – 33% of cases⁶. Sigmoidoscopy can be false negative in 10% of the cases. Rate of complete conventional colonoscopy varies, misses 10% of the carcinoma in the area viewed and can result in perforation in 1 in 500 – 1000 cases.

Since 1994 virtual colonoscopy has emerged as a promising tool in evaluation of large intestine⁷. The standard principle is thin section, spiral computed tomography of the air distended, prepared colon with interpretation of data based on both axial two dimensional images of the colonic mucosa and computer generated three dimensional reconstructed images.

In our study finding were similar in all the 76 patients with both virtual colonoscopy and conventional colonoscopy. Conventional colonoscopy was not able to evaluate the entire colon in 13 of the cases due to obstructive lesions or uncooperative patients. Virtual colonoscopy gave additional information about fat stranding, lymph node status which could not be evaluated in conventional colonoscopy.

In one of the study virtual colonoscopy had sensitivity of 100%⁸. In another study virtual colonoscopy had sensitivity and specificity of 83% and 95% respectively⁹. In our study sensitivity was 100%.

Rectum was the most common site in our study which accounted for 55% of the cases (n = 42). Virtual colonoscopy is relatively simple and is less invasive than conventional colonoscopy. Bowel preparation is required in both but virtual colonoscopy takes lesser time than conventional colonoscopy.

One of the concerns in relation to virtual colonoscopy is the radiation dose. 30 patients were scanned in supine position with radiation dose of 8 mSv and 38 were scanned in supine and prone position with dose of 18 mSv, which is well below the dosage limit.

CONCLUSION:

Virtual colonoscopy is as sensitive as conventional colonoscopy in colonic lesion assessment. In addition virtual colonoscopy has advantages like better compliance, better acceptability, and fewer complications with ability to depict lesion and its relation to surrounding structures and to evaluate extra colonic structures like peritoneum, lymph nodes and liver.

Main disadvantages being that there is no histological diagnosis.

REFERENCES:

- [1] Colorectal Cancer: A Review of Carcinogenesis, Global Epidemiology, Current Challenges, Risk Factors, Preventive and Treatment Strategies. Md. Sanower Hossain, Hidayah Karuniawati, Ammar Abdul rahman Jairoun, Zannat Urbi, Der Jiun Ooi, Akbar John, Ya Chee Lim, K. M. Kaderi Kibria, A.K. M. Mohiuddin, Long Chiau Ming, Khang Wen Goh, and Muhammad Abdul Hadi. *Cancers (Basel)*. 2022 Apr; 14(7): 1732.

Published online 2022 Mar 29. doi: 10.3390/cancers14071732.

- [2] Colorectal cancer screening: An updated review of the available options. Iyad A Issa and Malak Nouredine. *World J Gastroenterol*. 2017 Jul 28; 23(28): 5086–5096. doi: 10.3748/wjg.v23.i28.5086.
- [3] Incomplete colonoscopy: Maximizing completion rates of gastroenterologists. Mayur Brahma, MD, Jei Park, MD, Sigrid Svarta, MD, Jessica Tong, BSc, Ricky Kwok, BSc, and Robert Enns, MD. *Can J Gastroenterol*. 2012 Sep; 26(9): 589–592. doi: 10.1155/2012/353457.
- [4] Computed tomographic colonography and conventional colonoscopy for colon diseases: a prospective, blinded study. Giancarlo Spinzi M.D., Gianmarco Belloni M.D., Alberto Martegani M.D., Angelo Sangiovanni M.D., Carlo Del Favero M.D., Giorgio Minoli M.D. *The American Journal of Gastroenterology* Volume 96, Issue 2, February 2001, Pages 394–400.
- [5] Efficacy in standard clinical practice of colonoscopic polypectomy in reducing colorectal cancer incidence. F Citarda, G Tomaselli, R Capocaccia, S Barcherini, M Crespi; Italian Multicentre Study Group. *Gut* 2001 Jun;48(6):812-5. doi: 10.1136/gut.48.6.812.
- [6] Colon cancer screening Randall W. Burt. *GASTROENTEROLOGY* 2000; 119: 837-853 DOI: <https://doi.org/10.1053/gast.2000.16508>.
- [7] CT Colonography and Colorectal Carcinoma: Current Trends and Emerging Developments. Kadari M, Subhan M, Saji Parel N, et al. (May 11, 2022) *Cureus* 14(5): e24916. doi:10.7759/cureus.24916.
- [8] Comparison of CT colonography vs. conventional colonoscopy in mapping the segmental location of colon cancer before surgery Emanuele Neri, Francesca Turini, Francesca Cerri, Lorenzo Faggioni, Paola Vagli, Gabriele Naldini, Carlo Bartolozzi. *Abdom Imaging* 2010 Oct;35(5):589-95. doi: 10.1007/s00261-009-9570-3.
- [9] Comparison of 64-Detector CT Colonography and Conventional Colonoscopy in the Detection of Colorectal Lesions Cigdem Devir, Mahmut Kebapci, Tuncer Temel, and Aysegül Ozakyol. *Iran J Radiol*. 2016 Jan; 13(1): e19518. Published online 2016 Jan 7. doi: 10.5812/iranradiol.19518.

Research article

Investigating the molecular mechanisms of *Ashwagandha* phytochemicals in epilepsy through differential gene expression and pathway analysis

Srivarshini Govinda Srinivasan¹, Susha Dinesh², Sameer Sharma², Bhavana Sunkadakatte Venugopal¹, Martin Lucas A.³, Dinesh Soslagere Manjegowda¹

¹Department of Human Genetics, School of Basic and Applied Sciences, Dayananda Sagar University, Bangalore, 560078, Karnataka, India

²Department of Bioinformatics, BioNome, Bangalore, 560078, Karnataka, India

³Department of Anatomy, Dr. Chandramma Dayananda Sagar Institute of Medical Education & Research, Devarakaggalahalli, Harohalli, Kanakapura Road, Ramanagara Dt., 562 112, Karnataka, India

(Received: May 2023

Revised: August 2023

Accepted: September 2023)

Corresponding author: **Dinesh Soslagere Manjegowda**. Email: dineshmgowda1@gmail.com

ABSTRACT

Introduction and Aim: *Withania somnifera* (*Ashwagandha*) is a traditional Indian herb used in Ayurveda and Unani medicine, particularly in anti-inflammatory, anti-cancer, anti-stress, antioxidant, immune-boosting, and rejuvenating effects. Epilepsy is a severe neuropsychological condition that occurs sporadically and has a long-term effect on the electrical signals that travel between brain cells. The disorder is characterized by recurrent seizures that are brought on by a sudden increase in brain electrical activity. This is the outcome of abnormal neuronal discharges or coordinated neuronal hyperexcitability. The study's main objective is to find out the therapeutic phytochemical in treating Epileptic disorder.

Materials and Methods: This study investigated the potential use of phytochemicals from the *Ashwagandha* plant as epileptic seizure treatments that target key genes strongly associated with the disease. To forecast the binding affinity between the phytochemicals and the receptors, molecular docking simulations (PyRx) were used for the virtual screening.

Results: The preliminary screening of the twenty-two phytochemicals from *Withania somnifera* was based on their affinity for epilepsy. The results showed that withasomnine exhibited great binding affinity to the receptors, indicating their potential as targeted epileptic seizure therapeutics. The ligands revealed stronger binding with the epilepsy targets, and the binding score less than -7 kcal/mol was taken into consideration for further exploration. This research lays the groundwork for upcoming in-vitro and in-vivo studies to confirm the effectiveness of these phytochemicals as cancer therapies.

Conclusion: The results suggest that withasomnine derivatives from *Withania somnifera* could be a promising source of epilepsy therapies.

Keywords: KCNQ2; SCN1A; SCN9A; epilepsy; Ashwagandha root.

INTRODUCTION

Epilepsy is a condition affecting the central nervous system, marked by recurrent episodes of altered consciousness, potentially accompanied by seizures, and linked to unusual electrical activity in the brain. It is regarded as the clinical expression of an abnormal and excessive firing of a specific group of neurons in the brain (1-3). It is one of the most common neurological diseases worldwide, with an estimated 50 million people experiencing it globally. Regular seizures, unconsciousness, panic, jerks, blackouts, spasms, and shaking are typical symptoms of epilepsy (4). The disorder is characterized by recurrent seizures that are brought on by a sudden increase in brain electrical activity. This is the outcome of abnormal neuronal discharges or coordinated neuronal hyperexcitability. However, the incidence of these seizures differs from person to person.

Epileptic seizures, which result in unusually jerky or quivering motions in the body, can injure the brain or

other areas of the body. Even one seizure has the power to impact cognition, behaviour, and brain development. Clinically, seizures from epilepsy are harmful. These seizures negatively influence patients' lives, particularly those who have them regularly (5). Seizures are influenced by a variety of factors, including the site of seizure onset in the brain, patterns of propagation, brain maturity, complicating disease processes, sleep-wake cycle, medications, and a host of other variables (6). Epileptogenesis is the process through which an intact brain becomes capable of generating spontaneous, recurrent seizures. Over time, this disturbs regular neural functioning and might affect other neuronal networks.

It is not necessarily an increase in excitation or a loss of inhibition that causes the imbalance between excitation and inhibition that gives rise to epileptogenic networks; in some circumstances, such as when there are no seizures or limbic epilepsies in the developing brain, an abnormal upsurge in inhibition as well be pro-epileptogenic (7). The

identification of known targets which are available from the 3 databases such as OMIM, GeneCards, and DisGeNET are retrieved and further analysis is carried out to find out the potential targets of epilepsy. *W. somnifera*, often known as ashwagandha, is a traditional Indian herb used in Ayurveda and Unani medicine. Its well-known plant is utilized in conventional medicine and treatments. Steroid alkaloids and steroidal lactones with an ergostane structure (with anolides) are the main components of Ashwagandha extracts from a variety of sections. According to numerous toxicological tests, ashwagandha is a safe herb that can be consumed. Ashwagandha helps the brain and the neurological system work well and boost memory. There are 13 alkaloids in *W. somnifera*'s biochemical makeup. This herb's medical benefit is classified as an adaptogen, which is a nontoxic herb that acts generally to normalize physiological function by affecting the neuroendocrine system and HPA axis.

One of the most effective revitalizing ingredients in Ayurveda is ashwagandha. Ayurvedic and Unani treatments utilize their roots, seeds, and leaves. The medicine made from the ashwagandha root is effective in treating epilepsy, neurological problems, joint inflammation, and rheumatoid arthritis (8). In this present study the 4 major phytocompounds of *W. somnifera* i.e., Ashwagandha act as potential ligands for docking with 3 key potential therapeutic targets of epilepsy.

MATERIALS AND METHODS

Identification of known therapeutic targets acting on epilepsy

The GeneCards, OMIM, and DisGeNET databases were mined for Epilepsy associated target genes. GeneCards(<https://www.genecards.org/>) is accessible via search, comprehensive, user-friendly information on every human gene that has been predicted or annotated is provided by an integrated database. The knowledge base is automatically updated with genomic, transcriptomic, proteomic, genetic, clinical, and functional data from 150 web sources (9). DisGeNET(<https://www.disgenet.org/home/>) is one of these resources, with the goals of covering all disease domains (Mendelian, complex, and environmental disorders), with specific attention to the integration and standardization of data, and enabling free access to knowledge of the genes connected to human diseases (10). OMIM®(<http://omim.org/>), or Online Mendelian Inheritance in Man, is a comprehensive, reliable, and current research tool containing curated descriptions of human genes, phenotypes, and their connections (11).

Identification of common genes

The common genes were identified by Bioinformatics & Evolutionary Genomics Venn Diagram (<https://bioinformatics.psb.ugent.be/webtools/Venn/>)

online tool. The Venn diagram showed common genes between Gene Cards, OMIM, and DisGeNET databases. At the end of the analysis, 28 genes were found common between Gene Cards and DisGeNET databases, and no common genes were found between all three databases. The 28 genes were considered to find the potential target genes through the String database.

PPI network construction and identification of key genes

The STRING database (<https://string-db.org/>) systematically collects and integrates protein–protein interactions, physical interactions, and functional associations (12). The Shiny Go (<http://bioinformatics.sdstate.edu/go/>) database is used to retrieve data about gene enrichment analysis. The preliminary screening of 28 common genes was done using the STRING database to determine the potential targets for the disease. The screening was done using the string database from which 3 genes were found to be the therapeutic targets. The gene enrichment analysis gives us detailed information about the pathways that are involved in each gene.

Ligand retrieval

IMPPAT 2.0 contains curated data on the 17,967 phytocompounds and 1095 therapeutic applications of 4010 Indian medicinal plants (13). PubChem, a well-liked repository of chemical data, is available at <https://pubchem.ncbi.nlm.nih.gov> and has a variety of applications for AI and machine learning research (14). Secondary metabolites of Ashwagandha were derived from IMPPAT (Indian Medicinal Plants, Phytochemistry and Therapeutics) (<https://cb.imsc.res.in/imppat/home>) database. A total of 21 phytocompounds were derived excluding the duplicates and the compounds which had longer phytochemical names, especially from only root sources. The canonical SMILES (Simplified Molecular Input Line Entry System) and the 2D SDF (Standard Data Files) were retrieved from PubChem (<https://pubchem.ncbi.nlm.nih.gov/>) database for further research.

Protein retrieval and purification

In UniProtKB, there are two sets of proteins: UniProtKB/Swiss-Protein which has been verified through experimental methods or computational predictions and summarized in collaboration with experts for each entry; UniProtKB/Tremble which includes primarily computationally annotated entries created automatically (15). RCSB PDB(<https://www.rcsb.org/>) is unrestricted access to almost 200,000 experimentally determined 3D structures of biological macromolecules and their interactions with one another and small molecule ligands that have been persistently archived, thoroughly confirmed, and professionally curated (16). The 3-Dimensional structure of the proteins can be

downloaded from the RCSB PDB database. The crystal structures of KCNQ2 (PDB ID: 7CR1), SCN1A (PDB ID: 7DTD), and SCN9A (PDB ID: 7W9L) were resolved through X-Ray diffraction techniques. The crystal structures were purified in DS Biovia Studio Visualizer by removing the water molecules and heteroatoms. Main protein groups were retained for the current investigation to evade the complexity of the structure which can be viewed in the UniProt (<https://www.uniprot.org/>) database. The structure can be further enhanced by adding polar hydrogen atoms and the purified structure can be used for further study.

Validation of protein structure

Understanding the 3-Dimensional structures for molecular docking is essential as they determine how the interaction occurs between ligands and proteins. Therefore, the purified structures of Epilepsy key genes were validated using the servers PDBsum (<http://www.ebi.ac.uk/thomson-srv/databases/pdbsum/>), ProSA (<https://prosa.services.came.sbg.ac.at/prosa.php>), ProQ (<https://proq.bioinfo.se/ProQ/ProQ.html>).

Pharmacological studies

The process of discovering drugs is an uneven road, filled with challenges that cause a very small number of prospects to move from phytochemical compounds into commercially available products due in part to factors that include low bound affinity, unintended effects, or physicochemical properties like solubility and stability. Early in the drug development process, after hit compounds have been found, features including absorption, distribution, metabolism, excretion, and toxicity (ADMET) should be taken into account and optimized. Small molecules' physicochemical, drug-likeness, and ADMET properties were assessed using the ADMETlab 2.0 webserver (<https://admetmesh.scbdd.com/>) (17). A total of 21 ligands were initially screened for BBB yes and Lipinski is yes in SWISS ADME (<http://www.swissadme.ch/index.php>). After the initial screening, only 4 ligands were used for further investigation in ADMET LAB 2.0, PyRx, and DS Biovia Discovery Studio.

Molecular docking and visualization

In the world of drug development, molecular docking is a precise, efficient, and productive approach that is used to look at the intermolecular interactions that have been established between the candidate medication and the desired protein (18). The present

study has used the virtual screening software PyRx to perform molecular docking of Ashwagandha phytocompounds. The molecular interaction in the binding pocket of the target proteins was further visualized in DS Biovia Discovery Studio Visualizer for the best-docked complexes.

RESULTS

Identification of known therapeutic targets acting on epilepsy

The study's initial methodology used DEGs, but since there were only a few datasets available, additional analysis was conducted. The samples were gathered from the GEO2R database. Later, we retrieved the known therapeutic genes from OMIM, GeneCards, and DisGeNET, three databases. 114 genes from the DisGeNET database, 133 genes from Gene Cards, and 200 genes from OMIM. To look into the potentially significant genes of epilepsy, additional research was done with 447 genes from all three databases where common genes were detected.

Identification of common genes

The common genes identified for Epilepsy using the online tool for Venn diagram between Gene Cards and DisGeNET is 28 genes which are SCN1A, GRIN2A, SCN2A, GABRG2, SCN9A, GABRB3, CNTNAP2, LGI1, KCNQ2, CACNB4, SLC6A1, PIGQ, PCDH1, SCN8A, STX1B, POLG, STXBP1, CDKL5, HCN1, MECP2, PRRT2, ABCB1, SLC12A5, CHD2, NEXMIF, GRIN2B, SYNGAP1, KCND2 genes were further examined for finding the key genes for Epilepsy.

PPI network construction and identification of key genes

Using the string database 3 potential target genes such as KCNQ2, SCN1A, and SCN9A genes were identified at 0.7 confidence by hiding the disconnected nodes from the pathway analysis depicted below in Fig. 1. The functional enrichment analysis for all the genes performed in the database is shown in (Table 1) Gene enrichment analysis is done using the Shiny Go software depicted below in Figs. 2 and 3.

Ligand retrieval

The ligands from Ashwagandha were retrieved from the IMPPAT database and the structure of the ligands which have exhibited better binding with the protein structure of genes associated with epilepsy was used for molecular docking and visualization.

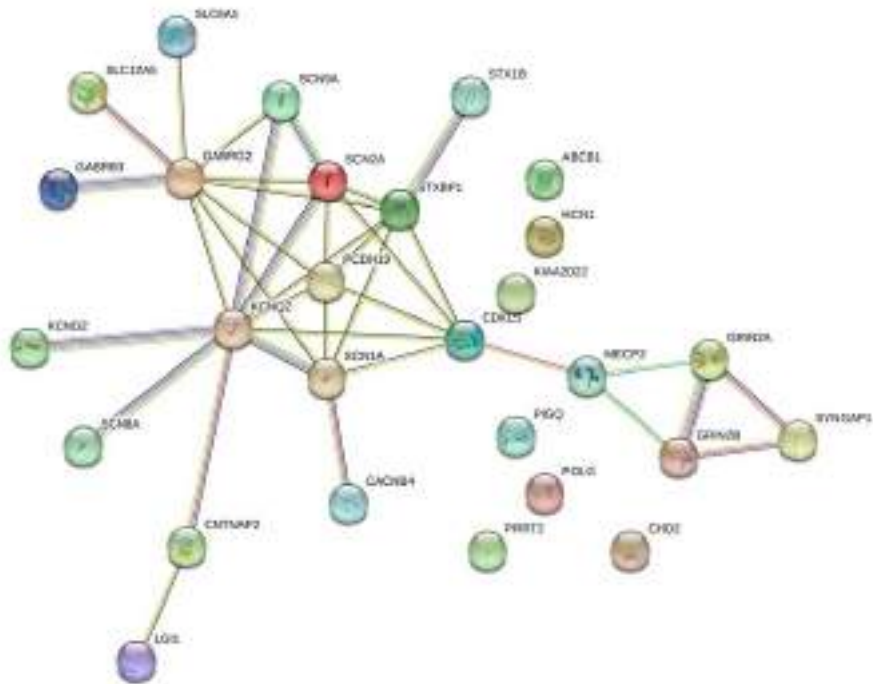


Fig.1: PPI Network Pathway from STRING

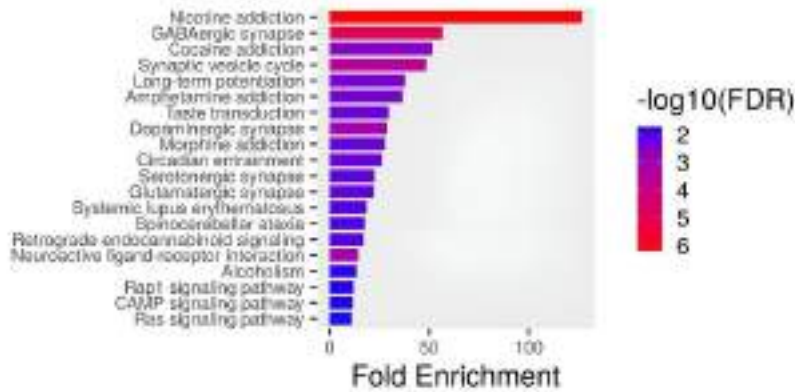


Fig.2: KEGG Fold Enrichment from Shiny GO

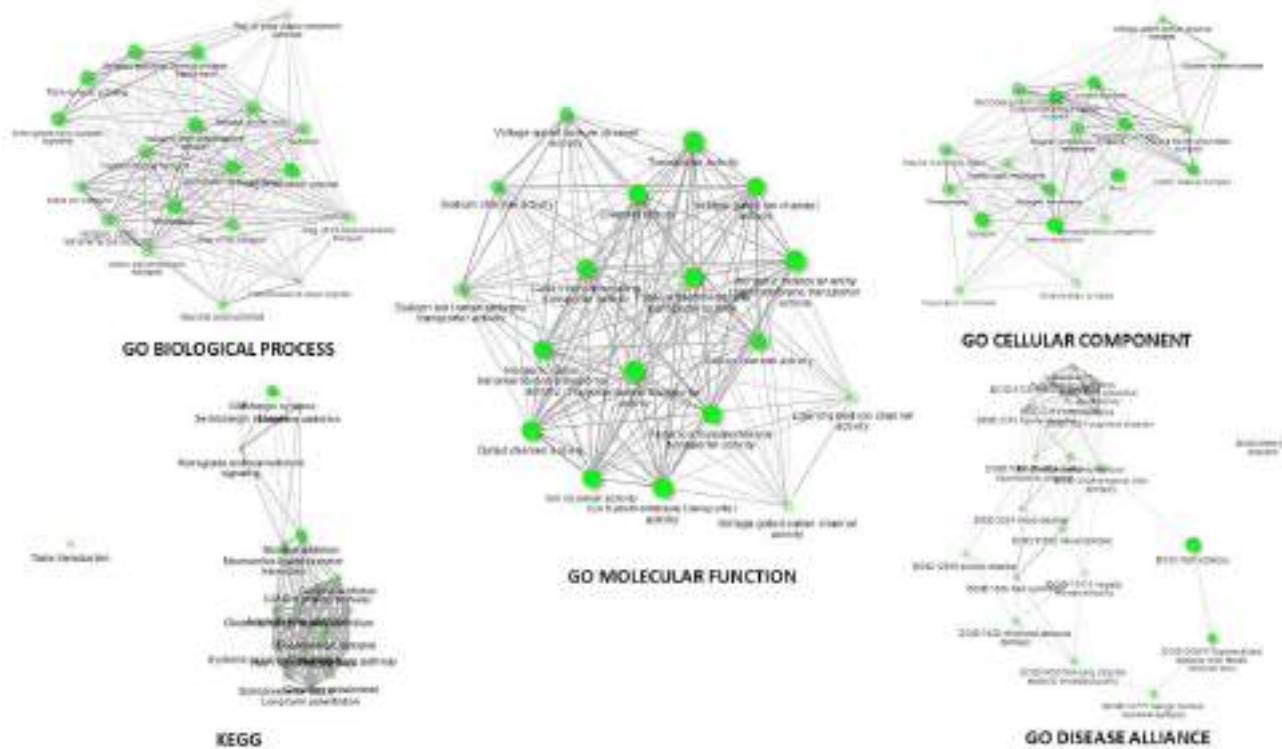


Fig. 3: Pathway database network from Shiny GO

Table 1: Functional enrichment network from string database

	GO-term	Description	Count in Network	Strength	False Discovery Rate
Biological process-gene ontology	GO:0032229	Negative regulation of synaptic transmission	2 of 7	2.3	0.0115
	GO:0010807	GABAergic Regulation of synaptic vesicle priming	2 of 7	2.3	0.0115
	GO:0071420	Cellular response to histamine	2 of 8	2.24	0.0138
	GO:0098976	Excitatory chemical synaptic transmission	2 of 9	2.19	0.0159
	GO:0050884	Neuromuscular process controlling posture	3 of 16	2.12	0.0006
Molecular function-gene ontology	GO:0022849	Glutamate-gated calcium ion channel activity	2 of 5	2.45	0.0044
	GO:0004972	NDA glutamate receptor activity	2 of 7	2.3	0.0071
	GO:0005248	Voltage-gated sodium channel activity	5 of 23	2.18	8.47E-08
	GO:0022851	GABA-gated chloride ion channel activity	2 of 3	2.03	0.0195
	GO:0015377	Cation: chloride symporter activity	2 of 17	1.91	0.0298
Cellular component-gene ontology	GO:0033268	Node of Ranvier	4 of 15	2.27	1.20E-06
	GO:0001518	Voltage-gated sodium channel complex	4 of 17	2.22	1.76E-06
	GO:0017146	NDA selective glutamate receptor complex	2 of 11	2.1	0.0056
	GO:0043194	Axon initial segment	3 of 18	2.07	0.00019
	GO:1902711	GABA-A receptor complex	2 of 13	2.03	0.0072
.	Pathway	Description	Count in Network	Strength	False Discovery Rate
Kegg pathway	hsa05033	Nicotine addiction	3 of 38	1.74	0.009
	hsa04721	Synaptic vesicle cycle	3 of 74	1.45	2.99E-02
	hsa04727	GABAergic synapse	3 of 86	1.39	0.0306
	Disease	Description	Count in Network	Strength	False Discovery Rate
Disease gene association	DOID:0060169	Benign familial infantile epilepsy	3 of 3	2.84	9.90E-06
	DOID:2846	Bruxism	2 of 2	2.84	0.0021
	DOID:2538	Landau-Kleffner syndrome	2 of 2	2.84	0.0021
	DOID:0080422	Dravet syndrome	5 of 6	2.77	5.46E-10
	DOID:0050703	Infancy electroclinical syndrome	5 of 8	2.64	1.34E-09

Validation of protein structure

By predicting how ligands will interact with target proteins, molecular docking can identify potential therapeutic possibilities. Therefore, the following analysis was used to verify the pure protein structures where all the structures had residues has more than 90% Ramachandran most favoured regions, and Z-scores for all the Epilepsy key genes were found to be within the range of their native proteins, thereby confirming the protein models used are high quality and these structures were further considered for docking.

Molecular docking

The docking in PyRx takes the ligands to be flexible and the macromolecules to be rigid. The binding affinity at zero RMSD serves as a measure of the ligand's effectiveness. In the present research as the ligands demonstrated better binding with the epilepsy targets, a binding score less than -7.7 was considered for further investigation (Table 2). It was found that withasomnine has a better binding with all the target epilepsy genes.

Table 2: Binding affinity of *Withania somnifera* phytochemicals with target epilepsy genes

NO.	LIGAND	PUBCHEM ID	KCNQ2	SCN1A	SCN9A
1	Withasomnine	442877	-7.2	-7.7	-7.7
2	Nicotine	89594	-6.3	-5.9	-5.6
3	Anahygrine	12306778	-6.7	-6.1	-6.3
4	Cuscohygrine	1201543	-6.6	-5.5	-5.5

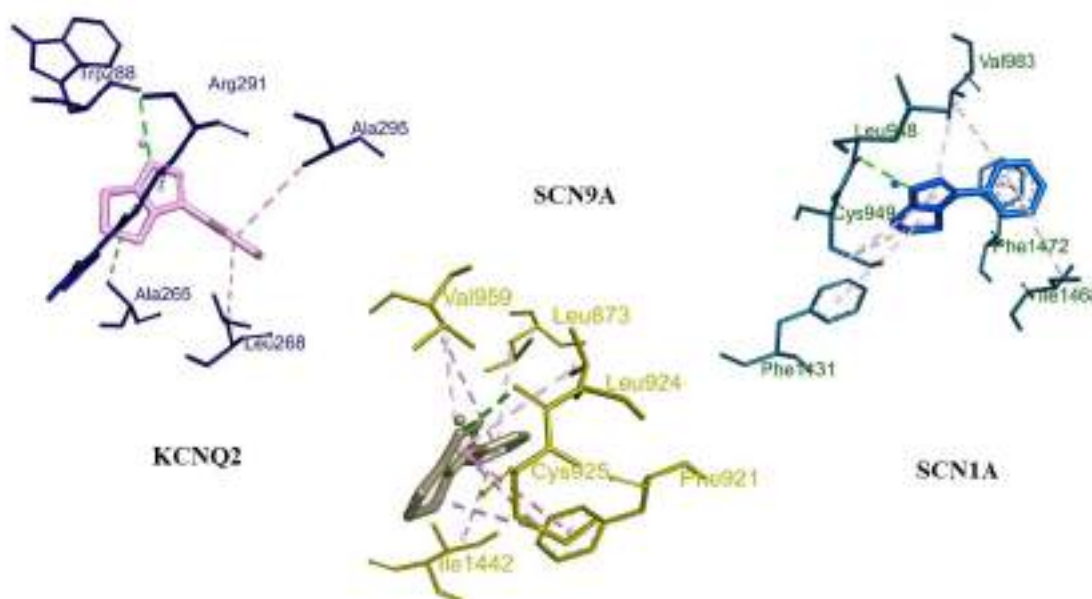


Fig. 4: Molecular interaction between key genes and ligands

Visualization

The binding affinity, RMSD/ub, and r/lb were measured after our ligands docked with the intended proteins. The 4 ligands that demonstrated the best binding in DS Biovia Discovery Studio Visualizer for each protein namely KCNQ2, SCN1A, and SCN9A were visualized, and the ligand as seen in Fig. 4.

Pharmacological studies

The ADMET qualities of *Withania somnifera* phytocompounds are researched since the bioactive compounds ought to have favourable drug-like effects. The Absorption and distribution (Table 3), medicinal chemistry and excretion metabolism properties (Table 4), and toxicity qualities (Table 5) of the four ligands that were evaluated using docking were examined. It is clear from the phrenological evaluation that every substance had beneficial pharmacological qualities.

Table 3: Absorption and distribution properties of *Withania somnifera* phytocompounds

Sl. No	PubChem CID	Caco-2 Permeability	Pgp-inhibitor	Pgp-substrate	HIA	VD	BBB Permeation
1	442877	-4.517	0.163	0.001	0.003	1.872	0.96
2	89594	-4.299	0	0.003	0.005	2.774	0.968
3	12306778	-4.79	0.431	0.012	0.093	1.129	0.517
4	1201543	-4.687	0.059	0.011	0.069	1.271	0.693

Caco-2: Caco-2 Permeability; Pgp inh/ Pgp-sub: the inhibitor and substrate of P-glycoprotein; HIA: Human intestinal absorption; BBB: Blood-brain barrier; VDss: Volume Distribution; Fu: fraction unbound in plasma; CL: Clearance rate; T1/2: Half-life of the small molecules.

Table 4: Medicinal and excretion metabolism properties *Withania somnifera* phytocompounds

Sl. No	PubChem CID	QED	SA Score	Lipinski rule	PAINS	CL	T (1/2)
1	442877	0.665	2.275	Accepted	0	10.351	0.195
2	89594	0.626	2.5	Accepted	0	15.401	0.672
3	12306778	0.787	3.398	Accepted	0	9.066	0.528
4	1201543	0.723	3.356	Accepted	0	10.62	0.746

QED: A measure of drug-likeness based on the concept of desirability; PAINS: Pan Assay Interference Compounds; Lipinski Rule of 5: Molecular weight less than 500 Daltons, nHD<5, nHA<10, and lipophilicity<4.15; SAScore: Synthetic accessibility score were accounted; CL: Clearance rate; T1/2: Half-life of the small molecules.

Table 5: Toxicity properties of *Withania somnifera* phytochemicals

No	PubChem CID	hERG	DILI	AMES Toxicity	Carcinogenicity	IGC50	LC50 FM
1	442877	0.028	0.701	0.808	0.768	3.426	4.461
2	89594	0.049	0.04	0.013	0.235	2.486	3.024
3	12306778	0.049	0.044	0.263	0.635	2.081	2.378
4	1201543	0.088	0.038	0.114	0.821	2.191	2.459

hERG: The human ether-a-go-go related gene; DILI: Drug-induced liver injury; AMES: The Ames test for mutagenicity; LC50 FM: 96-hour fathead minnow LC₅₀ were examined; IGC50: Tetrahymena pyriformis 50 percent growth inhibition concentration.

DISCUSSION

Epilepsy is one of the most prevalent neurological conditions. Epilepsy has a wide range of clinical traits and substantial genetic variation. To maintain a child's quality of life and enable unhindered development, quick diagnosis, and suitable treatment are crucial. Childhood epilepsy frequently affects young individuals. The development and increased accessibility of advanced genomic techniques in the last ten years has caused a significant change in etiological diagnosis of epilepsy. Daily increases in the number of causative genes have increased diagnostic yield. The yield of diagnostic tests has increased as a result of the daily increase in the number of causative genes. Epileptic key genes KCNQ2, SCN1A, and SCN9A have a strong association with the disease. The central nervous system (CNS) expresses the transmembrane protein Kv7.2 (encoded by KCNQ2), which joins forces with Kv7.3 to produce hetero-multimeric channels. Together with the KCNQ3 subunit, KCNQ2 encodes a voltage-gated potassium channel subunit that can create neuronal M channels that transport slowly activating and non-inactivating potassium currents. These currents control the excitability of central and peripheral neurons and contribute to the resting membrane potential. Myokymia, benign new-born seizures, and epileptic and developmental encephalopathies are all brought on by KCNQ2 mutations. Through the production of NaV1.1 in inhibitory interneurons, the SCN1A gene, which has a high association with epilepsy, contributes significantly to maintaining the cortical excitation-inhibition balance. The SCN1A and SCN9A mutations cause shortened sodium channels, which change how depolarizing impulses are transmitted across the neurons (19).

Ashwagandha, also known as *W. somnifera*, has been used for millennia to treat a variety of health issues. This herbal supplement's numerous health advantages make it the ideal rejuvenator of mental and physical wellness (20). Numerous studies have examined the efficacy and safety of *W. somnifera* extract, which have revealed that it is safe for use by people of all ages, including those who are pregnant (21). According to a study, *W. somnifera* have anticonvulsant characteristics when used with the GABAergic regulation of the pentylenetetrazol (PTZ)

seizure threshold paradigm. PTZ threshold rises in response to *W. somnifera*. The seizure threshold was raised when *W. somnifera* was also administered with GABA or benzodiazepines. *W. somnifera* elevates the seizure threshold via activating chloride channels, which alters the GABA receptor's activity and interferes with it. Therefore, the GABAergic neurotransmitter system is most likely the main mechanism by which the *W. somnifera* root extract raises the threshold of PTZ-induced seizure. Co-administration of *W. somnifera* and flax seed oil significantly shortens the convulsion phase in rats experiencing MES seizures. *W. somnifera* aqueous seed extracts have anticonvulsant activities by changing the levels of dopamine and serotonin in the hippocampus of pilocarpine-induced rat models (22). In recent decades, researchers and pharmaceutical companies have developed several methods for extracting natural chemicals that have been successfully utilized to treat epileptic seizures in preclinical animal models, including extracts, essential oils, and purified natural compounds. These discoveries, meanwhile, are still in their infancy, and further study is necessary before these medicines can be put on the market. These findings offer great hope for the management of cases of medication resistance in the treatment of epilepsy (23). As a result, because important genes play crucial functional roles in epilepsy, these were evaluated as possible targets in the current investigation. It was discovered that the phytochemicals from *Withania somnifera*, such as Withasomnine (442877), Nicotine (89594), Anahygrine (12306778), and Cuscohygrine (1201543), were among the top phytochemicals that had shown improved binding (Table 2 & Fig. 4) and beneficial pharmacological properties (Tables 3-5) with the target protein. Withasomnine was the main class of phytochemicals from *Withania somnifera* that effectively suppressed epilepsy genes. The substance withasomnine demonstrated substantially stronger inhibition than the other compounds, according to the findings of the current investigation.

CONCLUSION

Potential treatment targets include KCNQ2, SCN1A, and SCN9A because of their significant contributions to epileptic disease. Different forms of epileptic seizures may result from any changes to these essential genes. Through accurate and thorough

analyses of disease-gene-target-drug interaction networks, we were able to pinpoint many biological processes and molecular functions of epilepsy. *Withania somnifera* Dunal, also referred to as ashwagandha, is a key component of the traditional Indian medical system known as Ayurvedic medicine. Ashwagandha is one of Ayurveda's most potent revitalizing components. Their roots, seeds, and leaves are used in Ayurvedic and Unani remedies. Ashwagandha root extract is a potent remedy for rheumatoid arthritis, epilepsy, neurological conditions, and joint inflammation. According to a recent study, withasomnine has the potential to treat epilepsy and related illnesses while also acting as a potential anti-epileptic drug. To fully understand its mechanisms of action and potential clinical applications, more research is needed.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

- Mayuri, B., Kumar, D.S., Kishore, P. A Review on epilepsy. *Journal of Medical Science and Clinical Research*. 2019; 7(3):1362-1369.
- Raju, G.P., Dwajani, S., Rajendran, K., Adarsh, E. A study of rationale use of sodium valproate and levetiracetam as monotherapy in pediatric patients with epilepsy at tertiary care hospital. *Biomedicine*. 2022 Mar 5;42(1):160-164.
- Mahmood, I.A., Muslim, A.T., Kaddoori, H.G. The utility of hematological indices in differentiation between general and focal onset epilepsy. *Biomedicine*. 2022 Mar 5;42(1):64-71.
- Mishra, A., Batham, L., Verma, S., Mishra, S., Shrivastava, V. Management of epileptic seizures through an integrated approach including yagya therapy. *Interdisciplinary Journal of Yagya Research*. 2019;2(1):52-64.
- Beghi, E. The epidemiology of epilepsy. *Neuroepidemiology*. 2020;54(2):185-191.
- Bonilla-Jaime, H., Zeleke, H., Rojas, A., Espinosa-Garcia, C. Sleep disruption worsens seizures: neuroinflammation as a potential mechanistic link. *International Journal of Molecular Sciences*. 2021;22(22):12531.
- Thijs, R.D., Surges, R., O'Brien, T.J., Sander, J.W. Epilepsy in adults. *The Lancet*. 2019;393(10172):689-701.
- Yang, L., Wang, Y., Chen, X., Zhang, C., Chen, J., Cheng, H., et al., Risk factors for epilepsy: A national cross-sectional study from National Health and Nutrition Examination Survey 2013 to 2018. *International Journal of General Medicine*. 2021;14:4405-4411.
- Safran, M., Rosen, N., Twik, M., BarShir, R., Stein, T.I., Dahary, D., et al., The GeneCards Suite. *Pract. Guid. Life Sci*. 2021;Databases 1, 27–56. https://doi.org/10.1007/978-981-16-5812-9_2.
- Piñero, J., Ramírez-Anguita, J.M., Saüch-Pitarch, J., Ronzano, F., Centeno, E., Sanz, F., et al., The DisGeNET knowledge platform for disease genomics: 2019 update. *Nucleic acids research*. 2020;48(D1):D845-D855.
- Hamosh, A., Amberger, J.S., Bocchini, C., Scott, A.F., Rasmussen, S.A. Online Mendelian inheritance in man (OMIM®): Victor McKusick's magnum opus. *American Journal of Medical Genetics Part A*. 2021;185(11):3259-3265.
- Szklarczyk, D., Kirsch, R., Koutrouli, M., Nastou, K., Mehryary, F., Hachilif, R., et al., The STRING database in 2023: protein–protein association networks and functional enrichment analyses for any sequenced genome of interest. *Nucleic Acids Research*. 2023;51(D1):D638-D646.
- Kim, S., Chen, J., Cheng, T., Gindulyte, A., He, J., He, S., et al., PubChem 2023 update. *Nucleic Acids Research*. 2023; 51(D1):D1373-D1380.
- Vivek-Ananth, R.P., Mohanraj, K., Sahoo, A.K., Samal, A. IMPPAT 2.0: an enhanced and expanded phytochemical atlas of Indian medicinal plants. *ACS Omega*. 2023;8(9):8827-8845.
- UniProt Consortium. UniProt: The universal protein knowledgebase in 2023. *Nucleic Acids Res*. 2023;51(D1): D523-D531.
- Burley, S.K., Bhikadiya, C., Bi, C., Bittrich, S., Chao, H., Chen, L., et al., RCSB Protein Data Bank (RCSB. org): Delivery of experimentally-determined PDB structures alongside one million computed structure models of proteins from artificial intelligence/machine learning. *Nucleic Acids Research*. 2023;51(D1):D488-D508.
- Chang, Y., Hawkins, B.A., Du, J.J., Groundwater, P.W., Hibbs, D.E., Lai, F. A Guide to *in silico* drug design. *Pharmaceutics*. 2023;15(1):49.
- Er-rajiy, M., Imtara, H., Noman, O.M., Mothana, R.A., Abdullah, S., Zerougui, S., et al., QSAR, ADME-Tox, molecular docking and molecular dynamics simulations of novel selective glycine transporter type 1 inhibitor with memory enhancing properties. *Heliyon*. 2023;9(2): e13706.
- Blazekovic, A., Gotovac, Jercic, K., Meglaj, S., Duranovic, V., Prpic, I., Lozic, B., et al., Genetics of pediatric epilepsy: Next-Generation Sequencing in Clinical Practice. *Genes*. 2022; 13(8):1466.
- Umadevi, M., Rajeswari, R., Rahale, C. S., Selvavenkadesh, S., Pushpa, R., Kumar, K. S., et al., Traditional and medicinal uses of *Withania somnifera*. *The Pharma Innovation*.2012; 1(9):102-110.
- Mandlik, D.S., Namdeo, A.G. Pharmacological evaluation of Ashwagandha highlighting its healthcare claims, safety, and toxicity aspects. *Journal of Dietary Supplements*. 2021;18(2):183-226.
- Bhat, J.A., Akther, T., Najar, R.A., Rasool, F., Hamid, A. *Withania somnifera* (L.) Dunal (Ashwagandha); current understanding and prospect as a potential drug candidate. *Frontiers in Pharmacology*. 2022;13:1029123.
- Pina, L.T., Guimarães, A.G., Sampaio, L.A., Guimarães, J.O., Rabelo, T.K., Savi, F.M., et al., Plant-based pharmacological alternatives in the seizure treatment: A patent review. *Research, Society, and Development*.2022;11(2): e40411225940.



National Board of Examination - Journal of Medical Sciences
Volume 2, Issue 4, Pages 307–322, April 2024
DOI 10.61770/NBEJMS.2024.v02.i04.004

ORIGINAL ARTICLE

Anatomy as a Basic Medical Science: Perceptions of Allied Health Science Students in an Indian Medical School

Uma SV¹, Anitha Misquith², Anisha B³, Mahesh Chaulagain⁴, Lalita Shrestha⁴ and Harish Rangareddy^{5,*}

¹Professor, Department of Anatomy, Sri Madhusudan Sai Institute of Medical Sciences and Research, Muddenahalli, Sathya Sai Grama, Chikkaballapur, Karnataka-562101, India

²Assistant Professor, Department of Biochemistry, Sapthagiri institute of Medical Sciences and Research Centre, Hesarghatta main road, Bangalore, Karnataka-560090

³Associate Professor, Department of Anatomy, Dr. Chandramma Dayanand Sagar Institute of Medical Education and Research, Dayanand Sagar University, Harohalli, Bangalore, Karnataka-562112, India

⁴Medical Lab Technologist, Department of Biochemistry, Sapthagiri Institute of Medical Sciences and Research Centre, Hesarghatta Main road, Bangalore, Karnataka-560090, India

⁵Assistant Professor, Department of Biochemistry, Haveri Institute of Medical Sciences, Haveri, Karnataka-581110

Accepted: 06-February-2024 / Published Online 31-March-2024

Abstract

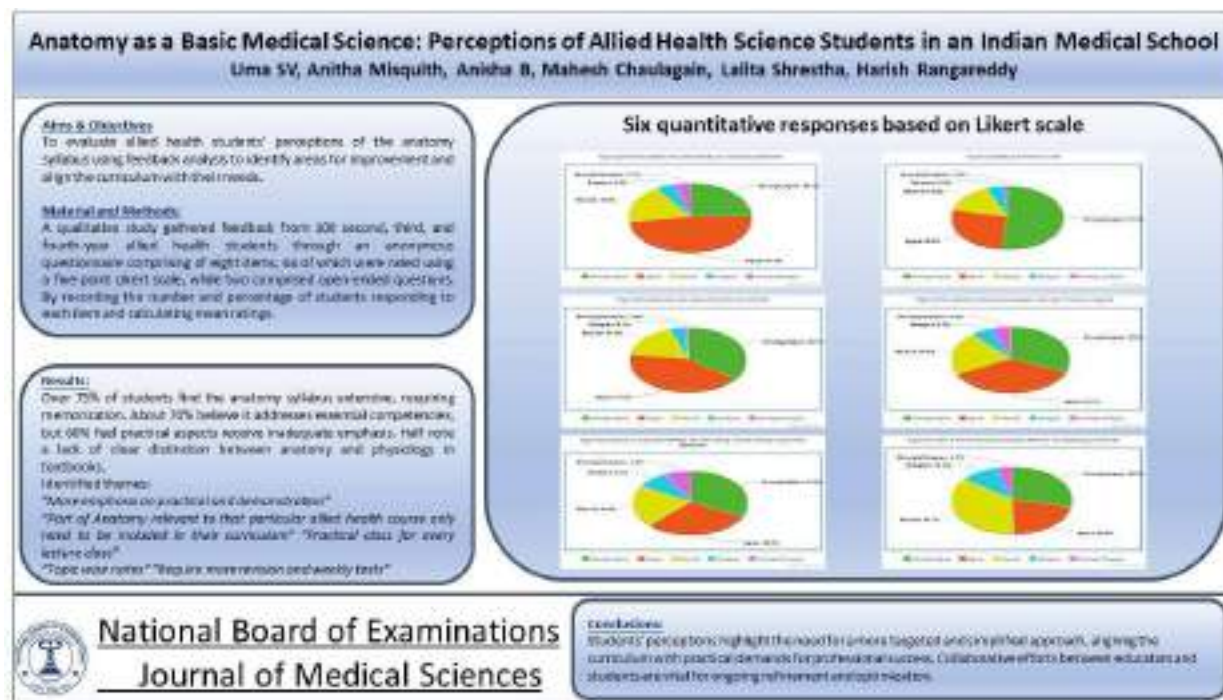
Introduction: Anatomy courses in health science disciplines, including allied health programs, face criticism for being extensive and lacking focus on career-relevant competencies. **Objectives:** To evaluate allied health students' perceptions of the anatomy syllabus using feedback analysis to identify areas for improvement and align the curriculum with their needs. **Methods:** A qualitative study gathered feedback from 100 second, third, and fourth-year allied health students through an anonymous questionnaire comprising of eight items, six of which were rated using a five-point Likert scale, while two comprised open-ended questions. By recording the number and percentage of students responding to each item and calculating mean ratings. **Results:** Over 75% of students find the anatomy syllabus extensive, requiring memorization. About 70% believe it addresses essential competencies, but 60% feel practical aspects receive inadequate emphasis. Half note a lack of clear distinction between anatomy and physiology in textbooks. **Conclusion:** Tailoring the anatomy syllabus to specific allied health courses is crucial, focusing on appropriateness, conciseness, and well-defined learning outcomes. Students' perceptions highlight the need for a more targeted and simplified approach, aligning the curriculum with practical demands for professional success. Collaborative efforts between educators and students are vital for ongoing refinement and optimization.

Keywords: Anatomy, allied health occupations, educational needs assessment

*Corresponding author: Harish Rangareddy

Email: harishreddy1349@gmail.com

Graphical Abstract



Introduction

Anatomy holds a pivotal position as a foundational basic science course in the realm of health science disciplines [1]. Frequently perceived as a subject inundated with factual information and terminologies requiring rote memorization, its true value comes to light when applied in a clinical context, making clinical exposure a driving force for motivation [1, 2]. During the initial year of health science studies, the extent of students' engagement with the subject is often influenced by the evaluation process, while the realization of its true significance occurs when anatomy is integrated into the understanding and management of diseased conditions within the realm of healthcare practice [2]. The existing literature also highlights a common perception among allied health students that anatomy is learned solely for examination purposes, leading to

concerns regarding retention and application of the acquired knowledge in their respective fields. Furthermore, a lack of confidence is observed in applying anatomical knowledge to practical situations within their professional practice [3].

Allied health sciences (AHS) students express that human anatomy and physiology are perceived as challenging due to the use of scientific language and the incorporation of numerous new terminologies, leading to content overload [4]. Similarly, medical students also regard anatomy as a subject with an extensive syllabus, yet essential for its significant clinical applications. In a study by Gupta S et al, a more streamlined approach to the anatomy curriculum in MBBS, focusing on general concepts to impart a functional understanding of the subject is advocated [5]. This embeds the perception of

information overload among medical and AHS students leading them to view anatomy as an extensive and demanding discipline.

Noteworthy is the distinctive significance of anatomy among the basic sciences, as it presents unique advantages by providing visual cues for effective learning and facilitating the establishment of connections between theoretical knowledge and practical application, particularly in clinical practice, thereby proving advantageous for students [6]. However, the lack of integration between basic medical sciences and clinical practice during the educational process may pose a challenge to the relevance of these subjects. Consequently, achieving proficiency in basic medical science knowledge becomes imperative as it serves as a fundamental prerequisite for augmenting the understanding of clinical medicine and optimizing the overall learning experience [7].

Despite the significance of anatomy as a foundational course in allied health science programs, there exists a prevailing opinion among different stakeholders that the syllabus is excessively extensive and lacks the necessary focus on competencies essential for their careers. Additionally, practical anatomy sessions that form core competency are found to be insufficiently emphasized within the curriculum. A notable trend in basic medical science subjects reveals a relatively higher frequency of failures in anatomy compared to other disciplines.

In light of these concerns, our study aims to gain insight into the perceptions of allied health science (AHS) students

regarding various aspects of anatomy as a fundamental medical science. Through an assessment of students' feedback and perceptions, this research endeavors to improve the anatomy curriculum, enhancing the overall learning experience in medical education. Understanding students' perspectives on the anatomy learning process is vital for identifying areas that require improvement and exploring opportunities to make the instruction more effective and relevant. By gathering and carefully analyzing student feedback, we can identify the strengths and weaknesses of the current anatomy education approach and develop strategies to optimize the efficacy of anatomy instruction. Through these endeavors, we can bridge the gap between the curriculum and students' needs, ensuring a comprehensive and enriching educational experience in the realm of allied health science programs.

Methods

Study design: Cross Sectional descriptive study including both quantitative as well as qualitative components.

Setting: The study was carried out at Sapthagiri Institute of Medical Sciences & Research Center, a tertiary health care and a teaching hospital in urban South India under Rajiv Gandhi University of Health Sciences in 2019.

Participant and sampling: The allied health sciences students were informed in person about the study purpose with a description by the researchers. To increase the heterogeneity of the sample second, third year students and interns of AHS were sampled purposively. Sample size (n) for the

survey was calculated with the following equations: $x = Z (c/100)^2 r (100-r)$ and $n = N x / ((N-1) E^2 + x)$, where N is the population size, E is the margin of error (10%), r is the fraction of responses (50%), and $Z (c/100)$ is the critical value for the confidence level c (5%). The estimated student population of Sapthagiri Institute of Medical Sciences at the time of conduct of study was >1000. We initially assumed a margin of error of 10%. The margin of error (E) was calculated with the following equations: $x = Z (c/100)^2 r (100-r)$ and $E = \text{Sqrt} \left[\frac{(N-1)x}{n} \right]$, where N is the population size, r is the fraction of responses that we were interested in, and $Z (c/100)$ is the critical value for the confidence level c . Sample size obtained was 96 which was rounded off to 100. The AHS students from specific undergraduate programs falling under the umbrella of allied health students viz., cardiac care technology, perfusion technology, respiratory care technology, imaging technology, medical laboratory technology, anaesthesia technology, operation technology and renal dialysis were included. While the paper provides a general context of allied health science programs, specifying individual programs was avoided to maintain a broader focus on the overall perception of anatomy education among allied health students and moreover all these programs had the same curriculum.

Data collection tool: A structured questionnaire was used for data collection. The questionnaire (Table 1) has eight items, of that six using the Likert five-point grading scale with a maximum of 5 and a minimum of 1 with a range of score of 0.8 and two open ended questions. The items of

the questionnaire were adapted based on previous literature [5]. Pilot testing of the questionnaire was done on the first group of twenty students. The internal reliability of the questionnaire was found to be satisfactory (Cronbach's alpha of 0.70).

Prior to participating in the study, students were comprehensively briefed about the objectives, methodology, and the nature of the questionnaire. The importance of honest and thoughtful responses was emphasized. This ensured that participants had a clear understanding of the study's purpose and the significance of their contributions. The inclusion of informed participants adds validity to the gathered feedback.

After obtaining ethical clearance from the institutional ethics committee of Sapthagiri Institute of Medical Sciences and Research Center, the cross sectional descriptive study with convenient sampling methodology was conducted. A total of 100 students including the second year, third year students and the fourth year interns of allied health science courses have been included in the study as convenient sampling method during the mid of 2019. The First year AHS students who were studying anatomy as one of their first year subjects and the students who had not passed Anatomy exam till august 2019 were excluded from the study. The second year ($n=40$), third year ($n=35$) students and interns ($n=25$) were included as they have completed anatomy and are engaged in their clinical posting, so they are more aware about the anatomy syllabus which they learnt and its application in clinical side. Among the 100 students, girls were 54

(n=54) and boys were 46 (n=46) and their age ranges from 19 to 24 years.

Steps were taken to ensure that the researchers involved in the subject selection process remained impartial and did not introduce personal biases. This involved having a separate team responsible for participant questionnaire administration and data collection, which was not part of the study.

Data analysis: The number and percentage of students responding to each item noted. SPSS version 16 software was used for calculation of the mean rating for

each item and then tabulated. For the quantitative section, descriptive calculations of frequency and percentage were done, and for the open ended questions section, an inductive approach was used; themes were extracted by analyzing the content of participants' opinions.

Results

Among the hundred students invited to participate, ninety-seven successfully completed the questionnaire, as shown in Table 1.

Table 1. Questionnaire and responses of the participants

Sl. No.	Item Please respond to the following Course: Year:	Strongly agree N (%)	Agree N (%)	Neutral N (%)	Disagree N (%)	Strongly disagree N (%)
1.	Syllabus in anatomy is too vast	50 (51.54)	26 (26.8)	15 (15.46)	5 (5.15)	1 (1.03)
2.	Is anatomy syllabus focused toward your required competencies?	24 (24.74)	46 (47.42)	18 (18.56)	5 (5.15)	4 (4.1)
3.	More of factual information in subject to remember	35 (36.08)	40 (41.23)	17 (17.52)	4 (4.1)	1 (1.03)
4.	Re- emphasis of anatomy knowledge in latter part of course is required	31 (31.96)	34 (35.05)	21 (21.65)	6 (6.18)	5 (5.15)
5.	Emphasis in practical knowledge like slide making, surface marking of blood vessels are given least importance	32 (32.99)	28 (28.87)	21 (21.65)	9 (9.27)	7 (7.21)
6.	There is lack of clear cut demarcation between anatomy and physiology in their textbooks	28 (28.87)	20 (20.61)	35 (36.08)	10 (10.30)	4 (4.1)
	Open ended questions 1. Mention two methods you prefer to learn anatomy 2. Give two reason for more failures in anatomy					

The findings of the six quantitative responses based on Likert scale are as follows

1. Syllabus in anatomy is too vast

This item has a majority in the Agree category (51.54% Strongly Agree, 26.8% Agree). It suggests that a significant portion of respondents feel the syllabus is indeed vast as shown in Figure 1.

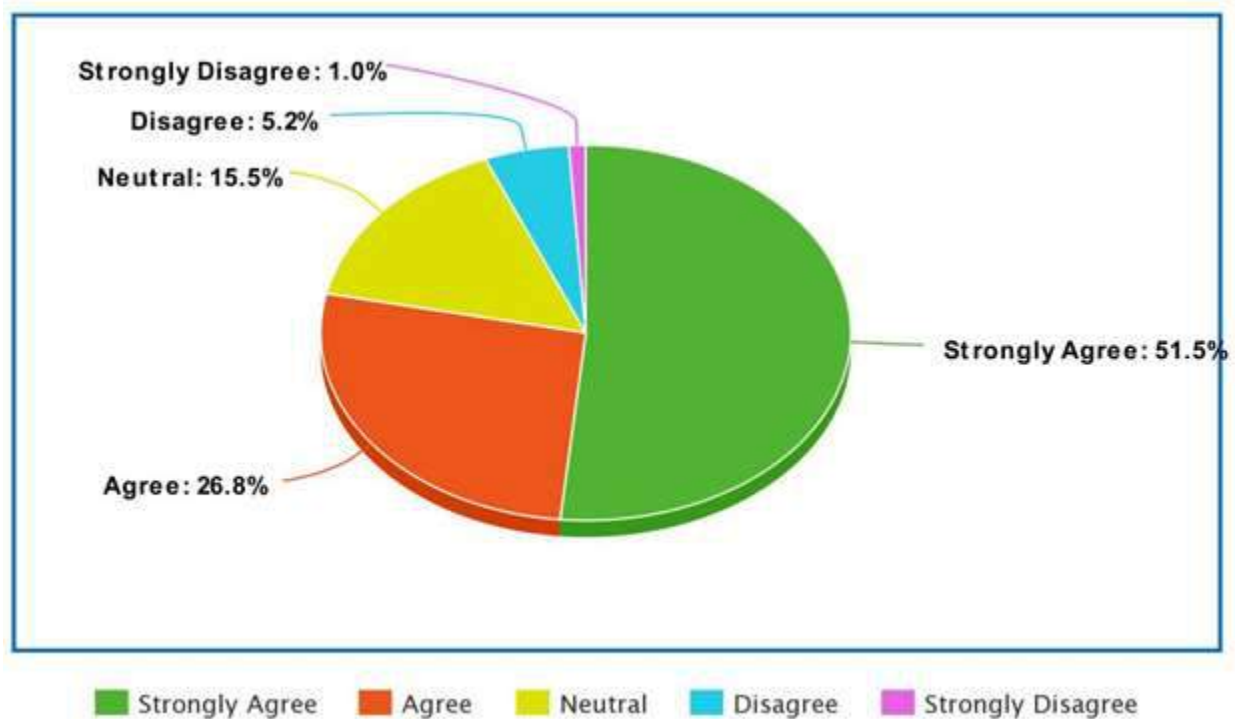


Figure 1. Syllabus of anatomy is vast

2. Is anatomy syllabus focused toward your required competencies?

A majority here as well in the Agree category (24.74% Strongly Agree, 47.42% Agree), indicating that respondents generally feel the syllabus is focused on required competencies depicted in Figure 2.

3. More of factual information in the subject to remember:

The majority falls in the Agree category (36.08% Strongly Agree, 41.23% Agree), suggesting agreement that the subject contains a significant amount of factual information revealed in Figure 3.

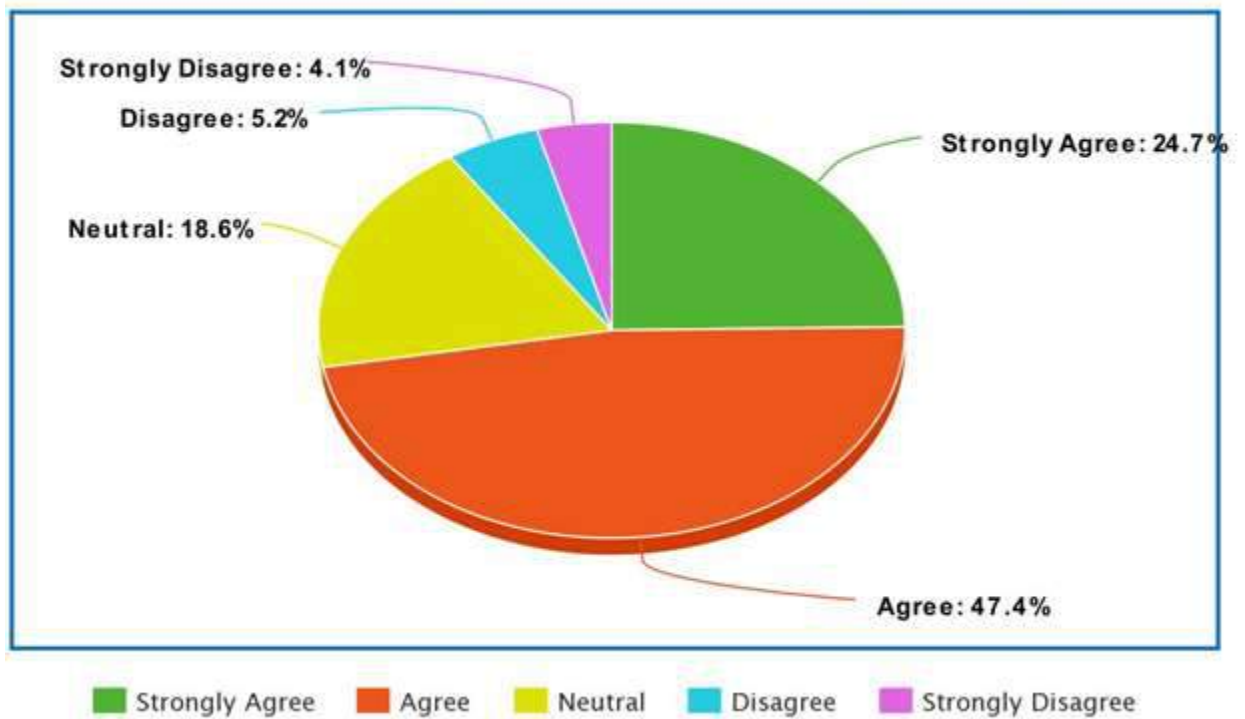


Figure 2. Anatomy syllabus is focused towards your required competencies

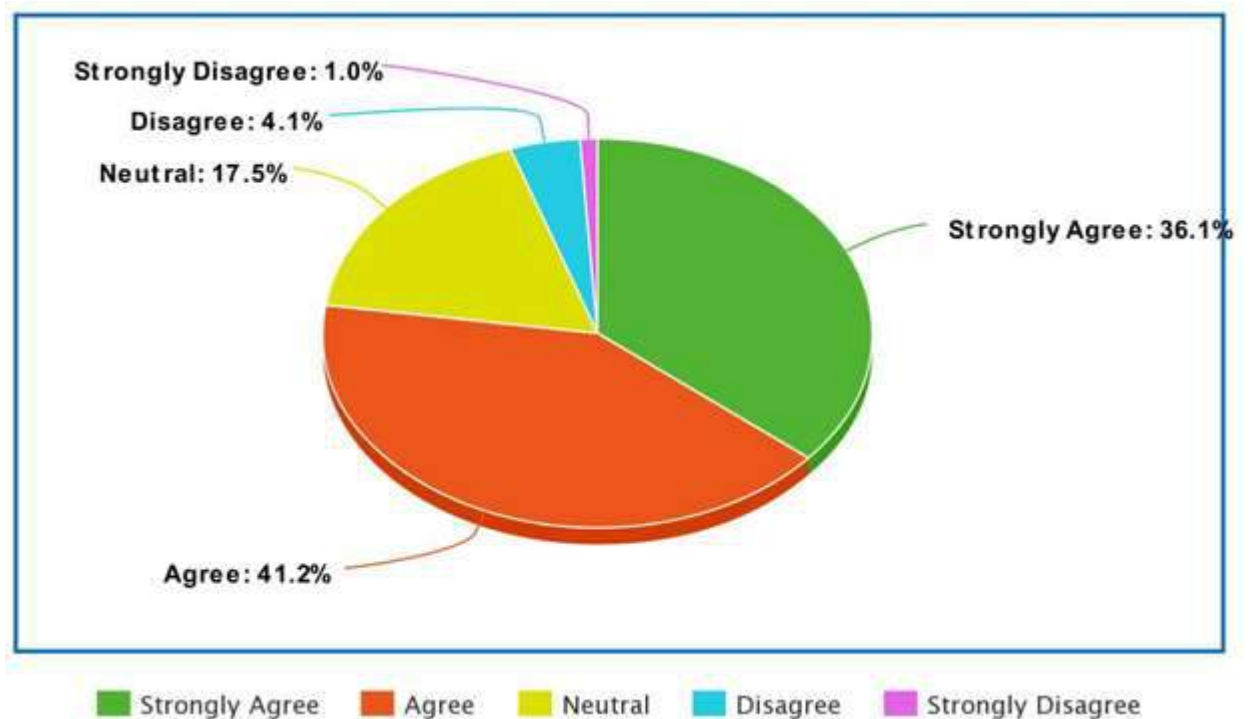


Figure 3. Anatomy has more factual information to remember

4. Re-emphasis of anatomy knowledge in the latter part of the course is required:

Responses are spread, but a substantial portion agrees (31.96%

Strongly Agree, 35.05% Agree) that re-emphasis in the latter part of the course is needed as shown in Figure 4.

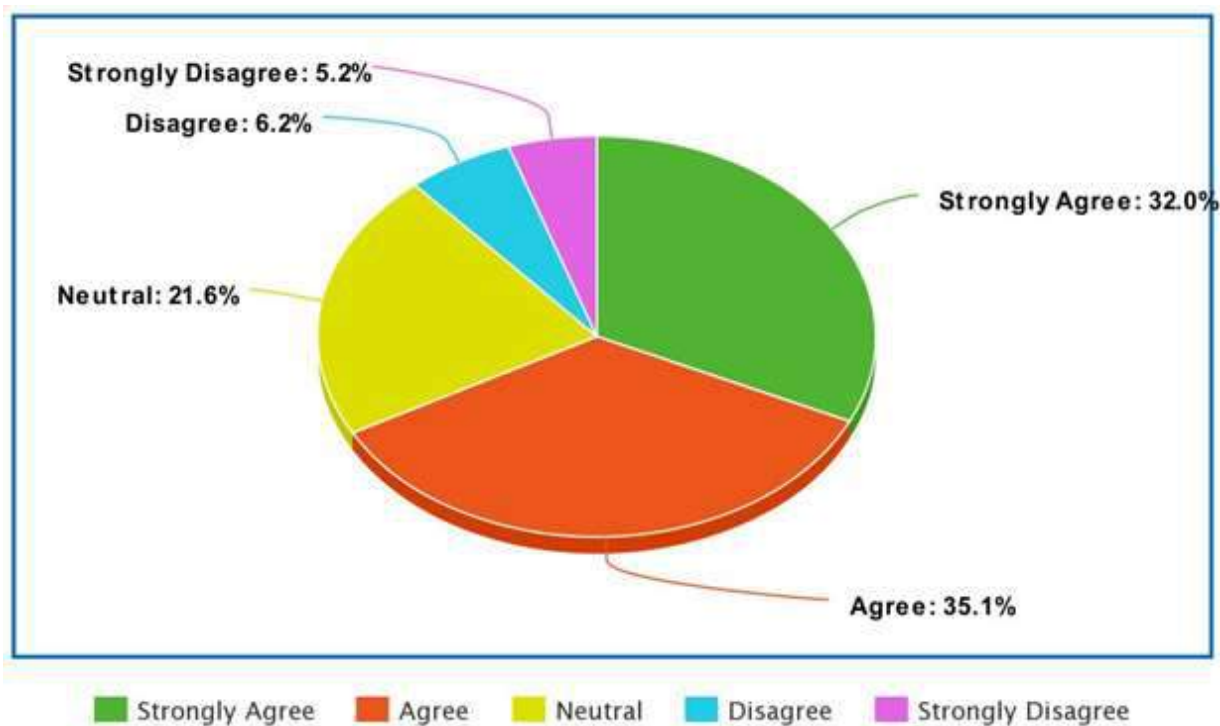


Figure 4. Re-emphasis of anatomy knowledge in later part of course is required.

5. Emphasis in practical knowledge like slide making, surface marking of blood vessels are given least importance:

There is a mixed response, but a considerable portion agrees

(32.99% Strongly Agree, 28.87% Agree) that practical knowledge is given less importance as depicted in Figure 5.

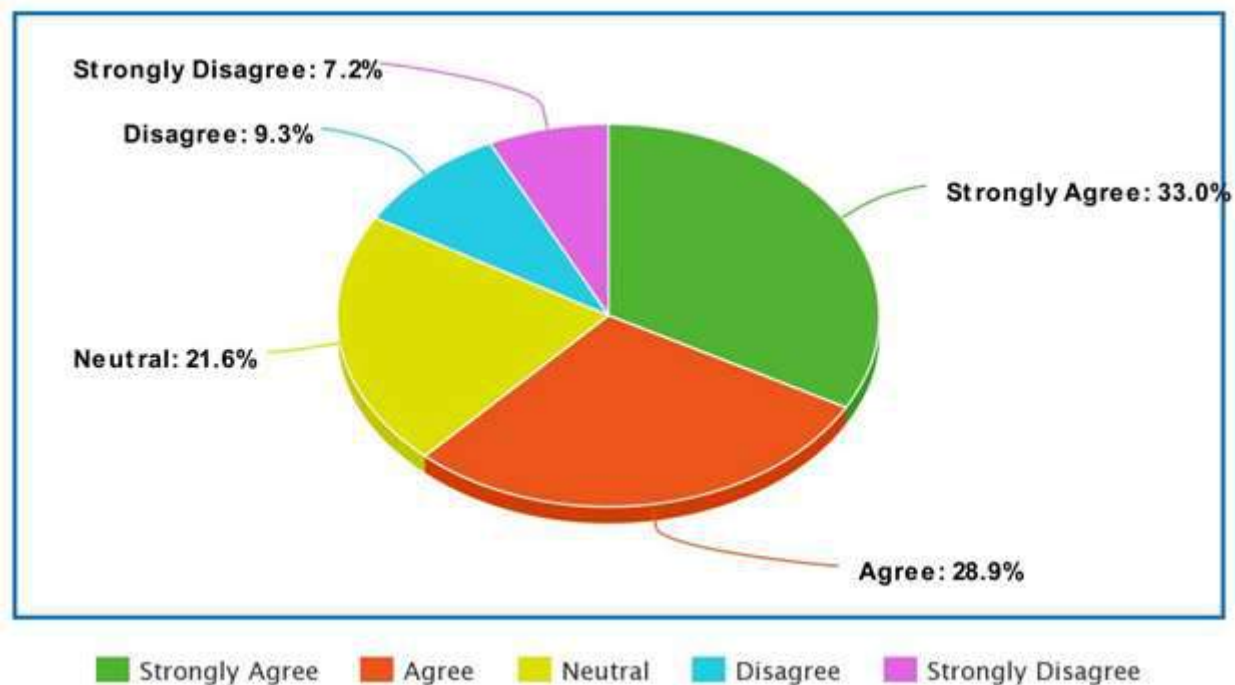


Figure 5. Emphasis on practical knowledge like slide making, surface making is given least importance.

6. There is a lack of clear-cut demarcation between anatomy and physiology in their textbooks:

A mixed response, with the highest percentage in the Neutral

category (36.08%). This suggests uncertainty or neutrality regarding the demarcation between anatomy and physiology in textbooks as revealed in Figure 6.

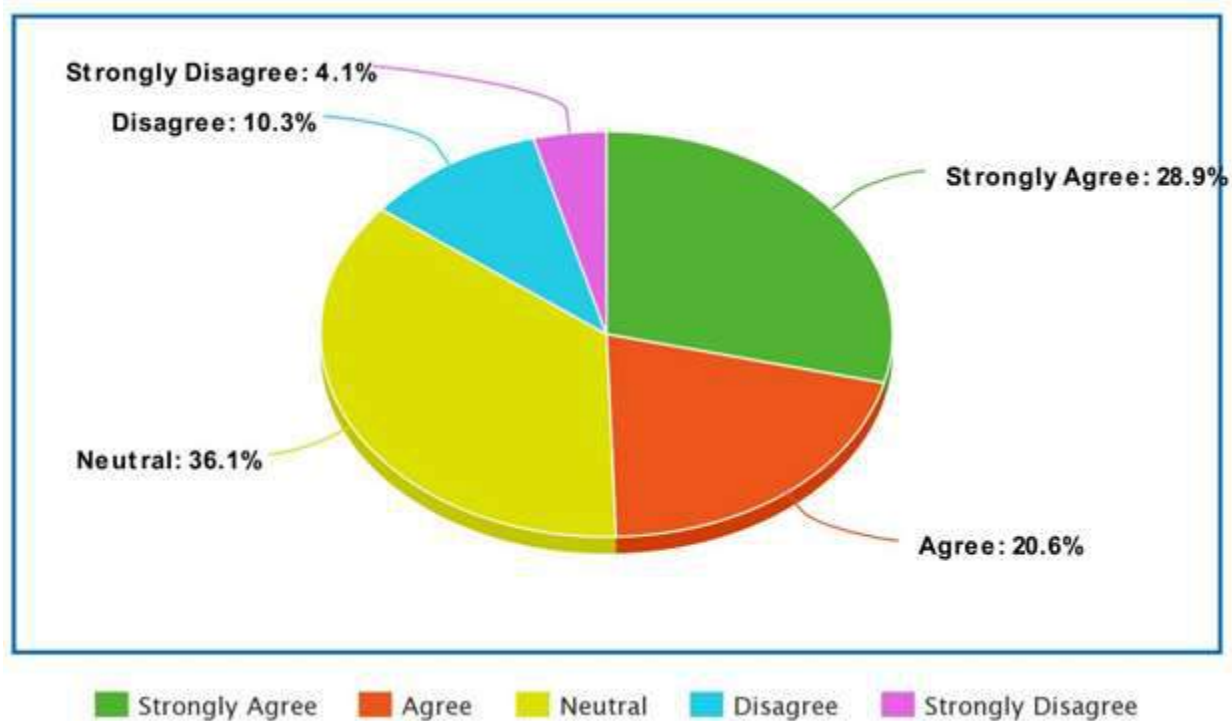


Figure 6. There is lack of demarcation between anatomy and physiology in textbooks

More than 75% of students felt that the Anatomy syllabus is vast and more factual information to remember. The summarized responses reveal that a significant majority, over 75% of students, perceive the Anatomy syllabus as extensive, demanding memorization of copious factual information. Around 70% of students acknowledge that the anatomy syllabus caters to their required competencies. However, 60% of students express concern about the limited emphasis on practical knowledge, such as slide making and surface marking of blood vessels.

For the open-ended questions of the methods they prefer for learning anatomy, the students responses include:

“More emphasis on practical and demonstration”

“Part of Anatomy relevant to that particular allied health course only need to

be included in their curriculum” *“Practical class for every lecture class”*

“Topic wise notes” *“Require more revision and weekly tests”*

According to the local university recommendation, the first year of all allied health courses like Respiratory care, Cardiac care, Medical lab technology, Renal dialysis, Operational technology all have a common syllabus as far as Anatomy is concerned. This makes the students feel their syllabus is vast. As the reasons for more failures in Anatomy, the students cited the following reasons:

“Syllabus of anatomy is too vast”

“Lots of new terminologies to understand”

“Textbook of anatomy is a common one and not according to their stream of courses”

“Less number of practical classes”

“Strict evaluation of the exam paper and increased requirement of 50 % pass percentage”

“Language problem and Students not comfortable asking doubts”

“More factual information in the subject so volatile and students find it difficult”

Furthermore, half of the students indicate a perceived lack of clear-cut demarcation between anatomy and physiology in their textbook. These findings provide valuable insights into the students' perspectives on the anatomy curriculum, highlighting both commendations and areas of potential improvement. Such feedback is instrumental in guiding curriculum refinement and enhancing the educational experience for the participating students.

Thematic analysis of the responses from the student questionnaire yielded four prominent themes that shed light on various aspects of their perceptions regarding the anatomy syllabus in allied health science programs.

1. *Perception of Vast and Factual Nature:* A significant number of students, over 75%, conveyed a common sentiment that the anatomy syllabus appears vast and overwhelming. They expressed apprehension about the extensive factual information that needs to be memorized, which may contribute to feelings of academic burden. This theme underscores the need to address the perception of content overload and explore strategies to streamline the

syllabus while ensuring essential concepts are retained.

2. *Alignment with Required Competencies:* Approximately 70% of students acknowledged that the anatomy syllabus is generally aligned with the competencies required for their future careers in allied health sciences. This positive perception indicates that the curriculum is designed to equip students with fundamental anatomical knowledge relevant to their professional roles. This theme highlights the importance of maintaining the alignment between curriculum content and the practical skills needed in the healthcare field.
3. *Inadequate Emphasis on Practical Knowledge:* A notable proportion, 60% of students, expressed concern about the limited emphasis on practical aspects of anatomy education, such as slide making and surface marking of blood vessels. Students considered these practical skills crucial for their clinical practice and emphasized the need for more hands-on experiences. This theme underscores the significance of incorporating practical sessions into the curriculum to enhance students' application-oriented learning.
4. *Ambiguity in Anatomy and Physiology Demarcation:* Half of the students perceived a lack of clear-cut demarcation between anatomy and physiology within their textbook. This finding suggests that the boundaries between these two essential subjects are not clearly delineated, which may lead to confusion in understanding their distinct concepts. This theme highlights the importance of clarifying and organizing

the curriculum to facilitate better comprehension and integration of these foundational sciences.

Collectively, these identified themes provide valuable insights into the students' perspectives on the anatomy syllabus. Addressing these themes in curriculum planning and implementation can lead to more focused and effective anatomy education, promoting a positive and enriching learning experience for allied health science students.

Discussion

The results of the present study are in line with the findings reported by other researchers globally, indicating that the perceptions and challenges surrounding anatomy education are prevalent across various medical and allied health science disciplines. In Gupta et al.'s study involving 200 MBBS students of different professional years, the issue of curriculum overload, particularly in anatomy, was identified as a significant problem faced by students [5]. This aligns with the current study's theme of "Perception of Vast and Factual Nature," where more than 75% of allied health science students felt that their anatomy syllabus is extensive and laden with factual information. The perception of content overload, leading to overburdened study and limited time for other subjects, resonates with both studies.

Similarly, Bergman's study on undergraduate perceptions of anatomy across 76 students revealed that clinical exposure acted as a prime motivating factor for studying anatomy [2]. This corresponds

with the current study's theme of "Alignment with Required Competencies," where around 70% of students acknowledged that the anatomy syllabus aligned with their essential competencies. The significance of clinical application and its role in motivating students to learn anatomy was evident in both studies.

Additionally, the findings from a study conducted in the United Kingdom (UK), focused on learning anatomy in the context of speech and language science students, are consistent with the current study's theme of "Inadequate Emphasis on Practical Knowledge" [3]. The UK study reported that students struggled with learning anatomy, found the amount of material daunting, experienced difficulty in memory retention, and lacked confidence in their knowledge base. These challenges are mirrored in the current study, where 60% of allied health science students expressed concern about the inadequate emphasis on practical knowledge like slide making and surface marking of blood vessels.

In the context of Australian University, a study focused on Biomedical Science (BMS) students revealed valuable insights into their perceptions of teaching methods employed in a first-year introductory anatomy and physiology unit. The BMS students recommended greater utilization of blackboard teaching, increased use of cadavers, and a higher number of dissections. Moreover, the students emphasized that their interest and engagement in a particular unit were driven by its relevance to their degree program [8]. This observation underscores the importance of tailoring anatomy education to the

specific needs of each branch within Allied Health Sciences (AHS). By providing detailed and focused anatomy content relevant to their future practice, students are more likely to become deeply interested and enthusiastic learners. For instance, a renal dialysis student would be more engaged in learning detailed renal anatomy, which is directly applicable to their practice.

Across different geographical and cultural backgrounds, a study in Ethiopia found that medical students displayed a positive attitude toward basic medical science subjects, particularly anatomy and physiology, as they perceived them to be highly relevant to their clinical practice [9]. A similar view was shared by medical students at all stages of their course, regardless of whether they were in their first year or final year [10]. These findings reinforce the significant role of anatomy in medical education and clinical studies.

Experts recommend that enhancing anatomy education can be achieved through the integration of relevant clinical applied anatomy and adopting active learning techniques [11, 12]. Vertically integrating anatomy education has also been suggested as a valuable approach, allowing students to participate more directly in their learning and yielding more favorable results compared to traditional passive methods [13].

In the United Kingdom, life science nurse educators collaborated with the Anatomical Society to develop a detailed discipline-specific core anatomy syllabus, systematically organized system-wise with defined learning outcomes. This syllabus enables nurse educators to emphasize the

relevance of anatomy to nursing practice, enhancing students' understanding and application of anatomy principles [14]. Similarly, involving allied health science practitioners and anatomy teachers in planning the syllabus for each allied course, incorporating defined learning outcomes, can create a curriculum that resonates with students and highlights the practical relevance of anatomy in their clinical practice.

The findings from various studies align with the current research, emphasizing the significance of tailoring anatomy education to meet the needs of specific disciplines within AHS. By incorporating relevant clinical applied anatomy, adopting active learning techniques, and creating well-structured syllabi with defined learning outcomes, educators can promote student engagement and interest in anatomy, leading to a more enriched and applicable learning experience. The similarity between the results of the present study and the findings from other researchers globally indicates a shared set of concerns and perceptions regarding anatomy education. These consistencies highlight the need for concerted efforts to address curriculum design, emphasize practical aspects, and ensure alignment with students' future professional needs.

In the context of improving teaching and learning in Anatomy, the integration of virtual learning methods can be a valuable approach. Virtual learning technologies offer innovative and interactive tools that can enhance students' understanding and engagement with anatomical concepts. Virtual anatomy platforms provide realistic

3D models and interactive simulations, allowing students to explore anatomical structures in a dynamic and immersive manner. Through these virtual environments, students can manipulate anatomical structures, visualize complex relationships, and gain a deeper understanding of spatial anatomy, which may be challenging to achieve through traditional teaching methods alone [15, 16].

Moreover, virtual learning platforms enable self-paced learning, allowing students to revisit challenging concepts and review materials as needed. This flexibility accommodates different learning styles and ensures that students can grasp fundamental anatomical knowledge at their own pace. Incorporating virtual anatomy dissection experiences can also be beneficial, particularly in cases where access to cadavers or physical dissection labs is limited. Virtual dissection tools provide a safe and ethical alternative for students to explore anatomical structures and practice dissection techniques (15, 16).

Additionally, virtual learning platforms can facilitate collaborative learning experiences. Students can engage in virtual group discussions, share insights, and work together on complex anatomical cases, promoting active learning and knowledge exchange. However, while virtual learning offers numerous advantages, it is essential to recognize its potential limitations. Some students may require additional support and guidance to navigate virtual platforms effectively, and educators should ensure that adequate training and resources are provided to facilitate seamless integration.

Limitations and suggestions

Limitations of this study include the potential for data saturation in the qualitative analysis. Although efforts were made to gather a diverse set of responses from 100 students, the sample size may not have been sufficient to reach data saturation. As a result, certain perspectives or insights from students might not have been fully captured, limiting the comprehensiveness of the study findings. Response bias is another noteworthy limitation. While the questionnaire was designed to maintain anonymity and encourage honest responses, students may have been inclined to provide socially desirable answers or refrain from expressing their true opinions due to various reasons such as fear of judgment or desire to conform to perceived norms. This bias could have influenced the reported perceptions, potentially leading to an underrepresentation or overrepresentation of certain viewpoints. Despite these limitations, the study provides valuable insights into the perceptions of allied health science students regarding their anatomy syllabus. To mitigate the limitations, future studies could employ larger sample sizes and diverse data collection methods, such as focus group discussions or interviews, to ensure data saturation and minimize response bias, thereby yielding more comprehensive and robust findings. The analysis did not specifically consider gender differences in perceptions. The primary focus was on understanding overall trends and commonalities in the perceptions of allied health students regarding the anatomy curriculum. While gender-specific analysis

could provide additional insights, it was beyond the scope of this particular study.

Conclusion

In conclusion, a significant majority of students, approximately three-fourths, perceive the anatomy syllabus to be extensive and overwhelming. Additionally, 60% of students express concerns about the insufficient emphasis on practical knowledge, such as slide making and surface marking of blood vessels, while half of the students identify a lack of clear-cut distinction between Anatomy and Physiology in their textbooks. To address these findings, it is crucial to tailor the anatomy syllabus for each allied health science course, incorporating defined learning outcomes that align with the specific needs of students in their future clinical practice. Moreover, the integration of practical skills relevant to their professional roles is essential to enhance the students' engagement and interest in anatomy education. By adapting the curriculum to meet the unique requirements of each allied health discipline and incorporating practical applications, educators can foster a more meaningful and enriching learning experience for the students. This approach will better prepare them for their respective healthcare roles and nurture a deeper appreciation for the importance of anatomy in their clinical practice.

Acknowledgments

This article was the result of a cross sectional study approved by Sapthagiri Institute of Medical Sciences and Research Center. The authors would like to express

their appreciation and gratitude to the Department faculty and students who participated in this study.

Authors' contributions

SVU, AM, AB, MC, LS, HR-All the authors participated in the process of the initial writing of the manuscript, its revision, presentation of the idea and initial design, and collection and analysis of data. Moreover, all authors accept the responsibility for the accuracy and correctness of the contents of the present manuscript and approve the final version of the manuscript.

Conflict of interests

The authors report no actual or potential conflict of interest.

Ethical considerations

This study was conducted based on the principles of the Declaration of Helsinki. Before the study, the approval of the Institutional Ethics Committee of Sapthagiri Institute of Medical Sciences and Research Center (No. IEC NO SIMS&RC/IECC06/2012) was obtained.

Funding

There was no funding for the study

References

1. Notebaert AJ. Student perceptions about learning anatomy. ProQuest Diss Theses. 2009; 148. Available from: <https://search.proquest.com/docview/304904306>.
2. Bergman EM, de Bruin AB, Herrler A, Verheijen IW, Scherpbier AJ, van der

- Vleuten CP. Students' perceptions of anatomy across the undergraduate problem-based learning medical curriculum: a phenomenographical study. *BMC Med Educ.* 2013 Nov 19;13:152. doi: 10.1186/1472-6920-13-152.
3. Smith CF, Martinez-Álvarez C, McHanwell S. The context of learning anatomy: does it make a difference? *J Anat.* 2014 Mar;224(3):270-8. doi: 10.1111/joa.12089. Epub 2013 Aug 12.
4. Sturges D, Mauner T. Allied Health Students' Perceptions of Class Difficulty: The Case of Undergraduate Human Anatomy and Physiology Classes. *Internet J Allied Heal Sci Pract.* 2013;11(4).
5. Gupta S, Gupta AK, Verma M, Kaur H, Kaur A, Singh K. The attitudes and perceptions of medical students towards basic science subjects during their clinical years: A cross-sectional survey. *Int J Appl Basic Med Res.* 2014 Jan;4(1):16-9. doi: 10.4103/2229-516X.125675.
6. Abdelrahman NuggedAlla MA. Perception and Significance of Basic Sciences for Clinical Studies. *Int J Hum Anat.* 2018;1(2):26–32.
7. Ginzburg SB, Brenner J, Cassara M, Kwiatkowski T, Willey JM. Contextualizing the relevance of basic sciences: small-group simulation with debrief for first- and second-year medical students in an integrated curriculum. *Adv Med Educ Pract.* 2017 Jan 18;8:79-84. doi: 10.2147/AMEP.S124851.
8. Anderton RS, Chiu LS, Aulfrey S. Student Perceptions to Teaching Undergraduate Anatomy in Health Sciences. *Int J High Educ.* 2016;5(3):201–16.
9. Teshome D, Tiruneh C, Berhanu L, Berihun G. Medical Students' Attitude and Perception Towards Basic Medical Science Subjects at Wollo University, Northeast Ethiopia. *Adv Med Educ Pract.* 2021 May 3;12:431-438. doi: 10.2147/AMEP.S309440.
10. Moxham BJ, Plaisant O. Perception of medical students towards the clinical relevance of anatomy. *Clin Anat.* 2007 Jul;20(5):560-4. doi: 10.1002/ca.20453. PMID: 17149736.
11. Staśkiewicz GJ, Walczak E, Torres K, Torres A, Mazgaj M, Kostek H, et al. What do clinicians think of the anatomical knowledge of medical students? Results of a survey. *Folia Morphol (Warsz).* 2007 May;66(2):138-42. PMID: 17594673.
12. Waterston SW, Stewart IJ. Survey of clinicians' attitudes to the anatomical teaching and knowledge of medical students. *Clin Anat.* 2005 Jul;18(5):380-4. doi: 10.1002/ca.20101.
13. Lunsford E, Diviney M. Changing Perspectives on Anatomy & Physiology: From Killer Class to Gateway Course. *Bioscene: The Journal of College Biology Teaching.* 2020; 46: 3-9.
14. Connolly SA, Gillingwater TH, Chandler C, Grant AW, Greig J, Meskill M, et al. The Anatomical Society's core anatomy syllabus for undergraduate nursing. *J Anat.* 2018 May;232(5):721-728. doi: 10.1111/joa.12782. Epub 2018 Feb 7.
15. Narang K, Imsirovic A, Dhanda J, Smith CF. Virtual Reality for Anatomy and Surgical Teaching. *Adv Exp Med Biol.* 2023;1397:135-149. doi: 10.1007/978-3-031-17135-2_8.
16. Gloy K, Weyhe P, Nerenz E, Kaluschke M, Uslar V, Zachmann G, et al. Immersive Anatomy Atlas: Learning Factual Medical Knowledge in a Virtual Reality Environment. *Anat Sci Educ.* 2022 Mar;15(2):360-368. doi: 10.1002/ase.2095. Epub 2021 Jun 30.

Evaluation of the Predictive Role of Neutrophil Lymphocyte Ratio and Mean Platelet Volume in Preterm Deliveries: A Cross-sectional Study

DISHA SAI M CHANDAVAR¹, JESSICA MINAL², KS RASHMI³

ABSTRACT

Introduction: Preterm birth is associated with high perinatal morbidity and mortality. Identifying women at risk for preterm labour early in pregnancy may improve pregnancy outcomes. Neutrophil-Lymphocyte Ratio (NLR) and Mean Platelet Volume (MPV) can be helpful in predicting preterm labour, as infection is an important factor in early preterm deliveries, with immunity playing a key role in preterm labour.

Aim: To evaluate the predictive role of the NLR and MPV in preterm deliveries.

Materials and Methods: This cross-sectional study was conducted in a tertiary care and research hospital from August 2022 to October 2023. Haematological and clinical data were retrieved for preterm deliveries (n=79, group I) and term deliveries (n=151, group II). The two groups were compared in terms of demographic characteristics, obstetric and laboratory findings, including maternal age, gravida, parity, birth weight, NLR, MPV, and haemoglobin levels. The data were analysed using Statistical Package for the Social Sciences (SPSS) version 29.0. One-way Analysis of Variance (ANOVA) was used to compare the mean values among different groups. Categorical

values were evaluated with Pearson's Chi-square test. Receiver Operating Characteristic (ROC) curve was used to assess the diagnostic properties of the tests.

Results: The two groups showed no statistical difference in terms of demographic parameters such as the mother's age (p-value=0.611), parity (p-value=0.798), and gravida (p-value=0.583). The NLR was higher in group I (5.8 ± 5.01) compared to group II (4.3 ± 1.75), and this difference was statistically significant with a p-value of <0.001 . MPV was observed to be lower in group II (8.7 ± 0.96) compared to group I (8.9 ± 1.07); however, this difference was not statistically significant (p-value=0.128). The mean baby weight and mean maternal haemoglobin in group I were significantly lower compared to group II.

Conclusion: In this study, the NLR value was significantly higher in patients with preterm deliveries compared to term deliveries. This study highlights the role of NLR as an emerging predictor of preterm deliveries and emphasises that NLR, obtained from an inexpensive and routinely conducted haemogram, has the potential to be used as an early indicator of preterm deliveries.

Keywords: Complete blood count, Inflammation, Labour, Pregnancy outcome

INTRODUCTION

Preterm delivery, defined as delivery before 37 weeks or 259 days of gestation, is classified into early preterm (<34 weeks) and late preterm (34-37 weeks) and is a significant factor contributing to perinatal morbidity and mortality [1,2]. In addition to the increased risk of mortality, children born preterm also face numerous challenges such as neurological deficits, learning disabilities, and respiratory problems [1]. Predicting preterm birth becomes crucial for healthcare workers to be prepared for timely interventions [3]. Developing strategies to improve access to effective care should be a research and operational priority, especially in developing countries like India [1]. Inflammation and infection play important roles in the aetiology of preterm birth, and identifying non invasive methods or markers associated with these conditions may be crucial [2]. Unfortunately, currently, there is a lack of effective diagnostic parameters for predicting preterm labour and its outcomes [1].

An increase in the number of leukocytes or neutrophils in subclinical inflammation is due to the systemic response to intrauterine infection regulated by the natural immune system. Neutrophil counts increase, and lymphocyte counts decrease, resulting in an increased NLR in spontaneous preterm birth. NLR is an affordable, simple, and readily available parameter of stress and inflammation that reflects the potent relationship between the innate (neutrophils) and adaptive (lymphocytes) immune response during illness and diseased conditions [2]. Clinical research has established the sensitivity of NLR for the diagnosis of systemic infection, sepsis, and its strong predictive and prognostic value [4]. The role of NLR

as an inflammatory parameter for the early prediction of preterm delivery has been explored in several studies; however, the results of these studies have been conflicting [4-7]. The normal range of NLR in healthy non geriatric adults is between 0.78 and 3.58 [8]. Women with a high NLR may be more likely to experience preterm labour progressing to preterm birth [2].

MPV, a routinely performed automated whole blood count parameter, is indicative of platelet function and activity, and it reflects the size of platelets. It plays an important role in immunological and inflammatory events [2]. The normal value of MPV is between 7.2 and 11.7 fL [9]. In some chronic inflammatory disorders, an inverse correlation between disease activity and MPV has been demonstrated [2]. In preterm labour, which is a highly inflammatory state, the consumption of large platelets at the site of inflammation causes a decrease in MPV levels [2].

Both of these indices, NLR and MPV are inexpensive and easily accessible parameters and they may serve as pivotal proinflammatory biomarkers in patients who experience preterm deliveries [2]. Therefore, interpreting the possible role of NLR and MPV based on routinely conducted Complete Blood Count (CBC) parameters may help predict the occurrence of preterm labour and preterm deliveries, enabling better preparedness for pregnant women, obstetricians, and the healthcare team to perform the necessary interventions [4]. Although the role of NLR in predicting preterm labour has been studied, regional research on the utility of this parameter is limited. The utility of MPV in predicting preterm labour also needs further exploration, as it is an area that has not been

adequately researched. The current study may provide possible indications for identifying surrogate first-line indicators of preterm deliveries, which could be useful in facilities that lack resources or have limited resources to manage preterm deliveries and care for preterm babies. The aim of the study was to evaluate the predictive role of the NLR and MPV for preterm deliveries, and to assess if a cut-off value can be established for these two parameters to predict delivery outcomes.

MATERIALS AND METHODS

This was a cross-sectional study conducted in the Central Laboratory, Haematology section at Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, a tertiary care centre in Ramanagara, Karnataka, India, from August 2022 to October 2023. Ethics committee clearance for the study was obtained from the Institutional Ethics Committee (IEC) (CDSIMER/MR/0048/IEC/2022). Since this was a retrospective study, a waiver of consent was granted.

Inclusion criteria: Pregnant women aged ≥18 years with available haematological records from the last/third trimester were included in the study.

Exclusion criteria: Patients with induced labour, multiple pregnancies, anomalies of the female genital tract, and a history of smoking were excluded from the study.

Sample size: A convenience sample of 230 patients was selected for the study from August 2022 to December 2023. These patients were classified into two groups: preterm (delivery before 37 weeks, group I= 79) and term (delivery at or after 37 weeks, group II=151).

Study Procedure

Patient medical records and electronic data were retrieved, and the two groups were compared with respect to demographic specifications and obstetric findings such as maternal age, gravida, parity, infant gender, mode of delivery, and laboratory findings including NLR, MPV, and haemoglobin levels. Relevant patient details were obtained from the laboratory database and medical case records. All samples were analysed on a Beckman five-part haematology analyser, and the results were standardised by conducting external and internal quality control checks daily in accordance with laboratory protocols. CBC parameters from the third trimester were retrieved, and laboratory parameters including haemoglobin, NLR, and MPV were recorded for all participants during the third trimester. NLR

was calculated by dividing the neutrophil count by the lymphocyte count obtained from the same run.

STATISTICAL ANALYSIS

The data were collected and analysed using the statistical software, SPSS version 29.0. The results were expressed as the mean±Standard Deviation (SD). Baseline demographic specifications of the study groups were described in terms of frequency, percentage, mean, and SD. Mean values between the groups were compared using one-way ANOVA. Categorical values were evaluated using Pearson's Chi-square test. A two-tailed p-value <0.05 was considered statistically significant. The diagnostic properties of significant tests were assessed using ROC curves. The optimal cut-off value for significant variables was determined, followed by the assessment of sensitivity, specificity, and the area under the ROC curve.

RESULTS

A total of 230 patients were included in the study, consisting of 79 patients who gave birth before 37 weeks of gestation (preterm, group I) and 151 patients who delivered at or after 37 weeks of gestation (term, group II).

The mothers' ages in the entire dataset ranged from 18 to 37 years, with an average age of 25.1±4.4 years. The average birth weight of the babies was 2.7±0.54 kg, ranging from 0.9 kg to 4.3 kg. The average NLR was 4.8±3.3, and the average MPV was 8.8±1.01 fL for the entire dataset of 230 patients. There were no statistically significant differences between group I and group II in terms of demographic parameters such as mother's age, parity, and gravida [Table/Fig-1].

There were statistically significant differences between the groups in terms of baby's birth weight and haemoglobin. The mean birth weight in group I was lower (2.3±0.59 kg) compared to group II (2.9±0.37 kg), and this difference was statistically significant (p-value <0.001). The mean maternal haemoglobin in group I was 11.5±1.51 g/dL, which was significantly lower compared to group II (12.0±1.43 g/dL) (p-value=0.013). NLR was higher in the preterm group I (5.8±5.01) compared to the term group I (4.3±1.75), and this difference was statistically significant with a p-value <0.001. MPV was slightly lower in the term group (8.7±0.96 fL) compared to the preterm group (8.9±1.07 fL), but this difference was not statistically significant (p=0.128) [Table/Fig-1].

Parameters	Total (n=230)	Group I (Preterm <37 weeks/<259 days) (n=79)	Group II (Term ≥37 weeks ≥259 days) (n=151)	p-value
Mothers age in years mean±SD	25.1±4.4 (18-37)	24.9±4.8 (18-37)	25.2±4.2 (18-37)	0.611 ^a
Mean gestational age (in days)	261.4±15.6 (201-287)	244.4±14.4 (201-258)	270.3±5.9 (259-287)	<0.001 ^a
Gravida±SD	1.8±0.96 (1-6)	1.9±1.16 (1-6)	1.8±0.84 (1-4)	0.583 ^a
Parity±SD	0.6±0.71 (0-3)	0.5±0.77 (0-3)	0.6±0.68 (0-3)	0.798 ^a
Baby's birth weight (kg) mean±SD	2.7±0.54 (0.9-4.3)	2.3±0.59 (0.9-3.6)	2.9±0.37 (2.1-4.3)	<0.001 ^a
Baby's gender %				0.815 ^c
Female	116	39/79=49.4%	77/151=51%	
Male	114	40/79=50.6%	74/151=49%	
Mode of delivery, %				0.767 ^c
FTNVD	125	44/79=55.7%	70/151=46.4%	
LSCS	105	35/79=44.3%	81/151=53.6%	
Mother's haemoglobin gm/dL mean±SD	11.8±1.48 (7.1-15.9)	11.5±1.51 (7.1-15.9)	12.0±1.43 (7.2-15.5)	0.013 ^a
Neutrophils % mean±SD	73.9±7.06 (49.3-95.9)	75.6±8.59 (53.5-95.9)	73.1±5.96 (49.4-88.6)	0.010 ^a
Lymphocytes % mean±SD	18.3±6.95 (2.6-79.3)	17.1±6.73 (2.6-35.6)	18.9±6.99 (7.6-79.3)	0.048 ^a
NLR mean±SD	4.8± 3.3 (1.0-37.2)	5.8± 5.01 (1.5-37.2)	4.3± 1.75 (1-11.6)	<0.001 ^a
MPV (fL) mean±SD	8.8±1.01 (6.4-13.7)	8.9±1.07 (6.4-13.1)	8.7±0.96 (7.1-13.7)	0.128 ^a

[Table/Fig-1]: Characteristics of descriptive and clinical data amongst different groups.
n: Number; %: Percentage; SD: Standard deviation; a: one-way variance analysis; c: Chi-square test; FTNVD: Full term normal vaginal delivery; LSCS: Lower segment ceasarean section; NLR: Neutrophil-lymphocyte ratio; MPV: Mean platelet volume

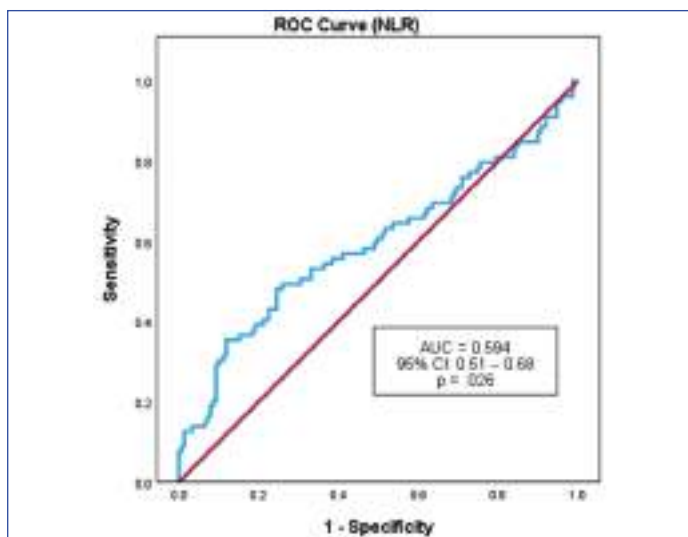
Further analysis of the preterm groups with respect to early preterm (<34 weeks) and late preterm (34-37 weeks) showed no significant differences between the different laboratory parameters [Table/Fig-2].

Laboratory parameters	<34 weeks n=18	34-37 weeks n=61	p-value
Haemoglobin (gm/dL) mean±SD	11.4±1.66 (7.1-13.5)	11.6±1.48 (7.9-15.9)	0.611 ^a
Neutrophils (%) mean±SD	73.8±12.1 (53.5-95.9)	76.1±7.3 (62.3-95.2)	0.324 ^a
Lymphocytes (%) mean±SD	18.6±9.95 (2.6-35.6)	16.6±5.46 (4-28.9)	0.271 ^a
NLR mean±SD	6.89±8.27 (1.5-37.2)	5.5± 3.59 (2.3-23.8)	0.318 ^a
MPV (fL) mean±SD	8.9±1.05 (6.4-10.7)	9.0±1.08 (7.1-13.1)	0.758 ^a

[Table/Fig-2]: Detailed distribution of lab parameters amongst different subgroups of preterm.

n: Number; %: Percentage; SD: Standard deviation; a: one way variance analysis; c: Chi-square test; NLR: Neutrophil-lymphocyte ratio; MPV: Mean platelet volume

ROC curve analysis to study the diagnostic value of NLR in predicting preterm deliveries showed that an NLR >4.33 had a sensitivity of 53% and specificity of 67% [Table/Fig-3,4].



[Table/Fig-3]: Receiver Operating Characteristic (ROC) curve for NLR values. AUC: Area under curve; CI: Confidential interval

Cut-off	Sensitivity (%)	Specificity (%)
3.83	65	45
3.90	63	48
3.95	61	50
3.99	58	54
4.01	57	56
4.15	56	60
4.24	56	62
4.33	53	67
4.48	51	70
4.71	49	72
4.86	47	75

[Table/Fig-4]: Diagnostic sensitivity and specificity of NLR at different cut-offs.

Correlation table								
Variables		Mothers_age	Baby_weight	Mother-HB	Mothers-N	Mothers-LY	Mothers-NLR	Mothers- MPV
Mothers_age	Pearson correlation	1	-0.008	0.037	-0.057	-0.048	-0.063	0.063
	Sig. (2-tailed)		0.907	0.580	0.386	0.466	0.341	0.339
Baby_Weight	Pearson correlation	-0.008	1	0.151*	0.012	-0.036	-0.137*	-0.054
	Sig. (2-tailed)	0.907		0.022	0.853	0.591	0.038	0.419
Mother-HB	Pearson correlation	0.037	0.151*	1	-0.118	0.084	-0.116	-0.141*
	Sig. (2-tailed)	0.580	0.022		0.075	0.205	0.080	0.033

Among the other laboratory parameters for the total samples, the mother's haemoglobin was positively correlated with the baby's birth weight and negatively correlated with MPV. Neutrophil count and NLR were positively correlated as expected. Other observations included a negative correlation between NLR and the baby's birth weight [Table/Fig-5].

DISCUSSION

In the current study, the predictive role of inflammatory markers such as NLR and MPV in preterm and term deliveries was investigated. It was observed that NLR was significantly higher in group I compared to group II. The diagnostic value of NLR in predicting preterm deliveries before 37 weeks demonstrated that an NLR >4.33 had a sensitivity of 53% and specificity of 67%. On the other hand, MPV was found to be lower in group II compared to group I, but this difference was not statistically significant. Therefore, MPV did not have a role in predicting the timing of deliveries. The observation of lower MPV in group II compared to the preterm group I is intriguing and warrants further validation in future studies.

Preterm delivery, defined as delivery before 37 weeks of gestation, is a significant factor contributing to perinatal morbidity and mortality, with long-term implications [1]. Various factors such as stress, infection, placental disorders like abruption and placenta previa, prior history of preterm birth or abortion, and inadequate maternal care contribute to preterm labour. Foetal inflammatory response syndrome, characterised by systemic inflammation and elevated interleukin-6 levels, is a key event in preterm labour initiation [10]. Given the crucial role of inflammation in triggering preterm labour, markers associated with neutrophils may have a predictive role in preterm deliveries [4]. This study aimed to investigate novel inflammatory markers for their predictive value in preterm and term deliveries.

The NLR has been found to have a correlation with the prognosis of systemic inflammatory diseases [3]. NLR is a simple marker derived from a CBC and has previously been observed to be increased in pregnancy complications such as preeclampsia, gestational diabetes mellitus, intrahepatic cholestasis of pregnancy, and hyperemesis gravidarum [11]. MPV, on the other hand, reflects platelet function and activity and plays a significant role in immunological and inflammatory events [3]. In highly inflammatory conditions like preterm labour, the consumption of large platelets at the site of inflammation leads to a reduction in MPV [2].

In a study conducted by Kurban Y et al., NLR was found to be higher in preterm births, which was consistent with the findings of present study [2]. Similarly, Melissa CL et al., observed a significant elevation of NLR in patients with preterm labour [12]. However, a study by Khatoon F et al., in the Indian population reported that although neutrophil levels were significantly elevated and lymphocytes were reduced in pregnant women with preterm labour, the NLR ratio itself was not significantly increased in the preterm labour group [13].

In a study by Christoforaki V et al., the NLR of pregnant women in the first trimester was compared between those who had a live birth at 37 weeks and those who experienced a miscarriage. There was no statistically significant difference in NLR between the two groups, with

Mothers-N	Pearson correlation	-0.057	0.012	-0.118	1	-0.715**	0.752**	0.064
	Sig. (2-tailed)	0.386	0.853	0.075		<0.001	<0.001	0.338
Mothers-LY	Pearson correlation	-0.048	-0.036	0.084	-0.715**	1	-0.645**	-0.042
	Sig. (2-tailed)	0.466	0.591	0.205	<0.001		<0.001	0.529
Mothers-NLR	Pearson correlation	-0.063	-0.137*	-0.116	0.752**	-0.645**	1	0.092
	Sig. (2-tailed)	0.341	0.038	0.080	<0.001	<0.001		0.165
Mothers- MPV	Pearson correlation	0.063	-0.054	-0.141*	0.064	-0.042	0.092	1
	Sig. (2-tailed)	0.339	0.419	0.033	0.338	0.529	0.165	

[Table/Fig-5]: Correlation across different variables for the entire sample.

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed); HB: Haemoglobin; N: Neutrophil; LY: Lymphocytes; NLR: Neutrophil-lymphocyte ratio; MPV: Mean platelet volume

values of 2.5±1.0 and 2.9±1.5, respectively. However, NLR values higher than 5.8 were only found in the miscarriage group, suggesting a potential clinical utility that requires further validation [11].

Hershko Klement A et al., investigated NLR values during pregnancy in both high-risk and normal-risk populations and found no difference between the two groups. They also noted that the peak value of NLR is reached during the second trimester, with these values positively correlating with age [14].

Another study by Ozel A et al., suggested that NLR values were significantly higher in the Preterm Premature Rupture of Membranes (PPROM) group compared to the threatened preterm labour group and the healthy control group. They concluded that NLR can be a cost-effective parameter in the management of PPRM [15].

In the current study, MPV was observed to be lower in group II compared to group I; however, this difference was not statistically significant. This finding contradicts the results of Kurban Y et al., where a significant decrease in MPV was found in the preterm birth group compared to the term group (p-value <0.05) [2]. Abd El-Rhaman Abd El-Fattah I et al., also investigated the role of MPV in predicting PPRM and found a positive correlation between these parameters, highlighting the potential of MPV in identifying patients at risk for PPRM [16]. Platelet activation plays a significant role in the pathophysiology of infection, inflammation, and malignancy. However, there is a limited number of studies examining the role of MPV in term and preterm labour, which suggests the need for further research in this area. Ekin A et al., demonstrated that women with PPRM had significantly lower MPV values in the first trimester compared to controls [17]. In present study, MPV was lower in the term group compared to the preterm group; however, this difference was not statistically significant. It's worth noting that present study specifically examined MPV values in the third trimester.

Limitation(s)

The study was conducted as an exploratory research to identify and determine the predictive role of NLR and MPV in preterm deliveries, given the intriguing yet controversial literature on this topic. The limitations of the present study were the small size of the study group and the lack of adjustment for potential confounders such as medications, chronic diseases like coronary heart disease, stroke, diabetes, and stress among the study groups. Although this study was cross-sectional, only patients without risk factors have been included. However, it cannot exclude certain subgroups with elevated NLR due to underlying conditions. The authors' preliminary observations in the present study therefore call for larger prospective case-control studies that may provide better insights and stronger evidence regarding the predictive role of these parameters.

CONCLUSION(S)

Preterm deliveries remain a critical healthcare issue, especially in developing countries like India. There is a need to predict these

events to enhance preparedness and improve access to effective care for preterm deliveries. The findings of this study demonstrate that the NLR value was significantly higher in patients with preterm delivery compared to term deliveries. Present study aimed to emphasise the role of NLR as an emerging predictor of preterm deliveries. Authors believe that NLR, obtained from an inexpensive and routinely performed haemogram has the potential to serve as an early indicator of preterm deliveries. Prospective studies with larger datasets and rigorous methodologies are necessary to validate the observations made in this study.

Acknowledgement

Authors would like to acknowledge the laboratory staff especially the non-teaching staff for their role and help in this study.

REFERENCES

[1] Beck S, Wojdyla D, Say L, Betran AP, Merialdi M, Requejo JH, et al. Worldwide incidence of preterm birth: A systematic review of maternal mortality and morbidity. *Bull World Health Organ.* 2010;88(1):31-38.

[2] Kurban Y, Alan Y, Uyar I, Atak Z, Aydemir Ö, Öktem A. Investigation of neutrophil/lymphocyte ratio and mean platelet volume in patients diagnosed with preterm labour. *Paediatr Respir Rev.* 2021;40:39-43. Doi: 10.1016/j.prrv.2020.05.008.

[3] Tolunay HE, Elci E. Importance of haemogram parameters for prediction of the time of birth in women diagnosed with threatened preterm labour. *J Int Med Res.* 2020;48(4):300060520918432. Doi: 10.1177/0300060520918432.

[4] Vakili S, Torabinaid P, Tabrizi R, Shojazadeh A, Asadi N, Hessami K. The Association of inflammatory biomarker of neutrophil-to-lymphocyte ratio with spontaneous preterm delivery: A systematic review and meta-analysis. *Mediators Inflamm.* 2021;2021:6668381. Doi: 10.1155/2021/6668381.

[5] Ma M, Zhu M, Zhuo B, Li L, Chen H, Xu L, et al. Use of complete blood count for predicting preterm birth in asymptomatic pregnant women: A propensity score-matched analysis. *J Clin Lab Anal.* 2020;34(8):e23313. Doi: 10.1002/jcla.23313.

[6] Isik H, Aynioglu O, Sahbaz A, Ankan I, Karcaaltincaba D, Sahin H, et al. Can plateletcrit, an underestimated platelet parameter, be related with preterm labour? *J Obstet Gynaecol.* 2015;35(7):676-80. Doi: 10.3109/01443615.2015.1004530.

[7] Daglar HK, Kirbas A, Kaya B, Kilincoglu F. The value of complete blood count parameters in predicting preterm delivery. *Eur Rev Med Pharmacol Sci.* 2016;20(5):801-05.

[8] Forget P, Khalifa C, Defour JP, Latinne D, Van Pel MC, De Kock M. What is the normal value of the neutrophil-to-lymphocyte ratio? *BMC Res Notes.* 2017;10(1):12. Doi: 10.1186/s13104-016-2335-5.

[9] Demirin H, Ozhan H, Ucgun T, Celer A, Bulur S, Cil H, et al. Normal range of mean platelet volume in healthy subjects: Insight from a large epidemiologic study. *Thromb Res.* 2011;128(4):358-60. Doi: 10.1016/j.thromres.2011.05.007.

[10] Suman V, Luther EE. Preterm Labour. 2023 Aug 8. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. PMID: 30725624.

[11] Christoforaki V, Zafeiriou Z, Daskalakis G, Katasos T, Siristatidis C. First trimester Neutrophil to Lymphocyte Ratio (NLR) and pregnancy outcome. *J Obstet Gynaecol.* 2020;40(1):59-64. Doi: 10.1080/01443615.2019.1606171.

[12] Melissa CL, Aaron HG, Jonathan HBS, Angel GR, James A. Neutrophil to lymphocyte ratio and red cell distribution width levels in preterm vs term births. *J Mol Genet Med.* 2018;12(1):317. Doi: 10.4172/1747-0862.1000317.

[13] Khatoon F, Gupta H, Sinha P, Tiwari K, Singh A. Prediction of preterm birth on the basis of complete blood count parameters. *J South Asian Feder Obst Gynaec.* 2020;12(5):288-90.

[14] Hershko Klement A, Hadi E, Asali A, Shavit T, Wiser A, Haikin E, et al. Neutrophils to lymphocytes ratio and platelets to lymphocytes ratio in pregnancy: A population study. *PLoS One.* 2018;13(5):e0196706. Doi: 10.1371/journal.pone.0196706.

[15] Ozel A, Alici Davutoglu E, Yurtkal A, Madazli R. How do platelet-to-lymphocyte ratio and neutrophil-to-lymphocyte ratio change in women with preterm premature rupture of membranes, and threaten preterm labour? *J Obstet Gynaecol.* 2020;40(2):195-99. Doi: 10.1080/01443615.2019.1621807.

[16]

Abd El-Rhman, Abd El-Fattah I, Mohammed Zakaria AE, Ragab Abd El-Aziz B, Ahmed Rezk A. The role of platelet count and mean platelet volume during first trimester in prediction of preterm premature rupture of membranes. Al-Azhar Medical Journal. 2022;51(1):57-72. Doi: 10.21608/amj.2022.212581.

[17]

Ekin A, Gezer C, Kulhan G, Avci ME, Taner CE. Can platelet count and mean platelet volume during the first trimester of pregnancy predict preterm premature rupture of membranes? J Obstet Gynaecol Res. 2015;41(1):23-28. Doi: 10.1111/jog.12484. Epub 2014 Aug 11. PMID: 25130327.

PARTICULARS OF CONTRIBUTORS:

- Undergraduate, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Harohalli, Karnataka, India.
- Associate Professor, Department of Pathology, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Harohalli, Karnataka, India.
- Associate Professor, Department of Obstetrics and Gynaecology, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Harohalli, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Jessica Minal,
Associate Professor, Department of Pathology, Dr. Chandramma Dayananda Sagar
Institute of Medical Education and Research, Dayananda Sagar University,
Harohalli, Karnataka, India.
E-mail: jes.minal@gmail.com

PLAGIARISM CHECKING METHODS: [\[Jain H et al.\]](#)

- Plagiarism X-checker: Nov 24, 2023
- Manual Googling: Dec 11, 2023
- iThenticate Software: Dec 23, 2023 (15%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Nov 22, 2023**
Date of Peer Review: **Dec 08, 2023**
Date of Acceptance: **Dec 27, 2023**
Date of Publishing: **Feb 01, 2024**

Screening for Cervical Cancer in Female Housekeeping Staff by Pap Smear: Our Experience from A Tertiary Care Centre in A Rural Region of Karnataka, India

Ratul Chakma¹, Archana Shetty², K S Anusha³, Nagendra Prasad⁴, Santosh Yatnatti⁵, P V Nikhil⁶

ABSTRACT

Introduction: Cancer of cervix uteri is the second most common cancer amongst women in India. It consists of a long preinvasive stage making it a potentially preventable disease. Our intent is to set stage for early cancer detection by screening our hospital housing keeping females. **Methodology:** A cross sectional study was conducted from May to October 2022 in the departments of pathology and OBG at a rurally located tertiary care hospital affiliated to a teaching Medical Institute. Primary objective was to screen for cervical cancer in female housekeeping staff by determining the cervical cytology findings in Pap smears as per the 2014 Bethesda Classification of cervical cytology (2014). Secondary objective was to assess awareness about Pap smear testing. **Results:** Out of the eighty female housekeeping staff forty four were included in the study. A questionnaire was given to assess awareness followed by Pap smear test. Inflammatory smears (47.7%) were most common followed by Bacterial vaginosis (15.9%) and Trichomonas Vaginalis infestation (9.1%). One case of ASCU-S was detected which was followed up with a cervical biopsy to rule out malignancy. Though 65.5% had heard about cervical cancer, 84.1% were not acquainted with pap smears. **Conclusion:** Screening by Pap smear helped in detecting potentially pre-cancerous lesions and infections enabling timely treatment. Lack of awareness has limited the utilization of Pap smear especially in the rural areas even in women working inside healthcare premises reflects the need for creating awareness and encouraging robust participation in screening programmes.

KEY WORDS: Cancer, Cervix, Cytology, Pap Smear, Screening.

Introduction

Globally 604,127 new cases of cervical cancer are diagnosed every year and 341,831 of women die from this disease^[1]. Cancer of cervix uteri is the second most common cancer amongst women in India, breast cancer being the first^[2]. A recent report based on 28 population-based cancer survey registries, the proportion of new cervical cancers to total women cancer varies from 5.5% to 26.5%^[3].

Access this article online

Quick Response Code:



Website: www.jmsh.ac.in

Doi: 10.46347/jmsh.v9i3.23.119

¹MBBS Student (Phase II), Dr. Chandramma Dayananda Institute of Medical Education & Research, Dayananda Sagar University, Ramanagara, 562112, Karnataka, India, ²MBBS, MD (Pathology), Professor, Department of Pathology, Dr. Chandramma Dayananda Institute of Medical Education & Research, Dayananda Sagar University, Ramanagara, 562112, Karnataka, India, ³MBBS, DGO, DNB, Assistant Professor, Department of OBG, Dr. Chandramma, Dayananda Institute of Medical Education & Research, Dayananda Sagar University, Ramanagara, 562112, Karnataka, India, ⁴MBBS, MS (OBG), Professor & HOD, Department of OBG, Dr. Chandramma, Dayananda Institute of Medical Education & Research, Dayananda Sagar University, Ramanagara, 562112, Karnataka, India, ⁵MBBS, MD (Community medicine), Associate Professor, Department of Community medicine, Dr. Chandramma Dayananda Institute of Medical Education & Research, Dayananda Sagar University, Ramanagara, 562112, Karnataka, India, ⁶Assistant Professor, Department of Pathology, Dr. Chandramma Dayananda Institute of Medical Education & Research, Dayananda Sagar University, Ramanagara, 562112, Karnataka, India

Address for correspondence:

Archana Shetty, MBBS, MD (Pathology), Professor, Department of Pathology, Dr. Chandramma Dayananda Institute of Medical Education & Research, Dayananda Sagar University, Ramanagara, 562112, Karnataka, India. E-mail: archanashetty2924@gmail.com

Mortality due to cervical cancer is also an indicator of health inequalities, as more than 86% of all deaths due to cervical cancer are occurring in developing countries, low- and middle-income countries^[4]. While cancer incidence has been declining in developed countries, developing countries like ours are yet to reach significant reduction in overall cancer incidence and mortality^[5,6].

The present study focuses on Pap smear - an effective and relatively inexpensive test which can be used both as a diagnostic tool or a screening test. Cervical cancer consists of a long preinvasive stage making it a potentially preventable disease by early detection and screening^[7,8]. In India, the proportion of women undergoing pap smear screening is only 2.6% -5% as compared to 68%-84% in developed countries^[9].

Karnataka is yet to gain momentum when it comes to Pap smear screening of women across the state^[10]. Our Medical Institute being located in a rural geographic region is an employment provider to many, with women being employed in various posts. The intent of this study is to set the stage for early cancer detection by first creating awareness and screening our hospital housing keeping females, who in spite of working in healthcare facilities do not routinely undergo screening due to ignorance, hesitation and associated stigma.

Methodology

This was a cross sectional study conducted from July to October 2022 in the departments of Pathology and OBG of a rurally located tertiary care hospital affiliated to a teaching Medical Institute. Primary objective was to screen for cervical cancer in housekeeping females by determining the cervical cytology findings in Pap smears as per the 2014 Bethesda Classification of cervical cytology (2014). Secondary objective was to assess awareness about Pap smear testing in the study population. Calculated sample size was forty two. Inclusion criteria: Women from 21 to 65 years of age. Exclusion criteria: Women not willing to participate in the study. Known / treated cases of cancer cervix, post hysterectomy females and women below 21 years and above 65 years. Of the eighty female housekeeping staff working in the hospital twelve were excluded based on the criteria. Consent was obtained from forty-four who were included in the study.

After recording demographic details, a validated questionnaire was given to the participants to

answer. A small induction session on educating women about cervical cancer and the need for pap smear was conducted by showing posters and print outs. This was followed by taking Pap smears after obtaining consent in the presence of a female nurse and an Obstetrician. Per speculum findings were noted and two smears were taken one each from ectocervix and endocervix using Ayer's spatula. Smears were fixed using spray fixative and sent to the laboratory. Staining was done using standard protocol for conventional pap staining.

Cytological findings were reported as per the Bethesda system for reporting cervical cytology (2014). Data was entered in Microsoft Excel 2016. Statistical analysis was done using IBM SPSS Statistics for Windows 9/10, Version 26.0, (IBM Corp Armonk, NY). Results were calculated as mean $\pm$ standard deviation. Chi square/Fischer's tests were used to assess and associate any significant correlation between age, religion, marital status and education with screening of cervical cancer. Approval was obtained for the study from the Institutional Scientific Committee and Institutional Ethics Committee Ref Letter – CDSIMER/MR/0022/IEC/2022.

Results

A total of 44 housekeeping staff were enrolled for the study. Age of participants ranged from 26 years to 64 years. Majority of them were in their 3rd decade of life with mean age being 38.6 years. Only 9% of the participants had an educational qualification of degree and above, with more than 52% having studied up to secondary education level. Most of the surveyed participants belonged to lower middle-class (45%) and middle class (34%) of socio-economic background as per revised BG Prasad Classification for socioeconomic status. Only one was unmarried while 97% were married and sexually active. Average age of getting married was 16.5 years, with minimum age at 13 years and maximum at 24 years. 73% were multiparous with maximum of four childbirths. Age of attaining menarche was between 12-13 years in 61% of women. Average age of getting married was between 15 to 19 years.

On per speculum examination, the following findings were noted (Figure 1). Among the abnormal findings, white discharge was noted in 17 cases, cervical hypertrophy in 6 cases, erosion in 10 cases, firm cervix and bleeding on touch in 4 cases each with normal finding in 3 cases. (Figure 2) Categorization of Pap smear cytology was as follows (Figure 3 a-c

&Figure 4 a-c)

For one case reported as ASC-US (Atypical Cells of Undetermined Significance), a follow up colposcopic guided cervical biopsy was taken which was reported as chronic cervicitis without dysplasia. Cases with reactive cellular changes were asked to come for a repeat pap smear after treating infection. Cases with infective etiology were treated accordingly.



Figure 1: Per speculum findings before taking pap smear

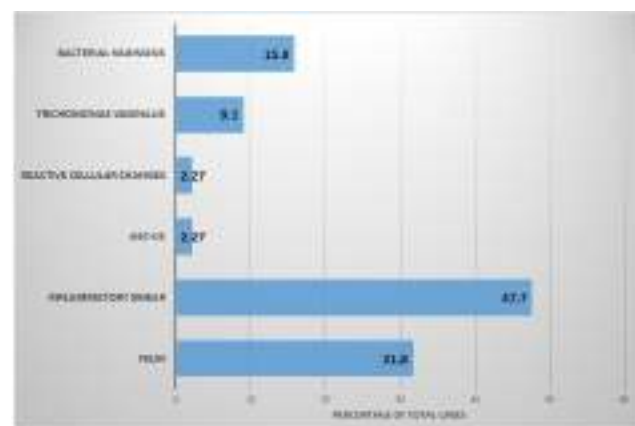


Figure 2: Categorization of papsmear cytology as per Bethesda System of Reporting of Cervical Cytology (2014)

Awareness Survey – Questionnaire

On analysis of the questionnaire 65.9% of participants had heard of cervical cancer before however, only 34.1% of participants stated that they knew the associated risk factors. A mere 11.4% of the participants were acquainted with symptoms of cervical cancer. Majority of participants (84.1%) included in the study, had never heard about pap smears (Table 1).



Figure 3: a: Photomicrograph showing normal Pap smear. Pap stain x 400. 3b: Photomicrograph showing inflammatory smear. Pap stain x 100. 3c: Photomicrograph showing aggregates of neutrophils (pus balls) (black arrow) Pap stain x 400

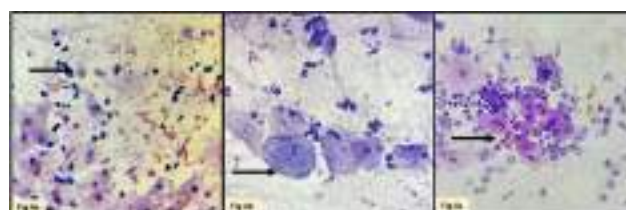


Figure 4: a: Photomicrograph showing Trichomonas vaginalis. (black arrow) Pap stain x 400. b: 'Clue' cells suggestive of bacterial vaginosis. (black arrow) Pap stain x 400. c: Photomicrograph showing group of ASCUS cells. (black arrow) Pap stain x 400

Only 2 out of the 44 participants in the study were aware about the availability of Pap smear testing facility being available at our hospital. There was statistically significant association between Pap smear findings and Age group among the study subjects with Fischer's exact test value of 7.816 with p-value 0.029.

There was no statistically significant association between PAP smear findings and religion, educational status, marital status, socio-economic status, parity, age at menarche and questions related to awareness about cervical cancer.

Discussion

Cervical cancer is next only to breast cancer as the most prevalent cancer in India^[2]. Cervical cancer is yet to be included among the top ten health priorities in India. This may be one of the contributory causes for lack of screening^[10]. Being a potentially amenable cancer to screening, pro-active initiatives that are already implemented must be scaled up for early detection and awareness of cervical cancer, especially among the rural population.

Table 1: Responses to questionnaire by study participants

Question (N =44)	Response	Frequency	Percent
Heard about cervical cancer?	Yes	29	65.9%
	No	15	34.1%
Awareness regarding risk factors associated with cervical cancer?	Yes	15	34.1%
	No	29	65.9%
Awareness about symptoms associated with cervical cancer?	Yes	5	11.4%
	No	39	88.6%
Heard about Pap Smear?	Yes	7	15.9%
	No	37	84.1%
Awareness of pap smear test availability in our hospital?	Yes	2	4.5%
	No	42	95.5%

Table 2: Comparative Analysis of key findings from other Indian studies with present study

Results	Verma et al [5]	Mishra et al [4]	Sachan et al [3]	Kulkarni et al [10]	Present Study
NILM *	56%	52.5%	48.8%	11.4%	31.8%
Inflammatory	32.5%	36%	42.7%	59.6%	47.7%
ASC-US †	1.0%	3.5%	2.9%	-	2.27%
ASCH ‡	-	0.5%	-	-	-
LSIL §	5.5%	4.0%	5.1%	-	-
Squamous Cell Carcinoma	-	-	-	-	-
Trichomonas vaginalis	-	-	-	1.9%	9.1%
Candida	-	-	-	0.4%	-
Bacterial vaginosis	-	-	-	2.3%	15.9%
Squamous metaplasia	-	-	-	34.9%	-

*NILM- Negative for intraepithelial lesion/ malignancy †ASC-US – Atypical Squamous Cell of Undetermined Significance ‡ASC-H – Atypical Squamous Cells Cannot Exclude High grade squamous intraepithelial lesion §LSIL – Low Grade Squamous Intraepithelial lesion

Cervix is amenable to screening by a number of methods like visual inspection with acetic acid (VIA), magnified VIA (VIAM) visual inspection with Lugol's iodine (VILI), and HPV DNA testing and pap smear cytology. Papanicolaou (Pap) smear screening continues to remain one of the most reliable methods to diagnose early symptoms and prevent aggravated form of cervical cancer. This cancer is preceded by a pre-malignant stage and it takes 10-15 years to progress to a malignant lesion providing a window of opportunity for early detection.

In our study, on examination 68.2% of the study population had an abnormality in cervix. In a

study by Verma et al per speculum examination of cervix revealed 50.5% of women with normal looking cervix, 25% had cervical ectopy, 13% chronic cervicitis and 11.5% had ectropion of cervix^[5]. Cytology was done in all the 200 women in the study with 56% of the smears reported as negative for intraepithelial lesions or malignancy. 32.5% were reported as inflammatory smears, 5.5% as LSIL and 2.5% as HSIL. Cytological diagnosis of precancerous lesions like LSIL & HSIL on pap smears has been correlated well with presence of p16 and Ki67 which are markers in predicting HPV infection (well established aetiology of cervical cancer) which can be further confirmed by HPV DNA testing^[11]. A

comparative analysis of key findings from this study and results reported by survey of literature are summarized in the table below. Results from the present study are overall in line with others.

Of the 44 participants in the present study, 77.3% had abnormal cytology. Most of them belonged to the 31-40 age group. ASC-US accounted to 2.27% of the sample smears. The percentage of ASC-US in this study is comparable to 2.9%, 1% and 3.5% in other similar studies^[3-5]. Recent guidelines recommend close monitoring, repeat cytology and testing for HPV in cases of ASCUS as this entity is associated with a potential to progress to neoplasia^[12]. In the present study, 47.7 % of the smears were inflammatory in nature with non specific etiology. This value is significantly higher than 32.5% and 36% and 42% in studies done by Verma et al and Mishra et al and Sachan et al respectively^[3-5]. However, there was a change in trend in a study done by Kulkarni et al in a tertiary care centre with 59.5% of the smears being inflammatory^[10]. It is recommended that persistent inflammation should be appropriately treated otherwise, the chance of development of cervical intraepithelial lesion increases^[13]. The incidence of Bacterial vaginosis (15.9%) and Trichomonas Vaginalis (9.1%) was also much higher in the present study compared to 1.9% and 2.3% respectively in the study done by Kulkarni et al.^[10]. This higher susceptibility to bacterial and fungal infections may be attributed to environmental factors as well as poor hygiene practices among this population, undermining need for creating awareness about hygiene practices. Microbial infections are known to be about 1.7 times more prevalent among women with difference between age at menarche and age at first sexual intercourse^[14]. Paul A Cohen et al have identified the following risk factors for cervical cancer -Early age of sexual debut, multiple sexual partners or a high-risk sexual partner, immunosuppression, history of sexually transmitted infection, history of HPV related vulvar or vaginal dysplasia^[14]. Among the above, early age at marriage and unawareness about screening programmes were key factors in our study. In our study, 25.4% of women though eligible for screening did not want to get themselves screened affirming the need for repeated interactions. Lack of awareness about Pap smear and its importance could also be a reason why attendance and participation even in a hospital which is easily accessible to them is very low. Findings of the present study imply that creating awareness about and screening for cervical cancer should be adopted as an integral

part of primary health-care setups in resource-poor countries where the same can be implemented through primary health-care workers, as it does not require a laboratory infrastructure. Though testing for HPV DNA is associated with higher sensitivity requirement of sophisticated laboratory infrastructure and high cost are challenges for it to be implementable^[15].

Limitations of the study

The sample size was small as we had targeted only a specific stratum of housekeeping females working in our hospital to meet the project timelines.

Recommendations from the present study :

Scope of this project can be applied to a larger population with more detailed demographic factors included in the survey to draw significant statistical inferences as a study in future.

Findings of this study will be beneficial if the same model can be replicated in other hospitals and medical institutions across India by initiating screening and awareness programmes involving women working within healthcare premises and spreading out to the public.

Conclusion

Screening by Pap smear has set the stage for early detection of cervical cancer and also helped in identifying potentially pre- cancerous lesions and infections enabling timely treatment among housekeeping females at our Medical Institute. Lack of awareness has limited the utilization of Pap smear especially in the rural areas even in women working inside healthcare premises reflecting the need for creating cervical cancer awareness and encouraging robust participation in screening programmes which need to be organized from grass root levels of rural regions to cover a wider susceptible female population.

References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA: A Cancer Journal for Clinicians. 2021;71(3):209-249. Available from: <https://doi.org/10.3322/caac.21660>.
2. Mathur P, Sathishkumar K, Chaturvedi M, Das P, Sudarshan KL, Santhappan S, et al. Cancer Statistics, 2020: Report From National Cancer Registry Programme, India. CO Global Oncology . 2020;6:1063-

1075. Available from: <https://doi.org/10.1200/GO.20.00122>.
3. Sachan PL, Singh M, Patel ML, Sachan RL. A Study on Cervical Cancer Screening Using Pap Smear Test and Clinical Correlation. *Asia-Pacific Journal of Oncology Nursing*. 2018;5(3):337–341. Available from: https://doi.org/10.4103/apjon.apjon_15_18.
4. Mishra P, Thapa R, Dinkar AK. A study on cervical cancer screening using pap smear in urban area in state of Meghalaya, India. *International Journal of Reproduction, Contraception, Obstetrics and Gynecology*. 2018;7(8):3113–3113. Available from: <http://dx.doi.org/10.18203/2320-1770.ijrcog20183300>.
5. Verma A, Verma S, Vashist S, Attri S, Singhal A. A study on cervical cancer screening in symptomatic women using Pap smear in a tertiary care hospital in rural area of Himachal Pradesh, India. *Middle East Fertility Society Journal*. 2017;22(1):39–42. Available from: <https://doi.org/10.1016/j.mefs.2016.09.002>.
6. Botelho MC, Alves H, Richter J. Estrogen Catechols Detection as Biomarkers in Schistosomiasis Induced Cancer and Infertility. *Letters in Drug Design & Discovery*. 2016;14(2):135–138. Available from: <https://doi.org/10.2174/1570180813666160720165057>.
7. Shekhar S, Sharma C, Thakur S, Raina N. Cervical Cancer Screening: Knowledge, Attitude and Practices among Nursing Staff in a Tertiary Level Teaching Institution of Rural India. *Asian Pacific Journal of Cancer Prevention*. 2013;14(6):3641–3645. Available from: <https://doi.org/10.7314/APJCP.2013.14.6.3641>.
8. Van Dyne EA, Hallowell BD, Saraiya M, Senkomago V, Patel SA, Agrawal S, et al. Establishing Baseline Cervical Cancer Screening Coverage — India, 2015–2016. *MMWR Morbidity and Mortality Weekly Report*. 2015;68(1):14–19. Available from: <https://doi.org/10.15585/mmwr.mm6801a4>.
9. Majumder S. Socioeconomic status scales: Revised Kuppaswamy, BG Prasad, and Udai Pareekh's scale updated for 2021. *Journal of Family Medicine and Primary Care*. 2021;10(11):3964. Available from: https://doi.org/10.4103/jfmpc.jfmpc_600_21.
10. Kulkarni PR, Rani H, Vimalambike MG, Ravishankar S. Opportunistic Screening for Cervical Cancer in a Tertiary Hospital in Karnataka, India. *Asian Pacific Journal of Cancer Prevention*. 2013;14(9):5101–5105. Available from: <https://doi.org/10.7314/apjcp.2013.14.9.5101>.
11. Silva DC, Gonçalves AK, Cobucci RN, Mendonça RC, Lima PH, Cavalcanti G. Immunohistochemical expression of p16, Ki-67 and p53 in cervical lesions – A systematic review. *Pathology - Research and Practice*. 2017;213(7):723–729. Available from: <https://doi.org/10.1016/j.prp.2017.03.003>.
12. Jahic M, Jahic E. Diagnostic Approach to Patients with Atypical Squamous Cells of Undetermined Significance Cytologic Findings on Cervix. *Medical Archives*. 2016;70(4):296–296.
13. Barouti E, Farzaneh F, Sene AA, Tajik Z, Jafari B. The pathogenic microorganisms in papanicolaou vaginal smears and correlation with inflammation. *Journal of Family and Reproductive Health*. 2013;7:23–30. Available from: <https://pubmed.ncbi.nlm.nih.gov/24971098/>.
14. Ghosh S, Pattanshetty SM, Mallya SD, Pandey D, Guddattu V, Kamath VG, et al. Cervical cytology and associated factors among tribal women of Karnataka, India. *PLOS ONE*. 2021;16(3):e0248963. Available from: <https://doi.org/10.1371/journal.pone.0248963>.
15. Cohen PA, Jhingran A, Oaknin A, Denny L. Cervical cancer. *The Lancet*. 2019;393(10167):169–182. Available from: [https://doi.org/10.1016/s0140-6736\(18\)32470-x](https://doi.org/10.1016/s0140-6736(18)32470-x).

How to cite this article: Chakma R, Shetty A, Anusha KS, Prasad N, Yatnatti S, Nikhil PV. Screening for Cervical Cancer in Female Housekeeping Staff by Pap Smear: Our Experience from A Tertiary Care Centre in A Rural Region of Karnataka, India. *J Med Sci Health* 2023; 9(3):263-268

Date of submission: 06.04.2023
 Date of review: 03.06.2023
 Date of acceptance: 04.09.2023
 Date of publication: 19.12.2023



Original Research Article

Utility of clinico-hematological risk assessment and severity score (chase score) in covid-19 patients

Supriya Sandeepa¹, Puneet K Nagendra², Bhargavi K N¹, Sandeepa H S^{3*}, Narendra Umashankar²¹Dept. of Pathology, CDSIMER-Rural Health Training Center (Dayanand Sagar), Ramanagara, Karnataka, India²Dept. of Respiratory Medicine, CDSIMER-Rural Health Training Center (Dayanand Sagar), Ramanagara, Karnataka, India³Dept. of Respiratory Medicine, Adichunchanagiri Institute of Medical Sciences, B.G Nagar, Karnataka, India

ARTICLE INFO

Article history:

Received 04-04-2022

Accepted 30-07-2022

Available online 07-12-2023

Keywords:

COVID-19

severity

Scoring system

Prognosis

Hematology parameters

Clinical outcomes

ABSTRACT

Background: Treating COVID-19 during pandemic situations is a challenge to utilize the resources judiciously. A proper triage and prognostication are very helpful. We aim to formulate a combined clinico-hematological scoring system in COVID – 19 patients and check its utility in prognostication in terms of mortality and development of complications in COVID-19 patients.

Materials and Methods: This retrospective cross-sectional study included patients that were admitted to CDSIMER for treatment. Demographic, clinical, laboratory and outcome data were extracted from the respective patient files stored at medical records department. We formed a clinico hematological scoring system that included 8 parameters and each parameter was scored as 1 or 2. Based on total score (range 8 to 16) obtained they were categorized into low risk and high risk for treatment outcomes.

Results: We studied data of 451 COVID-19 patients admitted in CDSIMER from April 2021 to July 2021. We observed 100% recovery in the patients with score 8, 9 and 10. The mortality began to appear from score 11 onwards, showing increasing trend of mortality with higher scores. Therefore, score of ≥ 11 was established as the cut off to determine high risk for mortality. Out of the total 451 COVID patients, 70.10% (n=316 cases) came under the high-risk category, out of which 13.60% (n=43) had mortality and despite high risk as many as 86.40% patients (n=273) recovered with or without complications. Low risk category had demonstrated 100% (n=351) recovered cases. The p value was significant (0.00) on comparing the outcomes in the two categories of the proposed scoring system.

Conclusion: Chase score is a novel scoring system easy and feasible to use in any hospital setting. The score helps clinicians to triage patients at admission to determine the standard of care, the need to carry out selective follow up investigations but not compromising in implementing the standard of care. Future prospective studies which can measure the internal and external validity of the score is very important.

This is an Open Access (OA) journal, and articles are distributed under the terms of the [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License](#), which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprint@ipinnovative.com

1. Introduction

The severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) causes the novel coronavirus disease (COVID-19). The sickness can range from a simple cold to more serious conditions such as severe acute

respiratory syndrome (SARS). A confirmed case is defined by epidemiological history and/or clinical aspects indicating that a suspected patient had contact with COVID-19 infected persons and/or had symptoms and signs of COVID-19 infection, as well as positive laboratory testing detecting virus nucleic acid.¹⁻³

Infectious agents, such as COVID 19, have been shown to play a role in the development of infection to

* Corresponding author.

E-mail address: drsupriyasandeep123@gmail.com (Sandeepa H S).

serious thrombotic events. A wide range of hematological abnormalities are found in affected patients, raising the risk of major thrombotic consequences in severe cases. Organ dysfunction, pulmonary embolism, septic shock, myocardial infarction, heart failure, and cerebral infarction are few of the fatal effects to list.^{4,5} They accomplish this by establishing a coagulation cascade. They bind to the angiotensin converting enzyme-2 (ACE-2) receptor on Type II lung pneumocytes, causing the kallikrein-kinin system to become dysregulated. The hypercoagulable state is thought to be caused by ACE-2 downregulation, which results in angiotensin II-mediated vascular dysfunction. Various hematological parameters and their clinical manifestations are indicators of the systemic inflammatory response.⁶

The battery of biochemical and hematological parameters that are currently performed as part of standard of care in accordance with the respective National COVID treatment policies are critical in classifying the severity of infection at presentation and assisting in the selection of treatment strategies. Hematologic measures and their ratios have a high prognostic value, are low-cost, and simple to administer and monitor.^{4,5} Researchers and physicians throughout the world can use this data to analyse and build a score system that will aid in the triage of COVID19 patients.

1.1. Added value of this study

Based on intensive data search, we were able to find a few studies that were based on clinical categories that can help us treat COVID-19 patients. There was a scarcity of information on simple prognostic tools' availability. Here, with the retrospective analysis of data on COVID-19 patients treated in our hospital, we propose a novel scoring system that can explore the available clinical information and hematological parameters to triage and prognosticate the COVID-19 patients even in resource-limited situations. The suggested 'CHASE' scoring system, which incorporates clinical and hematological data, is particularly useful in risk stratifying patients and guiding treating doctors in optimising therapy/referral to higher centres of healthcare and prognosticating disease.

2. Materials and Methods

2.1. Study design and participants

A cross-sectional study, retrospective data analysis of inpatients from Dr Chandramma Dayananda Sagar Institute of Medical education and Research (CDSIMER, Karnataka, India). Patients diagnosed with COVID-19 according to the Indian Council of Medical Research (ICMR) with positive SARS-CoV-2 RNA detection in throat swab specimens, both male & female adults presenting with mild to severe categories were eligible. Exclusion criteria were pediatric and pregnant patients, missing hematology

and clinical data, transfer to other medical facilities with unknown outcomes. The study was approved (number: CDSIMER/MR/0017/IEC/2021) by the institutional ethics committee of CDSIMER.

2.2. Definitions

According to Indian Council of Medical Research (ICMR), the mild form of severity of COVID-19 is without shortness of breath or hypoxia ($\text{SpO}_2 \geq 94\%$), moderate cases are with cough, fever, dyspnea, SpO_2 of 90 to 93% on room air and severe cases with severe respiratory distress, pneumonia, $\text{SpO}_2 < 90\%$ on room air.

CHASE Score is combination of clinical score and hematological score. Clinical Score= Age + Gender + Symptom duration + Comorbidity + SpO_2 ; Hematology Score= Hb+NLR+PLR. The scoring was done randomly allocating 1 for the lower limit of reference range and 2 for the higher limit of the reference value in each parameter. The reference range for each of parameters were referenced from the previously published literature. The points to the hematological and clinical parameters are as follows:

1. A. Hemoglobin (Hb) expressed in gram % 1 for $> 10 \text{ g\%}$; 2 for $\leq 10 \text{ g\%}$.
2. B. Neutrophil to Lymphocyte Ratio (NLR): Formula: (Absolute Neutrophil Count)/ (Absolute Lymphocyte count). 1 for < 3.13 , 2 for ≥ 3.13 .⁷
3. C. Platelet to Lymphocyte Ratio (PLR): Formula: (Platelet Count)/ (Absolute Lymphocyte count). 1 for < 180.22 , 2 for ≥ 180.22 .⁸
4. D. Age in years: 1 for < 50 years, 2 for ≥ 50 years.
5. E. Gender: 1 for female, 2 for male.
6. F. Duration of symptoms (days): the day of presentation from the day onset of symptoms. 1 for < 5 days of symptoms, 2 for ≥ 5 days of symptom.
7. G. Comorbidity: 1 for absence of one or more comorbidities like DM, HTN, IHD, CVA, Asthma, COPD, obesity. 2 for presence of one or more comorbidities like DM, HTN, IHD, CVA, Asthma, COPD, obesity.
8. H. Oxygen saturation (SpO_2) at room air on presentation, measured by fingertip pulse oximeter. 1 if SpO_2 is $\geq 94 \%$, 2 if SpO_2 is $< 94\%$.

Chase Score Interpretation: low risk for complications/ morbidity, mortality < 11 ; high risk for complications/ morbidity, mortality ≥ 11 .

2.3. Procedures

Hematology parameters were accessed from the laboratory Information system. The demographic, clinical and outcome data were extracted from respective patient files available at the Medical Records Department. A panel of laboratory parameters including hematological and other biochemical

parameters were done at admission to all the patients. They were repeated according to the clinician's discretion based on everyday clinical condition of the patient. All laboratory tests were done in the central laboratory of CDSIMER. The treating doctors judged the mode of treatment based out of the standard of care set by the ICMR. All data were entered into a microsoft excel sheet and checked by two physicians. Discharged patients were given written advice for isolation, treatment with appropriate drugs and advised to follow up after two weeks.

2.4. Statistical analysis

Categorical variables were presented as frequency rates and percentages and analysed using χ^2 test. The study outcomes were the survivors and non survivors. Complications in each group were also included. Ap value of 0.05 or less was considered statistically significant. We did statistical analysis using SPSS software.

2.5. Funding

The funder of the study had no role in study design, data collection, data analysis, data interpretation or writing the report. The researchers had full access to the data in the study and are responsible for the publication.

3. Results

We collected and analysed the data of 451 COVID-19 patients admitted in CDSIMER from April 2021 to July 2021. Table 1 shows distribution of cases with survivors and non survivors under each score. The score ranged from minimum of 8 to a maximum of 15, though 16 is the maximum according to the scoring system, we had no patients with the score 16. We observed 100% recovery in the patients with score 8, 9 and 10. The mortality began to appear from score 11 onwards, showing increasing trend of mortality with higher scores. Therefore, score of ≥ 11 was established as the cut off to determine high risk for mortality.

Out of the total 451 COVID patients, 70.10% (n=316 cases) came under the high-risk category, out of which 13.60% (n=43) had mortality and despite high risk as many as 86.40% patients (n=273) recovered with or without complications. Low risk category had demonstrated 100% (n=351) recovered cases. The p value was significant (0.00) on comparing the outcomes in the two categories of the proposed scoring system.

The development of complications in patients with high-risk and low risk categories was significantly different with a p value of 0.000. We observed complications in 27.40 % (n=135) in the low-risk category, patients, in comparison to 81 % (n=256) of patients in high-risk category (Table 3).

4. Discussion

Traditionally, scoring systems have been utilized and proven to be an adjuvant to supplement physician judgement in different areas of medicine. They have also aided in indicating the susceptibility and prognosis.⁶ A scoring system is needed to classify the patients in order to determine the need for follow-up, home isolation, quarantine or the conduction of further investigations.⁹ A prognostic model can be generated using the hematological parameters, risk factors, clinical parameters and outcomes. This scoring system helps identify patients with better prognosis after infection with SARS-Cov2. We propose a novel scoring system that is simple and based on numerous clinical and hematological parameters which can be used in any basic hospital setting.

Our scoring system categorized the COVID-19 patients as low risk and high risk based on giving points (1 or 2) to each of the clinical parameters like age, gender, duration of symptoms, presence of comorbidity, oxygen saturation on room air at presentation and hematological parameters like hemoglobin, NLR and PLR. There are totally 8 parameters with a total score ranging from a minimum of 8 to a maximum of 16. The high risk was defined as a total score of ≥ 11 . There was no mortality in low-risk patients and above 80 % of patients in high-risk group developed complications.

Let us look at few of the following scoring systems that were published in relation to the COVID-19. The scoring systems were a permutation and combination of clinical presentation, laboratory, and radiological parameters.

Jhala risk scoring system (JRSS) to assess the severity of disease risk was based on age, ethnicity, presence of any lung disease, presence of cardiovascular disease, smoking history, and diabetes history with laboratory parameters. The lab parameters that were used are D dimer, CRP, LDH, Troponin, Ferritin and CPK. A combined score of ≥ 7 was concluded to be an indication of intensive care.¹⁰

Zhang c et al inferred that age, white blood cell count, neutrophil count, glomerular filtration rate, and myoglobin were selected by multivariate analysis as candidates of scoring system for prediction of disease severity in COVID-19 with the result being probability of patients in high-risk group developing severe disease was 20.24 times than that in low-risk group.¹¹

In a scoring system by Yang F et al, the disease severity and mortality risk were assessed using Acute Physiology and Chronic Health Evaluation II (APACHE II); Sepsis-related Organ Failure Assessment (SOFA); multilobular infiltration, hypo-lymphocytosis, bacterial coinfection, smoking history, hypertension and age (MuLBSTA); and pneumonia severity index (PSI) scores. They concluded that older, overweight, male patients with a history of chronic illnesses and continuously decreased lymphocyte proportions and increased D-dimer levels might have higher

Table 1: Distribution of cases under each score with outcomes.

Chase score	Non survivors		Survivors	
	Number	Percentage	Number	Percentage
8	0	0	16	100
9	0	0	44	100
10	0	0	75	100
11	2	2.8	70	97.2
12	12	16.4	61	83.6
13	17	17.3	81	82.7
14	9	16.4	46	83.6
15	3	16.7	15	83.3
Total	43	9.5	408	90.50

Chi square= 33.04, p value= 0.000

Table 2: Distribution and comparison of mortality in high risk and low risk category

Chase score	Non-Survivors	Outcome Survivors	Total
High risk (≥ 11)	43 (13.60%)	273 (86.40%)	316 (70.10%)
Low risk (< 11)	0 (0.00%)	135 (100.00%)	135 (29.9%)
Total	43 (9.50%)	408 (90.50%)	451 (100.00%)

Chi square -20.30, p value- 0.000

Table 3: Distribution and comparison of complications in high risk and low risk category

Chase score	Complications		Total
	No	Yes	
High risk (≥ 11)	60 (19.00%)	256 (81%)	316
Low risk (< 11)	98 (72.60%)	37 (27.40%)	135
Total	158 (35.00%)	293 (65.00%)	451

Chi square -119.43, p value- 0.000

risks of death owing to COVID-19. The combination of SOFA MuLBSTA and PSI systems after admission might be sensitive in assessing the mortality risk of patients with COVID-19 who are in critical condition.¹²

Jiwa N et al developed two models. Model A consisted of two variables, presence of pneumonia and ischemia. Model B consisted of three variables, age > 65 years, supplemental oxygen ≥ 4 L/min, and C-reactive protein (CRP) > 10 mg. According to their study, Model B was the better of the two models tested, yielding a moderate Area under curve and a more robust separation of mortality between the highest and lowest scores.¹³

Altschul DJ et al conducted a severity score ranging from 0 to 10. It consisted of age, oxygen saturation, mean arterial pressure, blood urea nitrogen, C-Reactive protein, and international normalized ratio. Based on the risk categorization, the probability of mortality was 11.8%, 39% and 78% for patients with low (0–3), moderate (4–6) and high (7–10) COVID-19 severity score respectively.¹⁴

Our CHASE scoring system included only those crucial clinical and important hematology parameters that were feasible in a resource limited setting. We did not include the biochemical parameters as most of them were expensive and not available in all the hospital set-ups in our country. Many

of the studies arrived at scoring systems that triaged the patients at admission to decide on the treatment strategies and of less effective prognostic value. The CHASE scoring system not only helped in triaging but also could predict the outcome and development of complications effectively. This is important to implement strategies for more effective utilization of the limited medical resources during pandemic situations. CHASE score is the least complicated and very effective scoring system known so far.¹⁵

5. Conclusion

CHASE score is a novel scoring system easy and feasible to use in any hospital setting. The score helps clinicians to triage patients at admission to determine the standard of care, the need to carry out selective follow up investigations but not compromising in implementing the standard of care. The score is helpful as well during counselling the patients' caretakers as they can be conveyed with an objective assessment pattern to give them the ray of hope in the low-risk categories.

6. Recommendations and Limitations

Future prospective studies which can measure the internal and external validity of the score is very important. Studies are also required using this scoring system which can help us determine the place of treatment that is home or hospital-based treatment, follow-up protocol that can help strategize the treatment.

7. Source of Funding

None.

8. Conflict of Interest

None.

References

1. Prabhu S, Patil N. Study correlating lymphocyte to monocyte ratio and platelet to lymphocyte ratio with the severity in COVID-19 patients: a cross sectional study. *Int J Adv Med*. 2021;8(2):201–6.
2. Chen G, Wu D, Guo W, Cao Y, Huang D, Wang H, et al. Clinical and immunological features of severe and moderate coronavirus disease 2019. *J Clin Invest*. 2020;130(5):2620–9.
3. Wu P, Hao X, Lau EHY, Wong JY, Leung KSM, Wu JT, et al. Real-time tentative assessment of the epidemiological characteristics of novel coronavirus infections in Wuhan, China, as at 22. *Euro Euro Surveill*. 2020;25(3):200004. doi:10.2807/1560-7917.ES.2020.25.3.2000044.
4. Jamuna D, Sathiyarajewaran P, Devi MS, Kanakavalli K, Vinod NP. Survival analysis to assess the length of stay of novel coronavirus (COVID19) patients under Integrated Medicine - Zinc, Vitamin C & Kabasura Kudineer (ZVcKK). *Eur J Mol Clin Med*. 2020;7(10):1375–87.
5. Liao D, Zhou F, Luo L, Xu M, Wang H, Xia J, et al. Haematological characteristics and risk factors in the classification and prognosis evaluation of COVID-19: a retrospective cohort study. *Lancet Haematol*. 2020;7(9):671–78.
6. Yang AP, Liu JP, Tao WQ, Li H. The diagnostic and predictive role of NLR, d-NLR and PLR in COVID-19 patients. *Int Immunopharmacol*. 2020;84:106504. doi:10.1016/j.intimp.2020.106504.
7. Liu J, Liu Y, Xiang P, Pu L, Xiong H, Li C, et al. Neutrophil-to-lymphocyte ratio predicts critical illness patients with 2019 coronavirus disease in the early stage. *J Transl Med*. 2020;18(1):1–12.
8. Qu R, Ling Y, Zhang YHZ, Wei LY, Chen X, Li XM, et al. Platelet to lymphocyte ratio is associated with prognosis in patients with coronavirus disease-19. *J Med Virol*. 2020;92(9):1533–41.
9. Allam MF. Scoring system for the diagnosis of COVID-19. *Open Public Health J*. 2020;13(1):413–4.
10. Petersen J, Jhala D. Practical Risk Scoring System for Predicting Severity of COVID-19 Disease. *Clin Pathol*. 2022;15:2632010X211068427. doi:10.1177/2632010X211068427.
11. Zhang C, Qin L, Li K, Wang Q, Zhao Y, Xu B, et al. A Novel Scoring System for Prediction of Disease Severity in COVID-19. *Front Cell Infect Microbiol*. 2020;10:318. doi:10.3389/fcimb.2020.00318.
12. Yang F, Zou H, Gan J, Zhang Z, Zhao Y, Jiang C, et al. Important scoring systems for assessing the severity of COVID-19 based on COVID-19-related deaths in Wuhan, China. *Emerg Crit Care Med*. 2021;1(1):29–36.
13. Jiwa N, Mutneja R, Henry L, Fiscus G, Zu Wallack R (2021) Development of a brief scoring system to predict any-cause mortality in patients hospitalized with COVID-19 infection. *PLoS One*;16(7):e0254580. doi:10.1371/journal.pone.0254580.
14. Altschul DJ, Unda SR, Benton J, Ramos R, Cezayirli P, Mehler M, et al. A novel severity score to predict inpatient mortality in COVID-19 patients. *Scientific Rep*. 2020;10(1):16726. doi:10.1038/s41598-020-73962-9.
15. Maves RC, Downar J, Dichter JR, Dichter JR, Devereaux A, Geiling JA, et al. Triage of Scarce Critical Care Resources in COVID-19 An Implementation Guide for Regional Allocation. *Chest*. 2020;158(1):212–25.

Author biography

Supriya Sandeepa, Professor  <https://orcid.org/0000-0002-9548-3492>

Puneet K Nagendra, Assistant Professor  <https://orcid.org/0000-0002-9887-3699>

Bhargavi K N, Senior Resident  <https://orcid.org/0000-0002-1005-0904>

Sandeepa H S, Associate Professor  <https://orcid.org/0000-0002-6424-4915>

Narendra Umashankar, Assistant Professor  <https://orcid.org/0000-0002-3530-5096>

Cite this article: Sandeepa S, Nagendra PK, Bhargavi K N, Sandeepa H S, Umashankar N. Utility of clinico-hematological risk assessment and severity score (chase score) in covid-19 patients. *Panacea J Med Sci* 2023;13(3):699–703.



Original Research Article

Establishing pathology museum in a new medical college: Processes and challenges

Jessica Minal¹, Nikhil P V^{1*}, Himasree Edupuganti¹, Archana Shetty¹,
Supriya Sandeepa¹, Sandhyarani Kanna Mahadev¹, Nidha Gaffoor¹,
Aparna Muralidhar², Bhargavi K Nagabhushan¹, Nirupama Murali¹

¹Dept. of Pathology, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayanand Sagar University Harohalli, Ramanagar, Karnataka, India

²VPS Lakeshore Hospitals, Kochi, Kerala, India



ARTICLE INFO

Article history:

Received 31-05-2022

Accepted 13-09-2022

Available online 13-03-2024

Keywords:

Pathology Museum

Perspex Museum Jars

Kaiserling's solution

Innovative method

ABSTRACT

Background: A good pathology museum is intended to strengthen the intellectual material for the undergraduate students and visits to a pathology museum are an indispensable part of teaching pathology to medical students. The preservation of anatomy of pathological specimen is of utmost importance as the new successful current methods of therapy are changing the picture of diseases beyond recognition.

Objectives: We aim to elaborate the processes, difficulties and challenges faced in developing and setting up the pathology museum in a nascent medical college in a rural area.

Materials and Methods: The new museum was set up in accordance with the guidelines provided by the National Medical Commission in addition to the guidelines of the state university. Literature search and discussions with other medical colleges all over the country also played an important role in the setting up of the museum.

Conclusions: Our effort is to present our experience as hands on experience for setting up a pathology museum from a scratch for the pathologists, students and the technicians and also to increase the awareness to utilize the museum for innovative and interactive learning sessions for students by usage of QR coded specimens, museum catalogues, interactive E-kiosks and maintaining of log books.

This is an Open Access (OA) journal, and articles are distributed under the terms of the [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License](https://creativecommons.org/licenses/by-nc-sa/4.0/), which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprint@ipinnovative.com

1. Introduction

A museum is an institution where a collection of objects of artistic, cultural, historical or scientific importance are displayed and made available for public viewing.¹ The word "museum" is derived from the ancient Greek word mouseion, which denotes a place or temple dedicated to the muses.² Anatomical museums like Frederick Ruysch in Amsterdam were first started in the sixteenth and seventeenth centuries.³ Many general museums involving extension into natural history and physiology were

developed by William Hunter, for use in the schools of anatomy in London.^{4,5} Medical museums are significant medical tools, particularly in teaching institutions for both undergraduates and post graduates. A good pathology museum is a source of information on many diseases and visits to a pathology museum are a crucial part of teaching pathology to students in medicine.⁶ The function of the museum is to deliver a graphic or visual recapitulation of the concepts already taught and to reinforce the subject literary content.⁷ The preservation of anatomy of pathological specimen is of prime importance as the new successful current methods of therapy are changing the picture of diseases beyond recognition. Pathological

* Corresponding author.

E-mail address: nikhil.pv16@gmail.com (Nikhil P V).

museums are partly historical, depicting the pioneer work of diagnosticians and in part they are becoming museums in the literal sense of the word, presenting records of past states which are not seen now or of conditions of great rarity.⁸ For hundreds of years, educational and training programmes conceptualized in pathology museums have played an important role along the path to become a good physician.⁹ The exhibitions and displays in the museum should serve pedagogical purpose as well as have an aesthetic appeal. The preparation of a good museum specimen is dependent upon many minor technical points. The role of different methods of collection, preservation and display of museum specimen together constituting 'museum technology' plays an important role.¹⁰

2. Objective

This article elaborates the difficulties and challenges faced in developing and setting up the pathology museum in a nascent medical college in a rural area and present our experience as hands on experience for setting up a pathology museum from a scratch for the pathologists, students and the technicians. This article also emphasizes that good pathology museum is intended to strengthen the academic resources for the undergraduate students by usage of innovative teaching learning aids like E-kiosks, Quick response (QR) coded specimens, museum catalogues and video library.

3. Materials and Methods

The pathology museum was designated a floor space on the same floor near to the Pathology department for ease of mobility and connect. A space/room of 90 square meters was assigned for the pathology museum in accordance to the National Medical Commission (NMC) guidelines keeping in mind the possibility of further need for expansion in view of additional student capacity and postgraduate students.¹¹ A room with minimal pillars to avoid interruptions and with good ventilation, light and adequate wall space for the purpose of poster display was selected. Electric sockets with raw power were fixed to the wall where we intended to keep the computers, digital display, microscopes and interactive kiosk, all of which would be used for students learning and assessing purpose. Flood lights were installed to the roof and background lights were installed on the wooden racks for better illumination of the collected specimens and the posters. Wooden racks with glass shelves and background illumination lights were procured to keep the specimen jars (Figure 1). The racks with jars were placed in a strategic way to ensure the optimum utilization of the area of the museum keeping in mind the ease of navigation for visitors. Side slabs were laid for placing microscopes and desktops in student's area with seating capacity of at least 40 students as per NMC guidelines 2020.¹¹ A table for organ dissection

along with digital video camera to visualize the dissection, a projector and a screen along with seating area for students to visualize the projected images and videos/dissection was also arranged in a dedicated area. An ante room/curator room with adequate light and ventilation was designated behind the museum room. The ante room was equipped with a grossing table, area for storage of unmounted specimens, storage of museum related equipments, an exhaust fan and a sink with continuous water supply along with drain for the flow of water and chemicals.



Figure 1: Image of wooden rack

3.1. Collection and preparation of specimens

Majority of preserved specimens were collected from teaching medical colleges and diagnostic centers in and around Bangalore and Ramanagara districts due to lack of adequate number of inhouse specimens in the initial phases of development. Relevant information like history, clinical details and final histopathological diagnosis were also collected from respective centers. Few mounted brain specimens were directly procured from National Institute of Mental Health and Neuro Sciences (NIMHANS) hospital, Bangalore. All the specimens were collected from the respective teaching medical colleges and diagnostic centers by following proper protocols and after signing of memorandum of understanding (MOU) between both the parties. Decent number of specimens were preserved for museum from our institution histopathology lab in the later phases of development. Specimens for mounting were selected and segregated based on how carefully the specimens were handled during grossing and minimally distorted specimens were selected. Universal precautions were taken as per occupational safety and health administration guidelines as all specimens were considered potentially unsafe. Suitable protective measures such as usage of gloves, facemasks and eye gear were undertaken. The contact with chemicals was kept to minimal and the protective gear was disposed of appropriately. All the specimens to be mounted were carefully examined and

system wise names, museum reference numbers and labels were given to those specimens so as to allay confusion. The commonest cause of specimen distortion is contact with tap water which causes hemolysis and drying of specimens which we circumvented by using normal saline to wash the specimens. Specimens were preserved in 10% formalin before mounting. 10% formalin was prepared by following standard protocols [mixing one part of commercially available formalin (40% formaldehyde) with 9 parts of water].⁵ Due care was taken while using formalin as it is toxic and known carcinogenic. The International Agency for Research on Cancer (IARC) classifies formaldehyde as a human carcinogen. The sustained exposure to it can cause nasopharyngeal cancer and asthma while acute exposure causes various health-related issues such as irritation on various body parts like mucosal surfaces and skin.^{12,13}

Procurement of specimens and transportation was a challenge as our institute was located in a rural area which was almost 30 kms away from the city center. Due to absence of a museum curator, the senior residents and assistant professors volunteered to do procedures like selection and segregation of specimens, preparation of 10% formalin, mounting of specimens using electrical drilling machine, preparation of preservatives (Kaiserling solutions) etc.

3.2. Storage of specimens

The specimens were stored in such a way that it was easy to identify each specimen at a later stage. A reference book along with a desktop museum file was maintained with all necessary details about the specimens like specimen label, clinical details, gross and microscopic description and final histopathological diagnosis. Photographs of fresh and fixed specimens were clicked to assist in documentation of different gross pathology. Specimens were wrapped in cotton and hanged down with thread in a large bucket containing 10% formalin along with specimen labels. The quantity of 10% formalin in the bucket was maintained according to standard protocol for fixation which is approximately 15 to 20 times the size of specimen.⁵ Specimens were taken from this bucket as and when mounting was done. The instruments were cleaned post usage and hands were washed regularly to avoid spread of infection.

3.3. Mounting jars

Vendor selection for the museum jars was done after comparing the price, reliability, and quality of the jars. Different sized Perspex jars with lid and Perspex mounting plates were procured (Table 1, Figure 2A). Perspex jars were preferred over conventional and outdated glass jars as they offer many advantages like minimal ridges and distortions, better refractive index, improved transparency,

better strength and ability to withhold cracking with temperature changes when sealed.^{8,14} Procurement of ideal sized museum jars was often delayed due to covid waves interfering with the logistics for the same.

3.4. Equipment for mounting

Mounting was carried out in curator's room which was well equipped with all the materials required which is listed in Table 2.

The pathologists experienced difficulty in using drilling machines and it took some time for them to get accustomed to usage of drilling machines. There were occasional incidences of cuts and needle stick injuries which were treated immediately by following standard protocols. The possible risks including infections and exposure to flammable, toxic, allergenic or carcinogenic chemicals were curtailed by appropriate tissue fixation of the specimen before grossing.

3.5. Mounting technique

The specimens were inspected carefully after their retrieval from storage and any surface irregularity was recontoured. Specimen edges were trimmed to get proper shape. Specimens like intestine were cut through hollow viscous and cleaned thoroughly to visualize the inner surface. Specimens like cyst wall were cut open for better appreciation of pathology. Friable specimens were handled very carefully. Bile specimens were soaked in saturated solution of calcium chloride for 24 hours.⁴ Pins were put on specimens to hold them in position, after which the specimens were placed on a flat bench and placed in anatomical position over appropriately sized Perspex plate. Perspex plate were selected based on specimen size and a minimum of 2 cm clearance was left on both the sides as well as the top and bottom. The bottom clearance was necessary to avoid obscuring part of the specimen while putting the labels. Approximately 5 mm was added for the center plate for the depth of the specimen and a suitable Perspex jar was then selected from stock and labelled. Appropriately sized multiple holes were made in the Perspex plate according to specimen size using Bosch GSB 500W electric drilling machine. The specimens were affixed on to the Perspex plate firmly using sewing needle and nylon thread and transferred to labelled jar of appropriate size subject to availability of jars (Figure 2B)

3.6. Mounting fluid

In 1897, Kaiserling developed widely used museum mounting fluid, which has 3 different solutions with different but specific functions as shown in Table 3. These fluids are widely known as Kaiserling's solution⁵

All the steps should be taken to reduce the danger of formalin to technicians and pathologists. Formalin

Table 1: Size and number of the museum jars procured

S.No.	Sizes of Jars	Quantity
1	20cmX12cmX10cm	80
2	15cmX10cmX5cm	40
3	20cmX15cmX10cm	60
4	10cmX5cmX6cm	20
5	15cmX10cmX10cm	25
6	40cmX20cmX16cm	30
7	30cmX20cmX20cm	30
8	50cmX20cmX15cm	20
9	30cmX20cmX15cm	35
10	30cmX15cmX12cm	35
11	25cmX20cmX15cm	25

Table 2: List of equipments for mounting

S.No.	Equipments	Uses
1	Perspex mounting plates	On which specimen is mounted
2	Electric drilling machine –Bosch GSB 500W 500 RE Corded-Electric Drill, Tool Set with drilling bits	To drill perspex plates, to mount the specimens
3	Long sized sewing needles and nylon thread	For tying specimen firmly to plate
4	Cutting board, various instruments like scissors, forceps, probe, scalpel handle, disposable blades, long-bladed sharp knife, rulers	For grossing of the specimens
5	Thermocol	To stabilize the tissue while cutting and drilling
6	Diamond Marker	For numbering over perspex plate and jars
7	Goggles, surgical masks and hand gloves	For safety measures
8	Kaiserling's fluid	For fixation

Table 3: Kaiserling solution, composition and it's function⁵

	Composition	Function
Kaiserling solution I	Formalin (40%) 400 ml.	Primary Fixation
	Pot. nitrate 30 g.	Preservative
	Pot. acetate 60 g.	Preservative
	Tap water 2,000 ml.	
Kaiserling solution II	Ethyl alcohol 80%	Color restoration of the specimens
	Glycerin 500 ml.	Refractive media
Kaiserling solution III	Arsenious acid 1% 200 ml.	Preservative
	Pot. acetate 250 g.	Preservative
	Thymol 2.5 g.	Inhibits molds (Preservative)
	Formalin 0.5%	Fixative

**Figure 2:** A: Image of empty museum jars; B: Mounted specimen.

used universally for fixation of specimens predisposes to dermatitis with serious effects on the nasal mucosa causing sinusitis.¹⁵ Therefore, a museum mounting room must be thoroughly ventilated and an exhaust fan should be fitted for good air circulation. The protocol for mounting of specimens using Kaiserling solution is as follows: specimens to be mounted should be fixed in Kaiserling solution I for up to two weeks depending on their size, and larger specimens should be injected with formalin. The specimens should be transferred to Solution no. II (80% ethyl alcohol) for color restoration where they should be kept for a maximum of 1 hour with careful observation. Keeping for longer periods leads to the irreversible fading

of the color of the specimens. Finally the specimens should be transferred to jars with Solution no. III which is the mounting fluid. It contains arsenious acid and thymol to inhibit molds and glycerin (an expensive reagent,) for its effect on the refractive index. It is often difficult to get the arsenious acid into solution, but good results are obtained by making up 1% arsenic trioxide in water and steaming the solution for six hours in a steam sterilizer. The thymol is ground up and floated on the surface of the fluid.⁵ This technique has been modified by Pulvertaft in 1936, a method of restoring color to tissues by the addition of reducing agent to the mounting medium. Reducing agent used was sodium hydrosulphite and the technique widely known as Pulvertaft-Kaiserling method.⁸ Israel & Young (1978) used pure liquid paraffin as the third solution after color restoration with alcohol. This procedure reduces chances of discoloration of the mounting fluid by pigments in the specimen particularly bile-stained specimens.¹⁶

Getting expensive chemicals like glycerin, arsenious acid and sodium hydrosulphite was difficult for us, so we used limited chemicals temporarily with good results, as follows-

1. Solution 1: 10% Formalin for fixation
2. Solution 2: 80% Ethyl alcohol for restoration of color
3. Solution 3: 10% Formalin along with thymol for mounting

We plan to upgrade these solutions to standard Kaiserling solution once we receive the chemicals. Jars were sealed immediately after mounting and it was made sure that the lid was kept unperforated. Perforation of the lid was necessary with large glass jars to prevent cracking on cooling in winter but is a redundant practice with Perspex jars.

Subsequently, the mounted specimens were arranged as per organ system in an orderly pattern to facilitate visits from other specialties like Surgery, Oncology and Gynecology as well (Figure 3). Clinical histories and Pathology museum specimens are invaluable resources for getting an insight for scientific investigations.



Figure 3: Image of completed museum

3.7. Museum catalogue

A particularly designed museum catalogue for all museum specimen was made which had details of specimen label with final histopathological diagnosis, gross picture of the specimen, microphotographs. Gross and microscopic description was printed on it and laminated along with brief clinical details. 15 copies of this museum catalogue were made available for undergraduate students in accordance with the NMC guidelines.¹¹ This is useful for students and visitors to have a clear idea about the museum specimens. Subsequently, as an innovative method of teaching learning platform, quick response codes (QR codes) was generated linking to PDF documents of the museum catalogues with gross pathology, microscopy and clinical history concerning the specimens (Figure 4). This is to attract the medical students and fuel their interests towards the pathology museums. An E-kiosk at the museum was set up to guide and help the students. A video library was also set up, with short videos demonstrating important procedures such as frozen sections, grossing of radical specimens, etc. A few DOAP sessions related to museum were planned and the performance of these exercises were documented in practical record book and logbook. Kumar et al also concluded that innovations in Pathological museum are need of the hour for training undergraduate medical students to impart a structured module that enables successful self-guided learning of Pathology.¹⁷



Figure 4: Specimens with QR code

4. Conclusion

The conservation of pathology specimen is of highest importance at present, as the classical picture of diseases is being changed with the application of newer and better methods of treatment. The histologist/pathologist must always keep in mind the need to prepare uncommon or important specimens for permanent preservation and display. Museums in medical colleges have been the cornerstone in imparting knowledge to the medical students since time immemorial, however in addition to the

longstanding time - tested honored method of museum visits by students; there is definite need to incorporate innovative technology-based methods of training involving the usage of museum to train the students and staff. The intent of this article is to provide a reference model to our peers on the overview of establishing a functional pathology museum from its stage of inception. As laboratory physicians involved mainly in academics and diagnostics, our experience in setting up the museum gave insights into various facets of infrastructure, equipment, levels of documentation and techniques required to set up the museum.

5. Conflict of Interest

None.

6. Source of Funding

None.

Acknowledgments

We would like to acknowledge and express our heartfelt gratitude to our former Head of Department, late Dr. (Col) Nikhil Moorchung. The idea of the study was developed by him and it stemmed from his love for Pathology as well as teaching.

J.M, N.P.V and H.E played a role in developing the protocol and writing the manuscript; A.S, S.S, and S.R.K helped in drafting the manuscript; A.M, N.G, B.K.N and N.M revised the manuscript for important intellectual content. Dr. (Col) Nikhil Moorchung developed the idea of this study.

References

- Alexander EP, Alexander M, Decker J. Museums in motion: An introduction to the history and functions of museums. Rowman & Littlefield Publishers; 2017.
- Findlen P. The museum: its classical etymology and Renaissance genealogy. *J History Collection*. 1989;1(1):59–78.
- Miller SP. A history of comparative anatomy from aristotle to the eighteenth century. Cole FJ, editor. Macmillan & Company Limited; 1944.
- King R. John Hunter and the Natural History of the Human Teeth: dentistry, digestion, and the living principle. *J Hist Med Allied Sci*. 1994;49(4):504–20.
- Culling CF, Allison RT, Barr WT. Haematoxylin and its counterstain. In: Cellular Pathology Technique. 4th Edn. Butterworth-Heinemann; p. 111–52.
- Pradeepkumar NS, Joseph NM, Kotastane D, Kanade V. Students' perspective of a pathology museum. *Natl Med J India*. 2010;23(6):377.
- Plunkett O. The museum in postgraduate teaching. *Postgrad Med J*. 1966;42:115–9.
- Pulvertaft RJ. Museum techniques; A review. *J Clin Pathol*. 1950;3(1):1–23.
- Santi R, Ballestriero R, Canzonieri V, Gulczynsky J, De Gouveia R, Ariza A, et al. Voices from the past: results of the ESP history of pathology working group survey on pathology museums. *Virchows Arch*. 2022;480(6):1231–8.
- Patil S, Rao RS, Ganavi BS. The museum maze in oral pathology demystified-part I. *J Contemp Dent Pract*. 2013;14(4):770–6.
- NMC. minimum standard requirements; 2020. [28th July 2022]. Available from: https://www.nmc.org.in/ActivitiWebClient/open/getDocument?path=/Documents/Public/Portal/Gazette/MSR_50_100_150_200_250_08.06.2020.pdf.
- Patil S, Premalatha BR, Rao RS, Ganavi BS. Revelation in the field of tissue preservation-A preliminary study on natural formalin substitutes. *J Int Oral Health*. 2013;5(1):31–8.
- Kim KH, Jahan SA, Lee JT. Exposure to formaldehyde and its potential human health hazards. *J Environ Sci Health C Environ Carcinog Ecotoxicol Rev*. 2011;29(4):277–99.
- Kramer FM. Preparation of pathological specimens in natural color. *Am J Clin Pathol*. 1938;8(ts2_6):232–6.
- Riaz A, Malay K, Yadav AK, Gupta VK, Surabh A, Zaidi S. Pathology museum a need or just a protocol - a review. *Int J Adv Dent Res*. 2015;1(1):4–8.
- Israel MS, Young LF. Use of liquid paraffin in the preservation of pathological specimens. *J Clin Pathol*. 1978;31(5):499–500.
- Mahesh K, Kumar V. Role of innovations in pathology museum in imparting knowledge among medical students - a hospital based prospective study. *Int J Contemp Med Res*. 2019;6(6):39–44.

Author biography

Jessica Minal, Associate Professor  <https://orcid.org/0000-0001-8724-8962>

Nikhil P V, Assistant Professor  <https://orcid.org/0000-0002-8564-8791>

Himasree Edupuganti, Assistant Professor  <https://orcid.org/0000-0001-6536-4049>

Archana Shetty, Professor  <https://orcid.org/0000-0002-2419-1628>

Supriya Sandeepa, Professor  <https://orcid.org/0000-0002-9548-3492>

Sandhyarani Kanna Mahadev, Assistant Professor  <https://orcid.org/0000-0001-6049-3861>

Nidha Gaffoor, Assistant Professor

Aparna Muralidhar, PDCC Fellow  <https://orcid.org/0000-0002-4896-5800>

Bhargavi K Nagabhushan, Senior Resident  <https://orcid.org/0000-0002-1005-0904>

Nirupama Murali, Professor & HOD  <https://orcid.org/0000-0001-7509-5903>

Cite this article: Minal J, Nikhil P V, Edupuganti H, Shetty A, Sandeepa S, Mahadev SK, Gaffoor N, Muralidhar A, Nagabhushan BK, Murali N. Establishing pathology museum in a new medical college: Processes and challenges. *Panacea J Med Sci* 2024;14(1):128-133.

Case Report

An Unpropitious Surprise Post Vaginal Hysterectomy – A Case of Incidentally Discovered Extra-Gastrointestinal Stromal TumourJessica Minal¹, Nikhil P. V¹, Bhargavi Kalburgi Nagabhushan², Nirupama Murali¹, Nidha Gaffoor¹**Abstract**

Extra-gastrointestinal stromal tumours (EGIST) are rare mesenchymal tumours that arise outside the gastrointestinal tract and mainly affect the omentum, mesentery, and retroperitoneum. We report a case of EGIST in an elderly female patient at an unusual location. The patient was referred to our centre with hemoperitoneum post vaginal hysterectomy for the treatment of third-degree utero-vaginal prolapse. Ultrasonography (USG) of abdomen and pelvis was done which revealed a heterogenous tumour in the upper abdomen. The tumour mass measured 23x18x8.5cms and was abutting the greater curvature of stomach without infiltration. A diagnosis of extra-gastrointestinal stromal tumour, spindle cell type, high grade, with pseudo signet ring appearance was rendered based on the morphology and immunohistochemistry with CD117(c-kit) and DOG1. Rupture of cancerous mass in the abdomen is one of the causes to be kept in mind in hemoperitoneum and EGIST should be considered in the differential diagnosis of large, multi-nodular, primary lesions of the abdomen. A high degree of suspicion is needed as these patients present late and are often diagnosed incidentally during investigations for unrelated medical conditions. 10% of EGISTs are primarily disseminated and the site of origin cannot be established with certainty, emphasizing the enigma of its origin as encountered in the present case.

Keywords: Abdominal neoplasms, CD117 antigen, Immunohistochemistry, Pathology, DOG1, Gynaecology

International Journal of Human and Health Sciences Vol. 08 No. 02 April'24
DOI: <http://dx.doi.org/10.31344/ijhhs.v8i2.645>

Introduction

The most common primary mesenchymal tumour in the gastrointestinal tract (GIT) is the gastrointestinal stromal tumour (GIST) with an incidence of 11-15 cases per 100,000. These tumours arise from the interstitial cells of Cajal, which regulate the GIT peristalsis and demonstrate mutations in the platelet derived growth factor receptor (PDGFR- α) and c-KIT genes which lead to tyrosine kinase activation.^{1,2} Of much rarer occurrence, are extra-gastrointestinal stromal

tumours (EGIST), accounting for 10% of all GISTs, which originate from outside the GIT.³ These tumours are characterized by differentiation towards the interstitial cells of Cajal and have pathological, immunohistochemical and molecular biological characteristics like GIST.^{4,5} The diagnosis of EGIST is often unexpected.

Here, we report a case of EGIST in an elderly female patient, which was discovered incidentally after she underwent vaginal hysterectomy for third degree utero-vaginal prolapse and presented

1. Department of Pathology, Dr Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Karnataka, India.
2. Trident Diagnostics and Healthcare Pvt Ltd. Jagajyothi Nagara, Nagadevanahalli, Bengaluru, Karnataka, India.

Correspondence to: Dr. Nikhil P. V., Department of Pathology, Dr Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Karnataka, India. Email: nikhil.pv16@gmail.com

to our centre with hemoperitoneum post-surgery.

Case Summary

A 70-year-old female underwent vaginal hysterectomy at another hospital in a rural area, for the treatment of third-degree utero-vaginal prolapse. Soon after opening the pouch of Douglas, there was a gush of altered blood with subsequent blood loss of approximately 1.5 litres. The patient was referred to our centre immediately post vaginal hysterectomy for the management of hemoperitoneum. The previous scan reports were unavailable. Ultrasonography (USG) of abdomen and pelvis was done which showed a heterogenous tumour in the upper abdomen, adherent to the outer aspect of greater curvature of stomach, extending till the splenic hilum. The mass was not adherent to the bladder, bowel loops, liver, or spleen (Figure 1).



Figure 1: USG abdomen: A heterogenous tumour in upper abdomen measuring 23cms in maximum diameter.

The patient was taken up for emergency laparotomy. Gross hemoperitoneum was noted and a large mass was seen in the upper abdomen involving the greater curvature of stomach and extending till the splenic hilum. The mass was surgically resected and a sleeve gastrectomy with splenectomy was performed. The specimens were sent for histopathological examination. The tumour mass received in the histopathology section measured 23x18x8.5cms and was grey brown, irregular and nodular. Cut section showed grey white friable areas with haemorrhage (Figure 2).

The spleen measured 8 cm × 5.5 cm × 3.5cm and no gross tumour infiltration was seen. The fragment of gastric sleeve tissue measured 2x1.5cms and was unremarkable. The microscopy of the tumour mass showed spindled tumour cells arranged in short fascicles, nests, cords, and sheets. Individual cells were mild to moderately pleomorphic, with scant



Figure 2: Gross picture of the large, irregular, nodular tumour mass.

to moderate wispy eosinophilic cytoplasm (Figure 3A). Paranuclear vacuoles and foci of tumour cell palisades were seen. Occasional cells with pseudo-signet ring appearance were also noted (Figure 3B). The tumour showed extensive myxoid areas with thin walled ectatic blood vessels and areas of haemorrhage with mitotic count of 8-10 mitosis per 5mm². There was absence of necrosis. Spleen and stomach did not show tumour infiltration. Differential diagnosis of soft tissue sarcoma was ruled out as the tumour cells were negative for Masson- trichome stain. Immunohistochemistry showed positivity of tumour cells for CD117 and DOG1 and negative for CK5/6, smooth muscle actin (SMA) (Figure 3C and 3D).

A diagnosis of extra-gastrointestinal stromal tumour, spindle cell type, high grade, with pathologic stage of pT4 was rendered as per American Joint Committee on Cancer (AJCC), 8th edition.

Discussion

Gastrointestinal stromal tumour (GIST), was a hardly recognised entity until 2000, has now been better understood with discovery of an activating mutation of the c-kit tyrosine kinase and the ability to target those mutations with the specific tyrosine

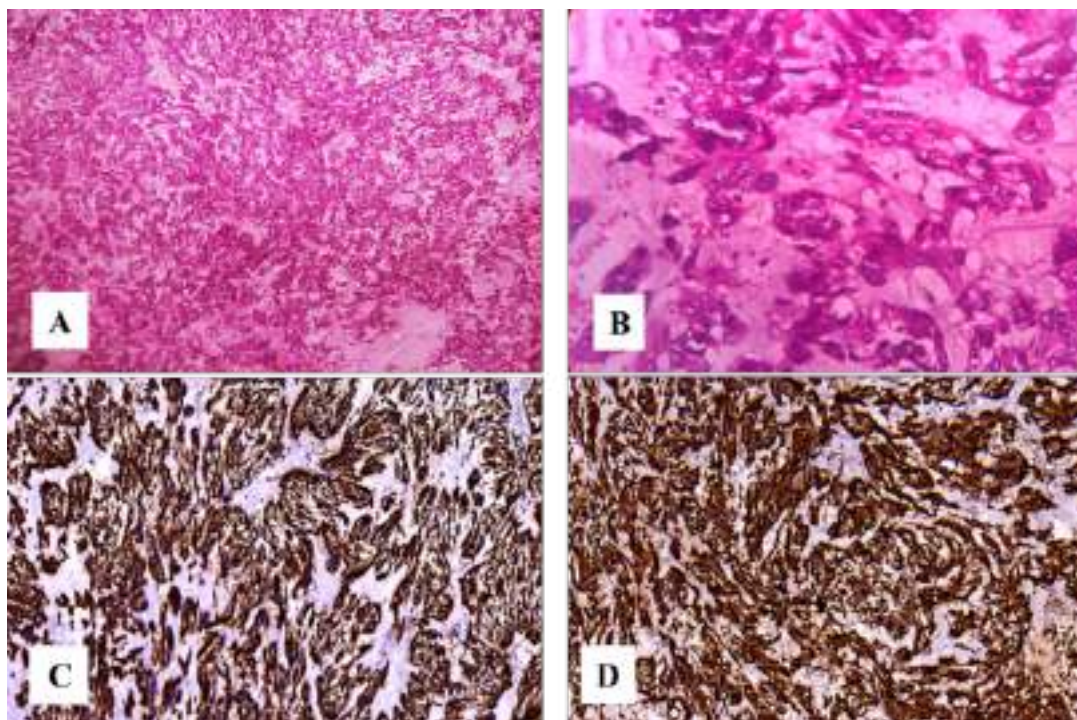


Figure 3: (A) Tumour cells arranged in predominantly short fascicles against a myxoid background (H&E, $\times 100$) (B) Pseudo-signet ring appearance of tumour cells (H&E, $\times 400$) (C) CD117 immunohistochemistry showed diffuse cytoplasmic positivity (IHC, $\times 400$) (D) DOG1 immunohistochemistry showed diffuse cytoplasmic and membranous positivity (IHC, $\times 400$).

kinase inhibitor (imatinib mesylate).²

EGISTs arise outside the GIT and mainly affect the omentum, mesentery, and retroperitoneum. Other uncommon sites include pancreas, gall bladder, pleura, paravaginal and periprosthetic tissue.⁴ It occurs in the elderly, most commonly in the 7th decade of life, as seen in the present case as well.⁶ In the present case, the tumour was abutting the greater curvature of the stomach. However, there was no infiltration into stomach on microscopic examination. The mass was not adherent to the bladder, bowel loops, liver, or spleen.

There are many hypotheses proposed regarding the origin of EGISTs:

- (1) these usually originate from mesenchymal undifferentiated stem cells
- (2) these arise from extra-intestinal undifferentiated mesenchymal cells capable of differentiating to interstitial cells of Cajal and
- (3) these lose the extramural contact with the intestinal wall in GIT.²

Many authors believe that mesenteric and omental GISTs originate from a primary intestinal or

gastric tumour and for unknown reasons, may become detached from the gastrointestinal wall during their development.⁷ It was difficult for us to determine whether the tumour had originated from the omentum or was it a detached mass from the GIT. Tumour haemorrhages may be the first presentation of an underlying mass.

10% of EGISTs are primarily disseminated and the site of origin cannot be established with certainty, emphasizing the enigma of its origin encountered in our case.⁴ A retrospective study by Yi et al stated the most common primary site was in the mesentery (n=15) followed by the retroperitoneum (n=13) and omentum (n=8).⁸ EGIST is an important differential diagnosis of masses in the abdomen such as leiomyoma and leiomyosarcoma, which show histologic similarities with GIST.⁶ They have no classical radiologic features, and has a wide range of differential diagnoses including leiomyosarcoma, liposarcoma, fibrosarcoma, paraganglioma, solitary fibrous tumour, schwannoma and lymphoma.² The presence of a bleeding mass of uncertain nature may result in a challenging situation for the surgeon, who is forced to perform a resection without knowing the

exact nature of the tumour and hence the extent of resection required.⁹

The histopathologic variants include epithelioid, spindle, vacuolated, nested and myxoid. In this case, we encountered the pseudo-signet ring appearance of tumour cells, which is rare and can pose a diagnostic challenge. Necrosis and brisk mitotic activity are adverse prognostic factors.⁴

EGISTs have a less favourable prognosis as compared to GISTs. Due to its extra- gastrointestinal location there is a delay in presentation of symptoms and subsequent impediment in its diagnosis.⁷ In contrast, early symptoms of intestinal obstruction in GISTs aid in its prompt diagnosis and treatment. Given the rarity of EGISTs, their management follows the guidelines of GISTs. Surgical resection with negative margins remains the standard treatment to be followed by targeted therapy by Imatinib mesylate if indicated.^{7,10,11}

Conclusion

Hemoperitoneum is rare as first presentation of EGIST and imaging plays a role in the diagnosis of hemoperitoneum, in elucidating a cause and detecting active haemorrhage. This case report attempts to create awareness to this unusual presentation of EGIST and stresses that rupture of a cancerous mass in abdomen should be considered as differentials in cases presenting with

hemoperitoneum. EGISTs are rare mesenchymal tumours and should be considered in the differential diagnosis of patients with large, multi-nodular, primary lesions of the abdomen. These patients present later in the course of disease with vague symptoms like tiredness and abdominal fullness and are often diagnosed incidentally during investigations for unrelated medical conditions. The case report also highlights the underreported pseudo signet ring appearance of tumour cells as it poses a diagnostic challenge. Complete surgical resection is the only effective modality despite significant advances in new chemotherapeutic drugs.

Acknowledgement: We would like to thank the faculty from the Department of Surgery, Department of Radiology and Department of Obstetrics and Gynaecology of our hospital for their support.

Conflict of interest: Authors declare no conflicts of interest.

Financial support and sponsorship: Nil.

Authors' Contribution: JM collected the case and compiled data of this study. JM, NPV and BKN wrote the preliminary manuscript; NM and NG critically revised the manuscript for important intellectual content. All authors approved the final manuscript for submission.

References

1. Valdes-Peregrina EN, Hernández-González M, de León-Pacheco O, Mendoza-Ramírez S. Extra-gastrointestinal stromal tumour. Report of primary tumour in the omentum. *Rev Med Hosp Gen Mex.* 2018;81(4):221-5.
2. Ashoor AA, Barefah G. Unusual presentation of a large GIST in an extraintestinal site: a challenging diagnosis dilemma. *BMJ Case Rep.* 2020;13(2):e229839.
3. Abidoye O, Johnson A. Extremely Aggressive Mesenteric Extragastrointestinal Stromal Tumor: A Case Report and Literature Review. *Cureus.* 2022;14(3):e23108.
4. Fukayama M, Goldblum J.R, Miettinen M, Lazar A.J. Mesenchymal tumours of the digestive system. In: Bosman F.T, Carneiro F, Hruban R.H, Theise N.D eds. WHO classification of tumours of the digestive system. 5th ed. Lyon, France: IARC publications; 2019. p.439-43.
5. Pandit N, Das GP, Dahal M, Awale L. An unexpected extra-gastrointestinal stromal tumor (E-GIST) on the jejunal mesentery. *J Surg Case Rep.* 2018;12:rjy339.
6. Thakur S, Pal K.M, Negi A, Chandrakant L, Manish G. Extra-Gastrointestinal Stromal Tumor (EGIST). *JMSCR.* 2020;8(7):524-7.
7. Angelico G, Spadola S, Trombatore C. Clinicopathological and Prognostic Features of Extragastrointestinal Stromal Tumors of the Omentum: A Review. *J Gastroenterol Res.* 2017;1(1):9-13.
8. Yi JH, Park BB, Kang JH. In Gyu Hwang, Dong Bok Shin, Sun Jin Sym et al. Retrospective analysis of extragastrointestinal stromal tumors. *World J Gastroenterol.* 2015;21(6):1845-50.
9. Almeida JI, Lima C, Pinto P, Armas I, Santos T, Freitas C. Spontaneous hemoperitoneum as a rare presentation of gastric lesions: Two case reports. *Int J Surg Case Rep.* 2022;91:106769.
10. Basnet S, Lakhey A. Extra-Intestinal Gastrointestinal Stromal Tumor of Omentum. *J Pathol Nepal.* 2014;4(8):682-4.
11. Lu LJ, Xu XP, Dong F, Min J. Diffuse primary extra-gastrointestinal stromal tumor of the peritoneum: A rare case report. *Medicine.* 2020;99(40):e22493.

Case report:**Primary Skeletal Muscle Diffuse Large B Cell Lymphoma in Lumbar Region – A Rare Occurrence**

Aparna Muralidhar¹, Kanna Sandhyarani Mahadev¹, Jessica Minal¹, Vidhya Venkatesan¹,
Vijaya V Mysorekar¹

Abstract

Diffuse large B cell lymphoma (DLBCL) is the most common type of non-Hodgkin lymphoma worldwide. Patients most often present with a rapidly growing tumour mass in single or multiple, nodal, or extranodal sites. Extranodal involvement is seen in up to 40% cases. Initial presentation as soft tissue lesion is rare. We report a case of extranodal DLBCL in an elderly male, presenting as a soft tissue mass in the left lumbar region, clinically suggestive of lipoma. The patient had no palpable lymphadenopathy. Complete blood counts were within normal limits. Initial ultrasonography was suggestive of abscess, possibly of tubercular origin. On fine needle aspiration cytology, features were of a malignant neoplasm; a lymphomatous process. Subsequent histopathological evaluation followed by IHC confirmed the diagnosis of DLBCL. Primary extranodal DLBCL involving the soft tissue is rare. Owing to its non-specific and unusual clinical presentation, accurate diagnosis may be delayed. Besides, imaging modalities are also diagnostically challenging due to a wide range of differentials, thereby emphasising the need for tissue diagnosis. Histopathological examination and immunohistochemistry are paramount in accurate diagnosis and tailoring treatment options.

Keywords: DLBCL, extranodal, cytology, histopathology, immunohistochemistry

International Journal of Human and Health Sciences Vol. 08 No. 01 January'24
DOI: <http://dx.doi.org/10.31344/ijhhs.v8i1.627>

Introduction

Diffuse large B cell lymphoma (DLBCL) is an aggressive, rapidly growing neoplasm composed of medium or large B lymphoid cells, with a diffuse growth pattern. Morphological, biological, and clinical studies have subdivided DLBCLs into variants, molecular subtypes, and distinct disease entities. Cases with no clear and accepted criteria for subdivision are classified as DLBCL NOS, which is further subdivided into germinal centre B-cell (GCB) subtype and activated B-cell (ABC) subtype.¹ The disease occurs over a wide age range, with slight male predominance. Patients may present with nodal or extranodal disease. Up to 40% of cases initially present with extranodal

involvement. Gastrointestinal tract is the most common extranodal site to be involved. Other sites include the bone, testes, spleen, Waldeyer ring, salivary glands, thyroid, liver, kidneys, and adrenal glands.¹ Lymphoma involving skeletal muscle is rare and accounts for only 5% cases.² DLBCL usually proves fatal if untreated, but it is potentially curable with treatment. The standard of care for treatment is R-CHOP (Rituximab, Cyclophosphamide, Doxorubicin, Vincristine, Prednisolone).³

Here, we report a case of incidentally detected extranodal DLBCL presenting at an unusual site (lumbar region) in an adult.

1. Department of Pathology, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Karnataka, India-562112.

Correspondence to: Dr. Jessica Minal, Associate Professor, Department of Pathology, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Karnataka, India-562112. Email: jes.minal@gmail.com

Case Report

A 68-year-old male presented with a painless swelling in the left lumbar region of two months duration, gradually increasing in size. There was no history of trauma/weight loss/fever. On examination, the swelling was 7cm×6cm×2cm in size, firm, non-tender, not fixed to overlying skin. The patient had undergone an abdominal ultrasound at another centre which was reported as abscess; possibly of tubercular aetiology. Rest of the general physical examination and systemic examination were unremarkable. The complete blood count was within normal limits. A provisional clinical diagnosis of lipoma was made, and fine needle aspiration cytology (FNAC) was advised. FNAC revealed highly cellular smears composed of singly scattered large atypical cells with high N-C ratio, irregular nuclear membrane, vesicular nuclei, and prominent nucleoli. Few binucleate and multinucleate forms, plasmacytoid cells, bizarre forms and mitotic figures were noted in a haemorrhagic background with prominent lymphoglandular bodies (Figure 1).

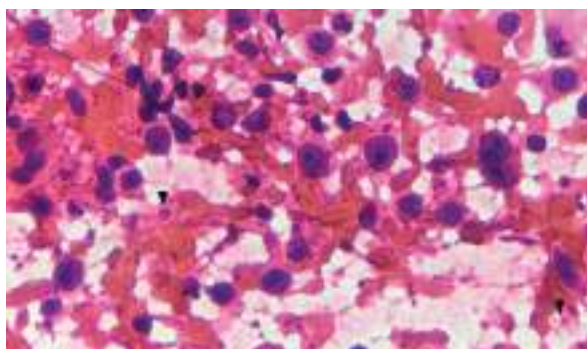


Figure 1: FNAC aspirate showing singly scattered large atypical cells with few binucleate forms and plasmacytoid cells in a haemorrhagic background with lymphoglandular bodies (arrow head) (H&E ×400)

Considering the cytomorphological features, a diagnosis of malignancy, possibly lymphoma was given. However, in view of the site of involvement, poorly differentiated sarcoma could not be ruled out and an excision biopsy was advised.

Then, an excision biopsy was performed, and the resected specimen was sent for histopathological examination. Grossly, the mass measured 7cm×3.7cm×3cm with a tan, firm, nodular appearance abutting all the resection margins. Skeletal muscle was noted on the posterior surface. (Figure 2). The microscopy showed sheets, nests and singly scattered cells with morphology as

described above. Skeletal muscle bundles at the periphery and the circumferential margins showed infiltration by tumour. (Figure 3).



Figure 2: Tan, firm, nodular mass abutting all the resection margins. Skeletal muscle noted on the posterior surface.

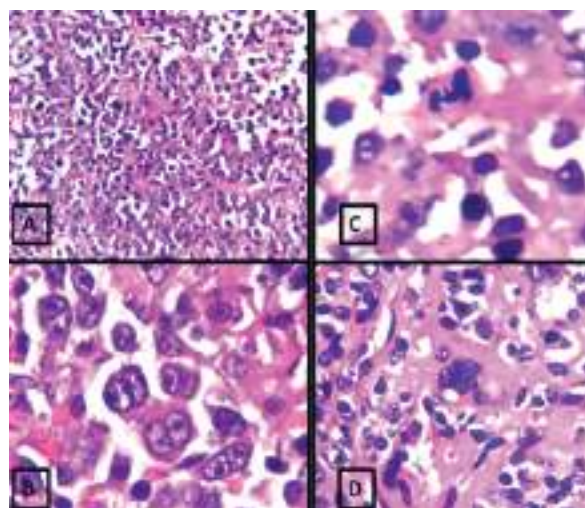


Figure 3: A) Atypical cells in sheets, nests and singly scattered cells with morphology as seen in cytology smears (H&E, ×100); B) Binucleate forms (H&E, ×400); C) Atypical mitotic figures (H&E, ×400); and D) Bizarre forms (H&E, ×400).

Immunohistochemistry was carried out to rule out a possibility of sarcoma (rhabdomyosarcoma) and confirm the diagnosis and subtype of non-Hodgkin lymphoma. Tumour cells were positive for LCA, CD20, BCL2 and MUM1. Ki 67 labelling index was 70% (Figure 4). They were negative for CD10, BCL6, C-MYC, CD3, CD5, CD30, CD138, ALK, EMA and Desmin. The final impression of DLBCL, activated B cell subtype was inferred. PET CT did not reveal any other site of involvement elsewhere in the body. Hence, a conclusion of primary skeletal muscle DLBCL in the lumbar region was made.

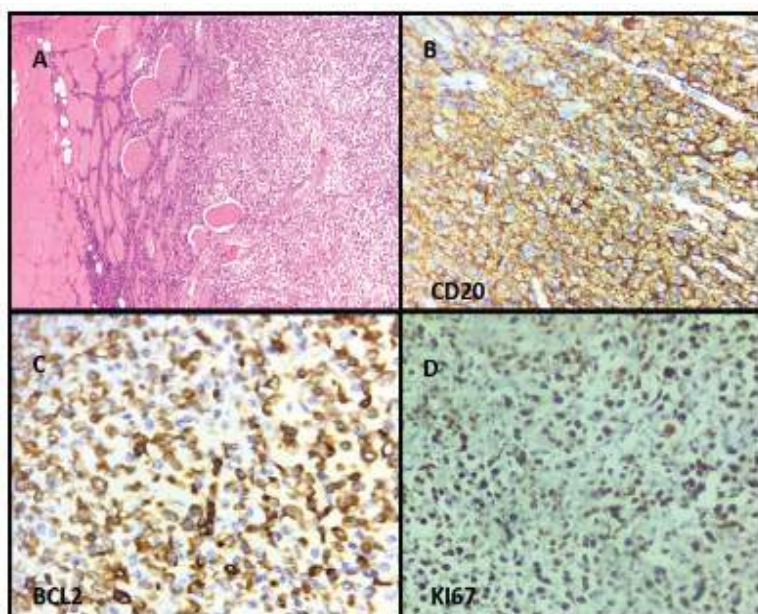


Figure 4: A) Skeletal muscle infiltration by tumor cells (H&E, ×40); B) membranous CD20 positive tumour cells; C) cytoplasmic BCL2 positive tumour cells; and D) nuclear Ki67 positive tumour cells (IHC, ×400)

Discussion

Diffuse large B cell lymphoma (DLBCL) is a heterogeneous category of lymphomas composed of large transformed B cells. DLBCL not otherwise specified (NOS), represents 80-85% of all cases.⁴ It is heterogeneous in terms of clinical presentation, genetic findings, response to therapy, and prognosis. Based on gene expression profiling, DLBCL NOS is subdivided into germinal centre B cell (GCB) subtype and activated B cell subtype. About 10-15% of cases are unclassifiable. Patients with the GCB subtype usually have better prognosis than those with the ABC subtype. Among the 40% cases presenting as extranodal lesions, soft tissue involvement has been reported in only 5% cases.²

Lymphoma occurring within the musculoskeletal system may occur as part of disseminated lymphoma, local extension from bone or rarely primary skeletal muscle lymphoma (PML).⁵ PML is exceedingly rare, accounting for less than 1% cases. The pathogenesis of PML is uncertain. One hypothesis is that skeletal muscle lymphoma can originate in aberrant lymph nodes within muscles. Some authors propose lymphomatous micro infiltrate originating from the adjacent bone as possible cause.⁶ In our case, the first hypothesis seems more likely as the FNAC smears

showed many lymphoglandular bodies (considered specific for lymphoid tissues and lymphoid malignancies). PML have been associated with a worse prognosis.^{5,7}

Cases of lymphoma involving skeletal muscle present with muscle pain, swelling and a rapidly enlarging mass. The commonly affected muscles are those of the extremities.⁷ On literature search, we came across very few cases of soft tissue DLBCL. All these were clinically suspected to be sarcomas and most cases involved the extremities.^{8,9,10} Uncommon sites include back, abdominal wall, pelvis and gluteal region.⁷ Our case is a primary skeletal muscle lymphoma presenting at the lumbar region of the back (which is an unusual site).

Skeletal muscle infiltration by lymphoma can mimic sarcoma, metastatic carcinoma, melanoma, and osteosarcoma causing diagnostic challenges. Morphologically, carcinomas have cohesive appearance, with nuclear moulding and streaming observed frequently. Lymphoma cells tend to be non-cohesive and exhibit a permeative quality.³ In contrast to sarcomas, lymphomas lack extracellular stroma and may present with confluent lymphadenopathy. However, IHC is essential for a confirmatory diagnosis.

The treatment of primary skeletal muscle lymphoma depends predominantly on the type of lymphoma. The prognosis of primary skeletal muscle lymphoma is poor in comparison to lymphoma confined to the lymphnodes.¹¹

The primordial treatment strategy for DLBCL is curative or palliative immunochemotherapy. The first-line treatment consists of R-CHOP; modifications should be considered in more challenging cases.¹¹ Studies have found positive BCL2 expression to be associated with poor prognosis, independent of international prognostic index and MYC expression.¹² In vitro studies have found BCL2 expressing cell lines to be sensitive to

venetoclax, (a highly selective BCL2 inhibitor).¹³

Conclusion

Primary skeletal muscle lymphoma is a rare entity and many of the cases belong to the group of diffuse large B cell lymphoma (DLBCL). Due to a broad differential diagnosis of muscle lesions on imaging, histological examination and immunohistochemistry play a pivotal role in the diagnosis, thereby guiding appropriate patient management. This case report attempts to create awareness to this unusual presentation of extranodal DLBCL and highlights the diagnostic

difficulties that can be present in these rare and often challenging cases often leading to delay in treatment.

Conflict of Interest: None declared.

Funding statement: Nil.

Authors' contribution: AM wrote the manuscript; KSM and VV helped to draft the manuscript; VVM and JM critically revised the manuscript. VVM and JM developed the idea of this case presentation. All the authors approved and submitted the manuscript.

References

1. Khoury JD, Solary E, Abela O, Akkari Y, Alaggio R, Apperley JF, et al. The 5th edition of the World Health Organization classification of haematolymphoid tumours: myeloid and histiocytic/dendritic neoplasms. *Leukemia*. 2022;36(7):1703-19.
2. Lee CH, Jeon SY, Yhim HY, Kwak JY. Disseminated soft tissue diffuse large B-cell lymphoma involving multiple abdominal wall muscles: a case report. *World J Clin Cases*. 2021;9(28):8557.
3. Fletcher CD. *Diagnostic histopathology of tumors*. New York: Elsevier; 2007.
4. Li S, Young KH, Medeiros LJ. Diffuse large B-cell lymphoma. *Pathology*. 2018;50(1):74-87.
5. Lim CY, Ong KO. Imaging of musculoskeletal lymphoma. *Cancer Imaging*. 2013;13(4):448-57.
6. Balogova S, Greksak R, Mizickova M, Noskovicova L, Babal P, Lukac L. Case report: skeletal muscle lymphoma as a result of slow centrifugal migration of untreated primary neurolymphomatosis? *Front Nucl Med*. 2022;2:804421.
7. Hatem J, Bogusz AM. An unusual case of extranodal diffuse large B-cell lymphoma infiltrating skeletal muscle: a case report and review of the literature. *Case Rep Pathol*. 2016;2016:9104839.
8. Siddiqui RS, Ferman D, Tuli S. Diffuse large B-cell lymphoma of the left upper extremity mimicking a sarcoma. *Cureus*. 2021;13(6):e15588.
9. Bolke E, Peiper M, Matuschek C, Schieren G, Glombick R, Förster C, et al. Extranodal diffuse non Hodgkin lymphoma in the thigh. *Eur J Med*. 2010;15(8):367-8.
10. Ansari SA, Agrawal T, Bhamra S. Diagnostic surprise on IHC: a rare case of intramuscular DLBCL in thigh region mimicking sarcoma. *IP Arch Cytol Histopathol Res*. 2022;7(3):205-7.
11. Zhang L, Lin Q, Zhang L, Dong L, Li Y. Primary skeletal muscle diffuse large B cell lymphoma: a case report and review of the literature. *Oncol Lett*. 2015;10(4):2156-60.
12. Roh J, Cho H, Yoon DH, Hong JY, Lee AN, Eom HS, et al. Quantitative analysis of tumor-specific BCL2 expression in DLBCL: refinement of prognostic relevance of BCL2. *Sci Rep*. 2020;10(1):10680.
13. Tsuyama N, Sakata S, Baba S, Mishima Y, Nishimura N, Ueda K, et al. BCL2 expression in DLBCL: reappraisal of immunohistochemistry with new criteria for therapeutic biomarker evaluation. *Blood*. 2017;130(4):489-500.

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/375974702>

Profile of Poisoning Cases in a Tertiary Care Centre in Rural South India

Article in Russian Journal of Forensic Medicine · November 2023

DOI: 10.17816/fm14217

CITATIONS

0

READS

120

3 authors, including:



Jayanth Sh Hosahally

Dayananda Sagar Institutions

48 PUBLICATIONS 185 CITATIONS

SEE PROFILE

DOI: <https://doi.org/10.17816/fm14217>

Profile of poisoning cases in a tertiary care centre in rural South India

K.B. Geetha, Jayanth S. Hosahally, Manju Prakash

Dr Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Devarakagallahalli, Ramanagara Dist, Karnataka, India

ABSTRACT

BACKGROUND: Poisoning is the fourth most common cause of mortality in rural India. The commonest agents in India appear to be pesticides, sedatives, chemicals, alcohol, animal & plant toxins and household toxins. Our hospital receives an average of 20 to 25 poisoning cases every month.

AIMS: To profile all cases of poisoning those are reported to casualty department at Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research (CDSIMER); to study the types and frequency of poisoning cases admitted to the centre; to study the socio demographic associations of the poisoning cases.

MATERIALS AND METHODS: Present study is a hospital record-based retrospective observational study of acute poisoning cases registered in the medicolegal register in the casualty of CDSIMER, which is a tertiary care centre situated in rural area near Harohalli, Ramanagara District, India.

RESULTS: Males constituted 58% of the cases and 33.52% of the cases were in the age group of 21–30 years. 81.4% of the cases were able to reach hospital between 1 to 8 hours. 56% of the cases recovered and were discharged within 3 days. In 22 cases the duration of admission was more than 2 weeks as they went into complications. Organo phosphorus group of insecticide was the most common type of poison consumed constituting to 40.8% of the cases followed by Snake bite. Attempt to suicide (60.35%) was more common than accidental poisoning.

CONCLUSION: Insecticides mainly Organophosphorus compound are the most common group of poisons which causes morbidity and mortality in rural Indian population especially in young adults between 21 to 40 years. Owing to the presence of forests in the region, Snake bite becomes the second largest type of poisoning. Suicide frequently prevails in the rural areas; financial problem is the leading cause for farmers to commit suicide.

Keywords: poisoning; insecticides; suicide; snake bite.

To cite this article:

Geetha KB, Jayanth SH, Manju Prakash. Profile of poisoning cases in a tertiary care centre in rural South India. *Russian Journal of Forensic Medicine*. 2023;9(4):383–390. DOI: <https://doi.org/10.17816/fm14217>

Received: 01.08.2023

Accepted: 23.10.2023

Published: 27.11.2023

ОБОСНОВАНИЕ

Отравления являются четвёртой по частоте причиной смертности в сельских районах Индии. Причин отравлений много: промышленные, случайные и преднамеренные. Использование ядовитых химических веществ практически во всех сферах человеческой жизни неуклонно растёт во всём мире, несмотря на ряд законов, регулирующих использование ядов. Существует более 9 млн природных и синтетических химических веществ, из них только 3000 становятся причиной отравлений (на их долю приходится более 95% зарегистрированных случаев) [1]. Наиболее распространённые возбудители отравлений в Индии — пестициды, седативные препараты, химикаты, алкоголь, токсины животных и растений, а также бытовые токсины.

В Индии все случаи отравлений носят судебно-медицинский характер, и в случае смерти пациента должно быть проведено дознание с последующим вскрытием тела судебным патологоанатомом. Это делается для выяснения обстоятельств, при которых произошло отравление, а также с целью установления точной причины и рода смерти. Судебный патологоанатом должен иметь представление о распространённых видах отравлений в своём регионе.

В нашу больницу ежемесячно поступает в среднем 20–25 пациентов с отравлениями. Такие высокие показатели вызывают тревогу и беспокойство, поэтому данное исследование было проведено с целью изучения структуры различных типов отравлений и факторов, связанных с их возникновением. Это позволит разработать план по повышению осведомлённости населения о различных видах ядов и обращению с ними, что поможет снизить частоту отравлений.

Цель исследования — составить общую характеристику всех случаев отравлений, зарегистрированных в отделении скорой помощи Института медицинского образования и исследований имени д-ра Чандраммы Даянанды Сагара (Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, CDSIMER), изучить типы и частоту отравлений, а также социально-демографические показатели пациентов, поступающих с отравлениями в наше учреждение.

МАТЕРИАЛЫ И МЕТОДЫ

Дизайн исследования

Ретроспективное наблюдательное исследование случаев острых отравлений, зарегистрированных в отделении скорой помощи в CDSIMER, которое является медицинским учреждением третьего уровня, расположенным в сельской местности вблизи города Харохалли (р-н Раманагара, Индия).

Исследование проводилось с января 2020 по сентябрь 2021 года (21 месяц). Данные собирали из судебно-медицинских регистров и историй болезни в CDSIMER.

Критерии соответствия

Критерии включения: все случаи отравления, зарегистрированные в отделении скорой помощи в CDSIMER, по которым имеются полные истории болезни и обширные записи, доступные для извлечения данных.

Критерии исключения: смерть пациента при поступлении, случаи отравления неизвестным веществом.

Этическая экспертиза

Исследование одобрено этическим комитетом CDSIMER (письмо № CDSIMER/MR/0026/IEC/2021 от 22.11.2021).

Статистический анализ

Данные о возрасте, поле, времени обращения в больницу, обстоятельствах отравления, о виде ядовитого вещества, длительности госпитализации, тяжести состояния и исходах фиксировали в предварительно структурированной форме. Полученные данные оформляли в виде таблиц и анализировали с помощью программы Microsoft Excel.

РЕЗУЛЬТАТЫ

Выборка исследования (участники/респонденты)

С января 2020 по сентябрь 2021 года в отделение скорой помощи CDSIMER поступило 522 человека с острыми отравлениями, из них 12 были пролечены в отделении, находились под наблюдением и были отправлены домой в течение 24 часов; 510 человек были госпитализированы, 20 из них умерли.

В течение 21 месяца (с января 2020 по сентябрь 2021 года) критериям включения соответствовали 522 случая отравления. Были изучены и проанализированы больничные карты этих пациентов. Качественные данные описательной статистики обобщались путём вычисления частотных и процентных показателей. Из 522 пациентов 10 были выписаны: все они были бессимптомны, употребили несмертельную дозу яда и поступили в больницу в течение 1 часа. Их показатели жизненно важных функций и результаты лабораторных исследований были в норме, поэтому они были выписаны в течение 24 часов на амбулаторное лечение.

Из 522 госпитализированных пациентов 58% были мужского пола, из них в возрастной группе 21–30 лет — 33,52%, 31–40 лет — 21,45%, 3 человека были в возрасте 81–90 лет (табл. 1).

Смогли добраться до больницы в период от 1 до 8 часов 81,4% пациентов, 11,4% — в течение одного часа; 2 человека поступили в нашу больницу через 2 дня после того, как им была оказана первичная медицинско-санитарная помощь, затем они были направлены в нашу больницу для дальнейшего лечения (табл. 2).

Из 510 госпитализированных пациентов умерло 20, из них 12 (60%) человек были мужского пола, при этом 10 умерших находились в возрастной группе 21–30 лет,

6 — в возрасте 31–40 лет, 4 — в возрасте 11–20 лет. Выздоровели и были выписаны из отделения в течение 3 дней 56% больных: выздоровевшие чаще всего находились в возрастных группах от 21 до 30 и от 31 до 40 лет. В 22 случаях длительность госпитализации составила более 2 недель в связи с развитием осложнений (табл. 3).

Основные результаты исследования

Фосфорорганическая группа инсектицидов была наиболее распространённым видом потребляемых ядов (40,8% случаев), за ней следуют укус змеи (23,4%) и передозировка лекарственных препаратов (21,3%). Данные распределения видов ядов по полу представлены в табл. 4. Инсектициды были самым распространённым ядом, от которого пострадали все возрастные группы старше 11 лет. Укусы змей чаще встречались у рабочего класса населения,

занятого на сельскохозяйственных работах. Отравление лекарственными препаратами чаще встречалось у детей до 11 лет и пожилых людей старше 50 лет. Попытки самоубийства (60,35%) встречались чаще, чем случайные отравления (39,65%). Среди укусов животных преобладали укусы ядовитых змей, пчёл и скорпионов, которые носили случайный характер (табл. 5).

ОБСУЖДЕНИЕ

Результаты, аналогичные нашим (58% пациентов мужского пола, из них 33,52% — в возрастной группе 21–30 лет), были получены в исследованиях, выполненных в городах Ахмеднагар и Белагави (Индия), где 32,18% и 38,2% больных относились к той же возрастной группе соответственно [2, 3]. В других исследованиях,

Таблица 1. Распределение случаев отравления по возрасту и полу пациентов

Table 1. Age and sex distribution of cases

Возрастная группа, лет	Мужчины, n=303 (58%)	Женщины, n=219 (42%)	Всего, n=522 (%)
01–10	10	7	17 (3,25)
11–20	60	42	102 (19,54)
21–30	98	77	175 (33,52)
31–40	68	44	112 (21,45)
41–50	23	20	43 (8,23)
51–60	22	18	40 (7,66)
61–70	15	10	25 (4,78)
71–80	4	1	5 (0,95)
81–90	3	0	3 (0,57)

Таблица 2. Временной интервал между инцидентом и поступлением в больницу

Table 2. Time interval between incident and arrival at hospital

Временной интервал	Число случаев, n (%)
Менее 1 ч	60 (11,4)
1–8 ч	425 (81,4)
8–24 ч	31 (6)
1–2 дня	4 (0,8)
Более 2 дней	2 (0,4)
Всего	522 (100)

Таблица 3. Продолжительность госпитализации

Table 3. Duration of hospitalisation

Продолжительность госпитализации, дней	Мужчины, n	Женщины, n	Всего, n (%)
1–3	166	120	286 (56,1)
4–7	86	60	146 (28,6)
8–14	30	26	56 (11)
Более 14	12	10	22 (4,3)
Всего	294	216	510 (100)

Таблица 4. Виды яда

Table 4. Type of poison

Виды яда	Мужчины, <i>n</i>	Женщины, <i>n</i>	Всего, <i>n</i> (%)
Фосфорорганические соединения	118	95	213 (40,8)
Укус змеи	70	52	122 (23,4)
Лекарственные препараты	60	51	111 (21,3)
Укус пчелы	20	15	35 (6,7)
Соляная кислота	15	1	16 (3,1)
Бензол	4	1	5 (0,94)
Укус скорпиона	3	2	5 (0,94)
Ацетон	4	0	4 (0,73)
Гипохлорит натрия	3	0	3 (0,57)
Формалин	2	0	2 (0,38)
Укус неизвестного насекомого	0	2	2 (0,38)
Стеклянный порошок	1	0	1 (0,19)
Йод	1	0	1 (0,19)
Диоксид кремния	1	0	1 (0,19)
Гидроуглерод	1	0	1 (0,19)
Всего	303	219	522 (100)

Таблица 5. Способ отравления

Table 5. Manner of poisoning

Способ отравления	Число случаев, <i>n</i> (%)
Самоубийство	315 (60,35)
Случайное отравление	207 (39,65)
Всего	522 (100)

проведённых в городах Манипал (52,15%) [4] и Белагави (60,1%) [3], чаще страдали мужчины. Возрастная группа 21–30 лет составляет подавляющее большинство населения Индии и находится в периоде построения карьеры. Из-за жизненных трудностей, таких как стресс, финансовая необеспеченность и любовные отношения, многие представители этой возрастной группы пытаются покончить с собой. Кроме того, они более склонны к авантюризму и рискованному поведению, что повышает вероятность случайных отравлений.

Только 11% пациентов смогли добраться до больницы в течение часа, а большинство (81,4%) — в период от 1 до 8 часов после инцидента. В исследовании, проведённом в Нью-Дели, среднее время до момента первого обращения пациента к врачу после отравления составило 60 (51,25–120) минут [5]. В Хайдарабаде более половины (51%) пострадавших обратились в больницу в течение 2 часов после приёма яда [6], тогда как в Варангале 80% всех пострадавших от отравления поступили в больницу

в течение 6 часов [7]. Наличие службы скорой помощи или других транспортных служб определяет время, затрачиваемое на доставку в больницу. Поскольку наша больница — это медицинское учреждение третьего уровня, расположенное в сельской местности и обслуживающее большое количество населения на обширной территории, доставка пациентов к нам в большинстве случаев занимает более часа. Более 40% больных получили первичную медицинскую помощь в другом учреждении, затем были направлены в нашу больницу. Это может быть причиной того, что пациенты поступают к нам позже, чем в другие больницы города.

На срок от 1 до 3 дней были госпитализированы 56,1% пострадавших, 4,3% провели в больнице более 2 недель. В исследовании, проведённом в специализированной больнице третичного звена в штате Западная Бенгалия, средняя продолжительность госпитализации составила 4 дня (межквартильный интервал 2–6 дней). Среди всех участников исследования 72,13% выздоровели

без последствий, 2,87% — с последствиями, 9,97% отказались от медицинской помощи, 15,03% умерли [8]. В нашем исследовании из 522 случаев отравления только 20 были летальными (3,83%).

Инсектициды, в основном фосфорорганические соединения, были наиболее распространённым видом потребляемых ядов, составившим 40,8% случаев, на втором и третьем месте — укус змеи (23,4%) и лекарственные средства. Тип отравления зависит от различных факторов, таких как сельская или городская местность, доступность того или иного яда и обитание ядовитых животных, характерных для данной местности. С учётом этих факторов передозировка лекарственных средств (21,3%) чаще встречалась в Нью-Дели [5], фосфорорганических веществ — в Хайдарабаде (41%) [6] и Манипале (36%) [4].

Случаи укуса змей имеют высокую тенденцию к росту в таких штатах, как Западная Бенгалия, и занимают второе место по распространённости в нашем районе (23,4%) и Манипале (16,2%) — сельской местности с обширными лесными массивами поблизости [4]. В Западной Бенгалии коррозионные и седативные вещества использовались чаще, чем фосфорорганические соединения [8]. Основное занятие жителей в нашем районе — сельское хозяйство. Инсектициды и пестициды находятся в свободном доступе у фермеров и членов их семей.

При анализе способов отравления было отмечено, что попытки самоубийства (60%) встречались чаще, чем случайные отравления (40%). Случаев отравления с целью убийства не зарегистрировано. Аналогичные результаты были получены и в других исследованиях. Так, в исследованиях, проведённых в Ахмеднагаре, Хайдарабаде, Варангале и Белгави [2, 3, 6, 7], самоубийства составили 64,36, 79, 52 и 67% случаев, а случайные отравления — 33,33, 14, 48 и 32,4% соответственно.

ЗАКЛЮЧЕНИЕ

Инсектициды, главным образом фосфорорганические соединения, являются наиболее распространённой группой ядов, вызывающих заболеваемость и смертность среди сельского населения Индии, особенно среди молодых людей в возрасте от 21 до 40 лет. Эти яды находятся в свободном доступе в ближайших магазинах, так как используются в сельском хозяйстве, которое является основным

родом деятельности нашего региона. Укусы змей ввиду наличия в регионе лесных массивов становятся вторым по значимости видом отравлений. Самоубийства — распространённое явление в сельской местности, основная причина — финансовые проблемы. Полученные результаты помогут не только клиницистам, но и судебным патологоанатомам и следственным органам в определении вида и способа отравления при аутопсии.

Вопросы оказания скорой и неотложной помощи в сельской местности по-прежнему вызывают озабоченность. Большинство случайных отравлений связано с укусами животных, в основном змей. В ранней диагностике и оказании специализированной помощи при отравлениях мог бы помочь полноценно функционирующий токсикологический центр. Снижению числа случаев отравления во многом способствовало бы обучение деревенских жителей навыкам оказания первой помощи при укусах змей и принятие мер, ограничивающих свободный доступ к инсектицидам.

ДОПОЛНИТЕЛЬНО

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Вклад авторов. Все авторы подтверждают соответствие своего авторства международным критериям ICMJE (все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией).

ADDITIONAL INFORMATION

Funding source. This study was not supported by any external sources of funding.

Competing interests. The authors declare that they have no competing interests.

Authors' contribution. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

СПИСОК ЛИТЕРАТУРЫ

1. Mittal C., Singh S., Kumar M.P., et al. Toxicoepidemiology of poisoning exhibited in Indian population from 2010 to 2020: A systematic review and meta-analysis // *BMJ Open*. 2021. Vol. 11, N 5. P. e045182. doi: 10.1136/bmjopen-2020-045182
2. Tandle R.M., Kadu S.S. Study of pattern of acute poisoning cases in females at a rural // *Int J Education Res Health Sci*. 2017. Vol. 3, N 3. P. 122–124. doi: 10.5005/jp-journals-10056-0053
3. Bannur V., Jirli P.S., Honnungar R.S., et al. Pattern of poisoning cases at a tertiary health care centre: A cross sectional study // *Medico-legal Update*. 2019. Vol. 19, N 1. P. 124–129. doi: 10.5958/0974-1283.2019.00025.2
4. Ramesha K.N., Rao B.H., Kumar G.S. Pattern and outcome of acute poisoning cases in a tertiary care hospital in Karnataka, India // *Indian J Crit Care Med*. 2009. Vol. 13, N 3. P. 152–155. doi: 10.4103/0972-5229.5854

5. Mathew R., Jamshed N., Aggarwal P., et al. Profile of acute poisoning cases and their outcome in a teaching hospital of north India // *J Family Med Prim Care*. 2019. Vol. 8, N 12. P. 3935–3939. doi: 10.4103/jfmpc.jfmpc_832_19
6. Nadeem M.N., Maqdoom M., Akif M.E. A prospective observational study on pattern of poisoning cases reported to emergency department of a teaching hospital in south India // *Biomed Pharmacol J*. 2020. Vol. 13, N 4. P. 1863–1869. doi: 10.13005/bpj/2061

7. Kumar S.V., Venkateswarlu B., Sasikala M., Kumar G.V. A study on poisoning cases in a Tertiary care hospital // *J Nat Sci Biol Med*. 2010. Vol. 1, N 1. P. 35–39. doi: 10.4103/0976-9668.71671
8. Chatterjee S., Verma V.K., Hazra A., et al. An observational study on acute poisoning in a tertiary care hospital in West Bengal, India // *Perspectives Clin Res*. 2020. Vol. 11, N 2. P. 75–80. doi: 10.4103/picr.PICR_181_18

REFERENCES

1. Mittal C, Singh S, Kumar MP, et al. Toxicoeidemiology of poisoning exhibited in Indian population from 2010 to 2020: A systematic review and meta-analysis. *BMJ Open*. 2021;11(5):e045182. doi: 10.1136/bmjopen-2020-045182
2. Tandle RM, Kadu SS. Study of pattern of acute poisoning cases in females at a rural. *Int J Education Res Health Sci*. 2017;3(3):122–124. doi: 10.5005/jp-journals-10056-0053
3. Bannur V, Jirli PS, Honnunar RS, et al. Pattern of poisoning cases at a tertiary health care centre: A cross sectional study. *Medico-legal Update*. 2019;19(1):124–129. doi: 10.5958/0974-1283.2019.00025.2
4. Ramesha KN, Rao BH, Kumar GS. Pattern and outcome of acute poisoning cases in a tertiary care hospital in Karnataka, India. *Indian J Crit Care Med*. 2009;13(3):152–155. doi: 10.4103/0972-5229.5854

5. Mathew R, Jamshed N, Aggarwal P, et al. Profile of acute poisoning cases and their outcome in a teaching hospital of north India. *J Family Med Prim Care*. 2019;8(12):3935–3939. doi: 10.4103/jfmpc.jfmpc_832_19
6. Nadeem MN, Maqdoom M, Akif ME. A prospective observational study on pattern of poisoning cases reported to emergency department of a teaching hospital in south India. *Biomed Pharmacol J*. 2020;13(4):1863–1869. doi: 10.13005/bpj/2061
7. Kumar SV, Venkateswarlu B, Sasikala M, Kumar GV. A study on poisoning cases in a Tertiary care hospital. *J Nat Sci Biol Med*. 2010;1(1):35–39. doi: 10.4103/0976-9668.71671
8. Chatterjee S, Verma VK, Hazra A, et al. An observational study on acute poisoning in a tertiary care hospital in West Bengal, India. *Perspectives Clin Res*. 2020;11(2):75–80. doi: 10.4103/picr.PICR_181_18

ОБ АВТОРАХ

* **Manju Prakash**, д-р медицины, профессор;
адрес: Департамент судебной медицины, Институт
медицинского образования и исследований им. д-ра
Чандрамма Даянанда Сагар, Университет Даянанда Сагар,
Харохалли, Канакапура, округ Раманagara, 562112, Карнатака,
Индия;
ORCID: 0009-0008-4237-7195;
e-mail: drmanjup@yahoo.co.uk

Geetha K.B., доцент;
ORCID: 0000-0002-8841-1407;
e-mail: dr_geethakb@yahoo.co.uk

Jayanth S. Hosahally, доцент;
ORCID: 0000-0001-5209-1133;
e-mail: veejay02@gmail.com

AUTHORS' INFO

* **Manju Prakash**, MD (Forensic Medicine), Professor & HOD;
address: Dept of Forensic Medicine, Dr Chandramma
Dayananda Sagar Institute of Medical Education and Research,
Dayananda Sagar University, Devarakaggalahalli,
Ramanagara Dist,
562112 Karnataka, India;
ORCID: 0009-0008-4237-7195;
e-mail: drmanjup@yahoo.co.uk

K.B. Geetha, MD, Associate Professor;
ORCID: 0000-0002-8841-1407;
e-mail: dr_geethakb@yahoo.co.uk

Jayanth S. Hosahally, MD (Forensic Medicine), Associate Professor;
ORCID: 0000-0001-5209-1133;
e-mail: veejay02@gmail.com

* Автор, ответственный за переписку / Corresponding author

DOI: <https://doi.org/10.17816/fm14217>

Profile of poisoning cases in a tertiary care center in rural South India

K. B. Geetha, Jayanth S. Hosahally, Manju Prakash

Dr Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Devarakagalahalli, Ramanagara Dist, Karnataka, India

ABSTRACT

BACKGROUND: Poisoning is the fourth most common cause of mortality in rural India. The commonest agents in India appear to be pesticides, sedatives, chemicals, alcohol, animal & plant toxins and household toxins. Our hospital receives an average of 20 to 25 poisoning cases every month.

AIMS: To profile all cases of poisoning those are reported to casualty department at Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research (CDSIMER); to study the types and frequency of poisoning cases admitted to the centre; to study the socio-demographic associations of the poisoning cases.

MATERIALS AND METHODS: Present study is a hospital record-based retrospective observational study of acute poisoning cases registered in the medicolegal register in the casualty of CDSIMER, which is a tertiary care center located in rural area near Harohalli, Ramanagara District, India.

RESULTS: Males constituted 58% of the cases and 33.52% of the cases were in the age group of 21–30 years. 81.4% of the cases were able to reach hospital between 1 to 8 hours. 56% of the cases recovered and were discharged within 3 days. In 22 cases the duration of admission was more than 2 weeks as they went into complications. Organo phosphorus group of insecticide was the most common type of poison consumed constituting to 40.8% of the cases followed by Snake bite. Attempt to suicide (60.35%) was more common than accidental poisoning.

CONCLUSION: Insecticides mainly Organophosphorus compound are the most common group of poisons which causes morbidity and mortality in rural Indian population especially in young adults between 21 to 40 years. Owing to the presence of forests in the region, Snake bite becomes the second largest type of poisoning. Suicide frequently prevails in the rural areas; financial problem is the leading cause for farmers to commit suicide.

Keywords: poisoning; insecticides; suicide; snake bite.

To cite this article:

Geetha KB, Jayanth SH, Manju Prakash. Profile of poisoning cases in a tertiary care center in rural South India. *Russian Journal of Forensic Medicine*. 2023;9(4):383–390. DOI: <https://doi.org/10.17816/fm14217>

JUSTIFICATION

Poisoning is the fourth leading cause of death in rural India. There are many causes of poisoning: industrial, accidental and intentional. The use of toxic chemicals in almost all areas of human life is steadily increasing throughout the world, despite a number of laws regulating the use of poisons. There are more than 9 million natural and synthetic chemicals, of which only 3000 cause poisoning (they account for more than 95% of registered cases) [1]. The most common poisoning agents in India are pesticides, sedatives, chemicals, alcohol, animal and plant toxins, and household toxins.

In India, all cases of poisoning are medico-legal in nature and if the patient dies, an inquest must be held followed by an autopsy by a forensic pathologist. This is done to clarify the circumstances under which the poisoning occurred, as well as to establish the exact cause and type of death. A forensic pathologist should have an understanding of the common types of poisonings in his or her region.

Our hospital receives an average of 20–25 patients with poisoning. Such high rates are alarming and worrying, so this study was conducted to study the structure of various types of poisonings and the factors associated with their occurrence. This will allow us to develop a plan to increase public awareness about various types of poisons and their handling, which will help reduce the frequency of poisonings.

The purpose of the study is to compile a general profile of all cases of poisoning reported in the emergency department of the Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research (CDSIMER), to study types and frequency of poisonings, as well as socio-demographic indicators of patients admitted to our institution with poisoning.

MATERIALS AND METHODS

Study design

A retrospective observational study of acute poisoning cases reported from the emergency department of CDSIMER, which is a tertiary care facility located in a rural area near Kharohalli (Ramanagara, India). The study was conducted from January 2020 to September 2021 (21 months). Data were collected from forensic registers

and clinical records in CDSIMER.

Eligibility Criteria

Inclusion criteria: all poisoning cases registered in the emergency department in CDSIMER for which complete patient records and extensive records were available for data extraction.

Exclusion criteria: death of the patient upon admission
captivity, cases of poisoning with an unknown substance.

Ethical review

The study was approved by the ethics committee of CDSIMER. (letter No. CDSIMER/MR/0026/IEC/2021 dated 22.11.2021).

Statistical analysis

Data on age, gender, time of treatment at the hospital, circumstances of poisoning, type of poisonous vein society, duration of hospitalization, severity of condition and outcomes were recorded in a pre-structured form. The obtained data were presented in the form of tables and analyzed using Microsoft Excel.

RESULTS

Study sample (participants/respondents)

From January 2020 to September 2021, 522 people with acute poisoning were admitted to the CDSIMER emergency department, of whom 12 were treated in the department, were monitored and were sent home within 24 hours; 510 people were hospitalized, 20 of them died. Over a 21-month period (January 2020 to September

2021), 522 cases of poisoning met the inclusion criteria. The hospital records of these patients were reviewed and analyzed. Qualitative descriptive statistics data were summarized by calculating frequencies and percentages. Of the 522 patients, 10 were discharged: all of them were asymptomatic, consumed a non-lethal dose of poison and were admitted to the hospital within 1 hour. Their vital signs and laboratory results were normal and they were discharged within 24 hours to outpatient care.

Of the 522 hospitalized patients, 58% were male, of which 33.52% were in the age group 21–30 years, 21.45% were 31–40 years old, and 3 people were aged 81–90 years (Table 1). 81.4% of patients were able

to get to the hospital in the period from 1 to 8 hours, 11.4% - within one hour; 2 people were admitted to our hospital 2 days after they received primary health care, then they were referred to our hospital for further treatment (Table 2).

Of the 510 hospitalized patients, 20 died, of which 12 (60%) were male, with 10 deaths in the 21–30 age group.

6 – aged 31–40 years, 4 – aged 11–20 years. 56% of patients recovered and were discharged from the department within 3 days: those who recovered were most often in the age groups from 21 to 30 and from 31 to 40 years. In 22 cases, the duration of hospitalization was more than 2 weeks due to the development of complications

employed in agricultural work. Drug poisoning was more common in children under 11 years of age and older adults over 50 years of age. Attempted suicide (60.35%) was more common than accidental poisoning (39.65%). Among animal bites, the predominant bites were those of (poisonous) snakes, bees and scorpions, which were random in nature (Table 5).

Main results of the study

Organophosphate insecticides were the most common type of poison consumed (40.8% of cases), followed by snakebite (23.4%) and drug overdose (21.3%). Data on the distribution of types of poisons by gender are presented in table. 4. Insecticides were the most common poison, affecting all age groups over 11 years of age. Snake bites were more common among the working class population,

DISCUSSION

Results similar to ours (58% of male patients, of which 33.52% were in the age group 21–30 years) were obtained in studies carried out in the cities of Ahmednagar and Belagavi (India), where 32.18% and 38.2% of patients belonged to the same age group, respectively [2, 3]. In other studies,

Table 1. Distribution of cases of poisoning by age and gender of patients

Table 1. Age and sex distribution of cases

Age group, years	Men, n=303 (58%)	Women, n=219 (42%)	Total, n=522 (%)
01–10	10	7	17 (3.25)
11–20	60	42	102 (19.54)
21–30	98	77	175 (33.52)
31–40	68	44	112 (21.45)
41–50	23	20	43 (8.23)
51–60	22	18	40 (7.66)
61–70	15	10	25 (4.78)
71–80	4	1	5 (0.95)
81–90	3	0	3 (0.57)

Table 2. Time interval between incident and admission to hospital

Table 2. Time interval between incident and arrival at hospital

Time interval	Number of cases, n (%)
Less than 1 hour	60 (11.4)
1–8 h	425 (81.4)
8–24 hours	31 (6)
1–2 days	4 (0.8)
More than 2 days	2 (0.4)
Total	522 (100)

Table 3. Duration of hospitalization

Table 3. Duration of hospitalization

Duration of hospitalization, days	Men, n	Women, n	Total, n (%)
1–3	166	120	286 (56.1)
4–7	86	60	146 (28.6)
8–14	thirty	26	56 (11)
More than 14	12	10	22 (4.3)
Total	294	216	510 (100)

Table 4. Types of poison

Table 4. Type of poison

Types of poison	Men, <i>n</i>	Women, <i>n</i>	Total, <i>n</i> (%)
Organophosphorus compounds	118	95	213 (40.8)
Snake bite	70	52	122 (23.4)
Medications	60	51	111 (21.3)
Bee sting	20	15	35 (6.7)
Hydrochloric acid	15	1	16 (3.1)
Benzene	4	1	5 (0.94)
Scorpion sting	3	2	5 (0.94)
Acetone	4	0	4 (0.73)
Sodium hypochlorite	3	0	3 (0.57)
Formalin	2	0	2 (0.38)
Unknown insect bite	0	2	2 (0.38)
Glass Powder Iodine	1	0	1 (0.19)
	1	0	1 (0.19)
Silica	1	0	1 (0.19)
Hydrocarbon	1	0	1 (0.19)
Total	303	219	522 (100)

Table 5. Method of poisoning

Table 5. Manner of poisoning

Method of poisoning	Number of cases, <i>n</i> (%)
Suicide	315 (60.35)
Accidental poisoning	207 (39.65)
Total	522 (100)

conducted in the cities of Manipal (52.15%) [4] and Belagavi (60.1%) [3], men were more likely to suffer. The 21-30 age group constitutes the vast majority of India's population and is in the career-building period. Due to difficulties in life such as stress, financial insecurity and love affairs, many in this age group attempt suicide. In addition, they are more prone to adventurism and risky behavior, which increases the likelihood of accidental poisoning.

Only 11% of patients were able to reach the hospital within an hour, and the majority (81.4%) did so within 1 to 8 hours after the incident. In a study conducted in New Delhi, the average time until the patient first contacted a doctor after poisoning was 60 (51.25–120) minutes [5]. In Hyderabad, more than half (51%) of victims were admitted to hospital within 2 hours of ingesting poison [6], while in Warangal, 80% of all poisoning victims were admitted to hospital

within 6 hours [7]. The availability of ambulance or other transport services determines the time it takes to get to the hospital. Since our hospital is a tertiary medical facility located in a rural area and serving a large population over a wide area, it takes more than an hour for patients to arrive at us in most cases. More than 40% of patients received primary medical care in another institution and were then referred to our hospital. This may be the reason why patients come to us later than to other hospitals in the city.

56.1% of the victims were hospitalized for a period of 1 to 3 days, 4.3% spent more than 2 weeks in the hospital. In a study conducted at a tertiary care hospital in West Bengal, the median length of stay was 4 days (IQR 2–6 days). Among all study participants, 72.13% recovered

without consequences, 2.87% with consequences, 9.97% refused medical care, 15.03% died [8]. In our study, out of 522 cases of poisoning, only 20 were fatal (3.83%).

Insecticides, mainly organophosphorus compounds, were the most common type of poison consumed, accounting for 40.8% of cases, followed by snake bites (23.4%) and medicines in second and third place. The type of poisoning depends on various factors, such as rural or urban areas, the availability of a particular poison and the presence of poisonous animals characteristic of the area. Taking these factors into account, overdose of drugs (21.3%) was more common in New Delhi [5], of organophosphates - in Hyderabad (41%) [6] and Manipal (36%) [4].

Snake bite cases have a high increasing trend in states like West Bengal and are the second most common in our district (23.4%) and Manipal (16.2%) - a rural area with extensive forest areas nearby [4]. In West Bengal, corrosives and sedatives were used more frequently than organophosphates [8]. The main occupation of residents in our area is agriculture. Insecticides and pesticides are freely available to farmers and their families.

When analyzing methods of poisoning, it was noted that suicide attempts (60%) were more common than accidental poisonings (40%). There have been no cases of poisoning with intent to kill. Similar results were obtained in other studies. Thus, in studies conducted in Ahmednagar, Hyderabad, Warangal and Belgavi [2, 3, 6, 7], suicides accounted for 64.36, 79, 52 and 67% of cases, and accidental poisonings - 33.33, 14.48 and 32.4% respectively.

CONCLUSION

Insecticides, mainly organophosphates, are the most common group of poisons causing morbidity and mortality among the rural population of India, especially among young people aged 21 to 40 years. These poisons are freely available in nearby stores, as they are used in agriculture, which is the main

type of activity in our region. Due to the presence of forests in the region, snake bites are becoming the second most important type of poisoning. Suicide is a common phenomenon in rural areas, the main reason being financial problems. The results obtained will help not only clinicians, but also forensic pathologists and investigative authorities in determining the type and method of poisoning during autopsy.

Issues of providing ambulance and emergency care in rural areas continue to cause concern. Most accidental poisonings are due to animal bites, mainly snakes. A fully functioning poison control center could help with early diagnosis and specialized care for poisonings. Reducing the number of cases of poisoning would be greatly facilitated by training villagers in first aid for snake bites and taking measures to limit free access to insecticides.

ADDITIONALLY

Source of financing. The authors declare that there was no external funding for the study. Conflict of interest. The authors declare that there are no obvious or potential conflicts of interest related to the publication of this article.

Authors' contributions. All authors confirm that their authorship meets the international ICMJE criteria (all authors made a significant contribution to the development of the concept, conduct of the study and preparation of the article, read and approved the final version before publication).

ADDITIONAL INFORMATION

Funding source. This study was not supported by any external sources of funding.

Competing interests. The authors declare that they have no competing interests.

Authors' contribution. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

BIBLIOGRAPHY

- Mittal C., Singh S., Kumar MP, et al. Toxicoepidemiology of poisoning exhibited in Indian population from 2010 to 2020: A systematic review and meta-analysis // *BMJ Open*. 2021. Vol. 11, N 5. P. e045182. doi: 10.1136/bmjopen-2020-045182.
- Tandle RM, Kadu SS Study of pattern of acute poisoning cases in females at a rural // *Int J Education Res Health Sci*. 2017. Vol. 3, N 3. P. 122–124. doi: 10.5005/jp-journals-10056-0053
- Bannur V, Jirli PS, Honnunar RS, et al. Pattern of poisoning cases at a tertiary health care center: A cross sectional study // *Medico-legal Updatee*. 2019. Vol. 19, N 1. P. 124–129. doi: 10.5958/0974-1283.2019.00025.2
- Ramesha KN, Rao BH, Kumar GS Pattern and outcome of acute poisoning cases in a tertiary care hospital in Karnataka, India // *Indian J Crit Care Med*. 2009 Vol. 13, N 3. P. 152–155. doi: 10.4103/0972-5229.5854

5. Mathew R., Jamshed N., Aggarwal P., et al. Profile of acute poisoning cases and their outcome in a teaching hospital of north India // *J Family Med Prim Care*. 2019. Vol. 8, N 12. P. 3935–3939. doi: 10.4103/jfmpc.jfmpc_832_19
6. Nadeem MN, Maqdoom M., Akif ME A prospective observational study on pattern of poisoning cases reported to emergency department of a teaching hospital in south India // *Biomed Pharmacol J*. 2020. Vol. 13, N 4. P. 1863–1869. doi: 10.13005/bpj/2061

7. Kumar SV, Venkateswarlu B., Sasikala M., Kumar GV A study on poisoning cases in a Tertiary care hospital // *J Nat Sci Biol Med*. 2010. Vol. 1, N 1. P. 35–39. doi: 10.4103/0976-9668.71671
8. Chatterjee S, Verma VK, Hazra A, et al. An observational study on acute poisoning in a tertiary care hospital in West Bengal, India. *Perspectives Clin Res*. 2020. Vol. 11, N 2. P. 75–80. doi: 10.4103/picr.PICR_181_18

REFERENCES

1. Mittal C, Singh S, Kumar MP, et al. Toxicoeidemiology of poisoning exhibited in Indian population from 2010 to 2020: A systematic review and meta-analysis. *BMJ Open*. 2021;11(5):e045182. doi: 10.1136/bmjopen-2020-045182.
- Tandle RM, Kadu SS. Study of pattern of acute poisoning cases in females at a rural. *Int J Education Res Health Sci*. 2017;3(3):122–124. doi: 10.5005/jp-journals-10056-0053
3. Bannur V, Jirli PS, Honnunar RS, et al. Pattern of poisoning cases at a tertiary health care center: A cross sectional study. *Medico-legal Update*. 2019;19(1):124–129. doi: 10.5958/0974-1283.2019.00025.2
4. Ramesha KN, Rao BH, Kumar GS. Pattern and outcome of acute poisoning cases in a tertiary care hospital in Karnataka, India. *Indian J Crit Care Med*. 2009;13(3):152–155. doi: 10.4103/0972-5229.5854

5. Mathew R, Jamshed N, Aggarwal P, et al. Profile of acute poisoning cases and their outcome in a teaching hospital of north India. *J Family Med Prime Care*. 2019;8(12):3935–3939. doi: 10.4103/jfmpc.jfmpc_832_19
6. Nadeem MN, Maqdoom M, Akif ME. A prospective observational study on pattern of poisoning cases reported to emergency department of a teaching hospital in south India. *Biomed Pharmacol J*. 2020;13(4):1863–1869. doi: 10.13005/bpj/2061
7. Kumar SV, Venkateswarlu B, Sasikala M, Kumar GV. A study on poisoning cases in a Tertiary care hospital. *J Nat Sci Biol Med*. 2010;1(1):35–39. doi: 10.4103/0976-9668.71671
8. Chatterjee S, Verma VK, Hazra A, et al. An observational study on acute poisoning in a tertiary care hospital in West Bengal, India. *Perspectives Clin Res*. 2020;11(2):75–80. doi: 10.4103/picr.PICR_181_18

ABOUT THE AUTHORS

* Manju Prakash, MD, professor;
Address: Department of Forensic Medicine, Institute of Medical Education and Research. Dr. Chandramma Dayananda Sagar, Dayananda Sagar University, Harohalli, Kanakapura, Ramanagara District, 562112, Karnataka, India;

ORCID: 0009-0008-4237-7195;
e-mail: drmanjup@yahoo.co.uk
Geetha KB, Associate
Professor; ORCID: 0000-0002-8841-1407;
e-mail: dr_geethakb@yahoo.co.uk

Jayanth S. Hosahally, Associate Professor;
ORCID: 0000-0001-5209-1133;
e-mail: veejay02@gmail.com

*
Corresponding author

AUTHORS' INFO

* Manju Prakash, MD (Forensic Medicine), Professor & HOD;
address: Dept of Forensic Medicine, Dr Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University, Devarakaggalahalli, Ramanagara Dist, 562112 Karnataka, India;

ORCID: 0009-0008-4237-7195;
e-mail: drmanjup@yahoo.co.uk
K. B. Geetha, MD, Associate Professor;
ORCID: 0000-0002-8841-1407;
e-mail: dr_geethakb@yahoo.co.uk

Jayanth S. Hosahally, MD (Forensic Medicine), Associate Professor;
ORCID: 0000-0001-5209-1133;
e-mail: veejay02@gmail.com

DOI: <https://doi.org/10.17816/fm14218>

Отсроченная смерть при незавершённом повешении: исследование причин и сопутствующих факторов по результатам аутопсии

J.S. Hosahally¹, Y.P. Girish Chandra², B.S. Hugar²

¹ Институт медицинского образования и исследований доктора ЧанDRAMмы Даянанды Сагара, DSU, Кафедра судебной медицины, Деверакаггалахалли, Индия;

² Медицинский колледж имени М.С. Рамайя, кафедра судебной медицины, Бангалор, Индия

АННОТАЦИЯ

Обоснование. Незавершённый суицид путём повешения часто приводит к патологическим состояниям у лиц, переживших странгуляционную асфиксию различной длительности. У госпитализированных пациентов могут возникать осложнения, приводящие к отсроченной смерти.

Цель исследования — оценить различные факторы, связанные с причинами отсроченной смерти в случаях незавершённого повешения, и предложить рекомендации по улучшению работы служб экстренной медицинской помощи.

Материалы и методы. Проспективное исследование по результатам аутопсии проводилось в период с 2012 по 2021 год на кафедре судебной медицины Медицинского колледжа им. М.С. Рамайя (Индия). В исследование были включены все случаи незавершённого повешения с последующей госпитализацией пациентов, которые впоследствии скончались от полученных осложнений и были подвергнуты судебно-медицинскому вскрытию.

Результаты. Пострадавшими, как правило, были женщины в возрасте от 19 до 30 лет. Более половины из них смогли добраться до больницы в течение 30 минут – 1 часа после инцидента, 47,8% испытывали асфиксию в течение 1–3 минут, при этом 65% пациентов ещё были живы более суток. Чаще всего встречалось неполное повешение со слабовыраженной странгуляционной бороздой, 95,7% из них закончились падением с высоты не менее 1 метра. При вскрытии чаще всего обнаруживали отёк головного мозга и лёгких. Смерть в большинстве случаев наступала в результате гипоксической энцефалопатии.

Заключение. Предикторами летального исхода при незавершённом повешении являются продолжительность странгуляции, большая высота падения, отсутствие контакта с опорой, отёк головного мозга и лёгких, гипоксия, гипотензия.

Ключевые слова: повешение; причина смерти; осложнения; самоубийство.

Как цитировать:

Hosahally J.S., Girish Chandra Y.P., Hugar B.S. Отсроченная смерть при незавершённом повешении: исследование причин и сопутствующих факторов по результатам аутопсии // *Судебная медицина*. 2023. Т. 9, № 4. С. 373–381. DOI: <https://doi.org/10.17816/fm14218>

DOI: <https://doi.org/10.17816/fm14218>

Delayed deaths in near-hanging cases: An autopsy study of causes and associated factors

Jayanth S. Hosahally¹, Y.P. Girish Chandra², Basappa S. Hugar²

¹ Department of Forensic Medicine, Dr Chandramma Dayananda Sagar Institute of Medical Education & Research, Devarakaggalahalli, DSU, India;

² Department of Forensic Medicine, MS Ramaiah Medical College, Bangalore, India

ABSTRACT

BACKGROUND: Near-hanging refers to individuals who survive a hanging injury for various durations. However, hospitalized patients succumb to complications resulting in delayed deaths.

AIM: to evaluate various factors associated with causes of delayed death in near-hanging events and provide insight into the improvement of emergency services.

MATERIALS AND METHODS: A prospective autopsy-based study was conducted at the Department of Forensic Medicine, M.S. Ramaiah Medical College, between 2012 and 2021. All near-hanging cases of hospitalized patients who later succumbed to complications and were subsequently subjected to medicolegal autopsy were included in the study.

RESULTS: Victims were commonly women aged 19–30 years. More than half of them could reach the hospital within 30 min to 1 hour, and 47.8% of them were suspended for between 1–3 min. Moreover, 65% survived for more than a day. Partial hanging with a faint ligature mark was more common, and 95.7% of them had taken off from a platform with a falling height of <1 metre. Cerebral edema and consolidation were the common postmortem findings in the brain and lungs. Death was attributed to hypoxic encephalopathy in the majority of the cases.

CONCLUSION: Longer the duration of suspension, higher fall height, noncontact with the ground while being suspended, cerebral edema, hypoxia, pulmonary edema, hypotension, and need for resuscitation are predictors of fatal outcomes in near-hanging events.

Keywords: hanging; cause of death; complications; suicide.

To cite this article:

Hosahally JS, Girish Chandra YP, Hugar BS. Delayed deaths in near-hanging cases: An autopsy study of causes and associated factors. *Russian Journal of Forensic Medicine*. 2023;9(4):373–381. DOI: <https://doi.org/10.17816/fm14218>

Received: 02.08.2023

Accepted: 22.09.2023

Published: 27.11.2023

DOI: <https://doi.org/10.17816/fm14218>

不完全缢吊导致的延迟死亡：根据尸检结果对死亡原因和相关因素的研究

Jayanth S. Hosahally¹, Y.P. Girish Chandra², Basappa S. Hugar²

¹ Department of Forensic Medicine, Dr Chandramma Dayananda Sagar Institute of Medical Education & Research, Devarakaggalahalli, DSU, India;

² Department of Forensic Medicine, MS Ramaiah Medical College, Bangalore, India

简评

论证。不完全缢吊自杀往往会导致不同时间段的勒死窒息幸存者出现病理状态。住院患者可能会出现导致延迟死亡的并发症。

该研究的目的是评估与不完全缢吊导致的延迟死亡原因有关的各种因素，提出关于改善紧急医疗服务的建议。

材料与方法。这项前瞻性尸检研究是2012年至2021年在印度M. S. Ramaiah医学院（M. S. Ramaiah Medical College）法医学系进行的。该研究包括所有不完全缢吊并随后住院治疗的病例。这些患者随后死于并发症，并接受了法医学尸体检验。

结果。受害者多为19至30岁的女人。半数以上的受害者能在事发后30分钟至1小时内到达医院。47.8%的患者在1-3分钟内经历了窒息。同时，65%的患者在超过一天后仍然存活。最常见的是不完全缢吊，勒痕不明显，其中95.7%的病例是从至少1m的高处坠落。尸体解剖时最常发现的是脑水肿和肺水肿。大多数病例死于缺氧性脑病。

结论。不完全缢吊致死的预测因素包括：勒死时间长、坠落高度高、未与支撑物接触、脑水肿和肺水肿、缺氧、低血压。

关键词：缢吊；死因；并发症；自杀。

引用本文：

Hosahally JS, Girish Chandra YP, Hugar BS. 不完全缢吊导致的延迟死亡：根据尸检结果对死亡原因和相关因素的研究. *Russian Journal of Forensic Medicine*. 2023;9(4):373–381. DOI: <https://doi.org/10.17816/fm14218>

收到: 02.08.2023

接受: 22.09.2023

发布日期: 27.11.2023

BACKGROUND

Hanging is a cause of asphyxia-related death where the body is suspended by a ligature around the neck, and the weight of the body induces a constricting force around the neck. Near-hanging refers to individuals who survive a hanging injury for various durations. These cases constitute <1% of admissions in the intensive care unit [1]. Although hospitalized, patients succumb to complications resulting in delayed deaths. The type of hanging, duration of suspension, time required to reach the hospital, and vital parameters of the patient on hospital arrival are factors associated with outcomes.

AIM

This study aimed to evaluate various factors associated with causes of delayed death in near-hanging events and provide insight into the improvement of emergency services.

MATERIALS AND METHODS

This prospective autopsy-based study was conducted at the Department of Forensic Medicine, M.S. Ramaiah Medical College, between 2012 and 2021. All near-hanging cases of hospitalized patients who later succumbed to complications and were subsequently subjected to medicolegal autopsy were included in the study. Autopsy findings, findings from the visit to the scene of occurrence in certain cases, facts provided by the investigating officer, in-depth interviews of eyewitnesses, and hospital case records were analyzed.

Ethical review

Ethics approval was obtained from the Ethics Committee of MS Ramaiah Medical College.

RESULTS

In this study, 28 (60.9%) patients were between 19 and 30 years old, and 12 (26.1%) were <18 years old. Moreover, 36 (78.3 %) were female, and 10 (21.1 %) were male. In 32 (69.6%) patients, the near-hanging event occurred on the weekdays. Most of the incidents (n = 22, 47.8%) occurred between 8 pm and 8 am. Forty-six cases occurred indoors in the residence of the patients. The police were the investigating authorities in 38 cases (82.6%) and the executive magistrate in the remaining (Table 1).

Basic life support was initiated by the ambulance technicians for 36 patients, and 10 patients were brought to hospitals in other modes of transport, and life support was initiated at the hospital. Moreover, 34 and 38 patients had hypoxia and hypotension on arrival to the hospital emergency, respectively. Forty patients were intubated and put on mechanical ventilation (Table 2).

Twenty-four patients could reach the hospital emergency in 30 min to 1 h, 20 reached within 30 min, and 2 came after 1 h. Moreover, 22 (47.8%) patients were suspended by ligature for 1–3 min before being brought down, and 14 were brought down after being suspended for 3–5 min. Further, 16 (34.8%) patients survived for 1–3 days, and 14 (30.4%) of them lived for >3 days (Table 3).

Hanging was successful in 34 cases (73.9%) where the body was suspended completely. Height fallen was measured as the distance from the platform to the feet. The height was 0.5–1 m in 28 cases (60.9%) and <0.5 m in 16 (34.8%). A single ligature mark was found in all patients, was present above the thyroid cartilage in 38 (82.6 %), and was oblique in 40 (87%). The ligature marks were broad and narrow in 34 (73.9%) and 12 (26.1%) patients, respectively. It corresponded to the material used. Rope was used in 12 cases, causing a narrow ligature mark, and cloth materials like saree, veil, bedsheets, and curtains were used as ligature materials in 34 cases, which caused broader ligature marks. The mark was interrupted in 38 (82.6%) patients (Fig. 1) and

Table 1. Demographic profile and circumstances

Parameters	N = 46 (%)
Age group	
• <18 years	12 (26.1%)
• 19–30 years	28 (60.9%)
• >30 years	6 (13%)
Sex	
• Male	10 (21.1%)
• Female	36 (78.3%)
Days	
• Weekends	14 (30.4%)
• Weekdays	32 (69.6%)
Time	
• 8 am–2 pm	8 (17.4%)
• 2 pm–8 pm	16 (34.8%)
• 8 pm–8 am	22 (47.8%)
Indoors	46 (100%)
Inquest conducted by	
• Police	38 (82.6%)
• Magistrate	8 (17.4%)

Table 2. Clinical data

Parameters	N = 46 (%)
Basic life support at the scene	36 (78.3%)
Hypoxia on hospital arrival	34 (74%)
Hypotension on hospital arrival	38 (82.6%)
Mechanical ventilation on hospital arrival	40 (86.9%)

Table 3. Time parameters

Time between the incident and presentation	
• <30 min	20 (43.5)
• 30 min–1 h	24 (52.2)
• >1 h	2 (4.3)
Duration of suspension	
• <1 min	8 (17.4)
• 1–3 min	22 (47.8)
• 3–5 min	14 (30.4)
• >5 min	2 (4.3)
Survival time	
• <6 h	4 (8.7)
• 6–12 h	4 (8.7)
• 12–4 h	8 (17.4)
• 1–3 days	16 (34.8)
• > 3 days	14 (30.4)

was continuous in the remaining. In 18 of them (39.1%), the mark was prominently visible (Fig. 2), whereas it was faint in 28 (60.9%) cases (Fig. 3). Nail scratch abrasions were found in two cases. A knot was found in the occipital region in 24 (52.1%) cases, and the right side of the neck was the second common site of knot in 18 (39.1%). The knot was fixed in 28 (60.9%) cases, and a slip knot was noted in 18 (39.1%).

The ligature mark was an abrasion, and as it heals, the gross color change was recorded during autopsy, which would determine the age of the injury. In 16 cases, the ligature mark was reddish brown, which corresponded to injury aged 1–3 days (Fig. 1). The survival time (Table 3) also correlated with the age of the injury.

Internal examination of the neck revealed bruising of neck tissues in four cases and fracture of the hyoid bone in



Fig. 2. Prominent ligature mark.

two. The airways were congested in the majority of the cases (n = 44). The brain was edematous in 36 (78.3%) cases and softened in 4. Six patients had both edema and softening of the brain. Computed tomography of the brain was performed in all cases. Edema was a common finding in the brain (n = 32), followed by anoxic injury (n = 8), and both were seen in 6 cases.

Common lung findings included consolidation (n = 16), edema (n = 16), and aspiration (n = 10). Four patients had both edema and consolidation. The heart including the coronary arteries was intact in all cases. The spleen was softened in eight cases. In 12 cases, gross findings were confirmed by histopathological examination.

Hypoxic encephalopathy was the most common cause of death (n = 20), followed by aspiration pneumonia (n = 12). Infection/septicemia and asphyxia were the causes of death in 4 and 2 patients, respectively. In eight cases, death was attributed to a combination of pathology, i.e., hypoxic encephalopathy with aspiration pneumonia (n = 2) and hypoxic encephalopathy with infection (n = 6).



Fig. 1. Interrupted ligature mark on a victim who survived for 3 days.



Fig. 3. Faint ligature mark.

DISCUSSION

A total of 1,53,052 suicide events were reported in India in 2020, and 57.8% (88,460) of the victims resorted to hanging to end their lives [2]. Near-hanging refers to a person who survives a hanging event and reaches the hospital. Thus, factors in near-hanging cases must be identified to determine the prognosis; this would serve as feedback to improve emergency medical services.

Factors that affect the survival period include duration of suspension, force of constriction, type of hanging (complete or partial), initiation of early resuscitative measures, time taken to reach the hospital, and status on hospital arrival. Incomplete encircling of the neck by ligature and partial hanging are also attributed to minimized hypoxic–ischemic damage to the brain [3].

In this study, the majority of the patients (60.9 %) were between 19 and 30 years old, and 78.3% were females. According to Rao, women and men were equally affected, and the majority were between 31 and 40 years old [4]. However, in Australia, young men between their late teenage years and mid-30s predominated [5]. In this study, the height fallen was 0.5–1 m in 28 (60.9%) cases, and Boots et al. recorded it to be <1 m in height in 85% of the cases [5]. Hanging was complete in 34 (73.9%) cases, where the body was suspended completely, and the remaining 12 (26.4 %) were partial hanging, i.e., some parts of the body were in contact with the ground. One-third of the cases were partial hanging in the study by Boots et al., whereas 7 out of 10 cases were partial hanging in the study by Sane et al [5,6].

Ropes were used as ligature materials in 26% of the cases and cloth materials in 74%. In contrast, ropes or cords (42%) were more commonly used than clothing or bed linen (23%) in the study by Boots et al [5]. The ligature mark was interrupted in 38 cases (82.6%) and was continuous in the remaining, similar to that reported by Rao reporting showed discontinuity in 80.58%. The knot was fixed in 28 cases (60.9%) and a slip type in 18 (39.1%), which was in contrast to the findings of Rao where a slip knot was used in the majority of the noose, contributing to 97.73% (n = 258) of the suspensions [4].

The ligature mark was present above the thyroid cartilage in 38 cases (82.6%) and was oblique in 40 (87%) similar to the observations by Rao (82.58% and 87.88%, respectively) [4].

In 16 cases, the ligature mark was reddish brown, which corresponded to the injury aged 1–3 days. The color of the ligature mark depends on the duration of the suspension, complexion of the victim, and survival period. However, studies correlating the age of the injury (survival period in the present study) and the color of the ligature mark are limited. During hospitalization, the color of the ligature mark (abrasion) changes depending on the stage of healing. Abrasion is a blunt force injury where aging can be determined by gross color changes. Rao et al. reported dark-brown ligature marks in 52% of cases, red in 21.33%, and

Table 4. Autopsy findings

Parameters	N = 46 (%)
Type of hanging	
• Complete	12 (26.1%)
• Partial	34 (73.9%)
Height fallen	
• < 0.5 m	16 (34.8%)
• 0.5–1 m	28 (60.9%)
• > 1 m	2 (4.3%)
Number of ligature mark	
• Single	46 (100%)
Level of the ligature mark	
• Above the thyroid cartilage	38 (82.6%)
• At the thyroid cartilage	8 (17.4%)
Direction of the ligature mark	
• Oblique	40 (87%)
• Horizontal	6 (13%)
Width of the ligature mark	
• Wide	34 (73.9%)
• Narrow	12 (26.1%)
Continuity of the ligature mark	
• Interrupted	38 (82.6%)
• Continuous	8 (17.4%)
Prominence of the ligature mark	
• Faint	28 (60.9%)
• Prominent	18 (39.1%)
Peri-ligature injuries	
• Nail scratch abrasions	2 (4.3%)
• Nil	44 (95.7%)
Stage of healing of the ligature mark	
• Bright-red color (fresh)	10 (21.7)
• Bright-red scab (12–24 h)	12 (26.1)
• Reddish-brown scab (1–3 days)	16 (34.8)
• Dark-brown scab (4–7 days)	6 (13.0)
• Scab fallen off (>7 days)	2 (4.3)
Position of the knot	
• Occiput	24 (52.1%)
• Chin	2 (4.3%)
• Right side of the neck	18 (39.1%)
• Left side of the neck	2 (4.3%)

Table 4. Ending

Parameters	N = 46 (%)
Type of knot	
• Slip	18 (39.1%)
• Fixed	28 (60.9%)
• Neck tissues	
• Pale	42 (91.3%)
• Contused	4 (8.7%)
External examination	
• Dried salivary stains	6 (13%)
• Bluish discolored nail beds	8 (17.4%)
• Petechiae	6 (13%)
• Petechiae and tongue bite	2 (4.3%)
• Tongue bite	2 (4.3%)
• Defib mark	2 (4.3%)
Ligature material	
• Saree	20 (43.5%)
• Dupatta/veil	14 (30.4%)
• Bedsheet/curtain	4 (8.7%)
• Rope	8 (17.4%)
Brain gross findings	
• Edema	36 (78.3 %)
• Softening	4 (8.7 %)
• Edema and softening	6 (13.1 %)
• Infarct/abscess	Nil
Lungs gross findings	
• Consolidation	16 (34.7 %)
• Aspiration	10 (21.7 %)
• Edema	16 (34.8 %)
• Consolidation + edema	4 (8.7 %)
CT brain findings	
• Edema	32 (69.8 %)
• Anoxic injury	8 (17.4%)
• Edema and anoxic injury	6 (13 %)
Cause of death	
• Aspiration pneumonia	12 (26.1)
• Aspiration pneumonia + hypoxic encephalopathy	2 (4.3)
Infection	
• Infection + hypoxic encephalopathy	6 (13)
• Hypoxic encephalopathy	20 (43.5)
• Asphyxia	2 (4.3)

pale in 14.67%. [7]. However, the age of the ligature mark (abrasion) did not correlate with its color.

Bruising of neck tissues was seen in 4 (8.69%). Jayprakash and Sreekumar observed damage to the sternocleidomastoid fiber in 19.6% of their cases. (8) The hyoid bone was fractured in 2 (4.35%) cases, and Rao also reported similar findings (6.06%) [4].

Common lung findings included consolidation (43%), edema (43%), and aspiration (21.7%). However, Boots et al. observed aspiration in 9% of the cases and pulmonary edema in 2%. [5].

In 12 cases, gross findings were confirmed by histopathological examination. In an autopsy study of 8 cases by Swapna Debbarma et al., [9] histopathological examination revealed pulmonary edema in 6 cases and pneumonia in 2. The brain had a hypoxic injury in 5 cases and congestion only in 3.

During autopsy, the brain was edematous in 36 (78.3%) cases and softened in 4. CT of the brain was conducted during hospitalization in all cases. Edema was the common finding in the brain (n = 32), followed by anoxic injury (n = 8), and both were seen in 6 cases. In a hospital-based study where CT was done in 29% of the near-hanging cases, Boots et al. observed that 13% of the patients had cerebral edema [5]. Congestion, edema, and softness of the brain were found in 5 of 8 cases in an autopsy study by Swapna Debbarma et al [9].

Moreover, 78% had a Glasgow Coma Scale of 3 and received basic life support at the scene by ambulance paramedics and the remaining 10 on hospital arrival. In addition, 52% of the cases reached the hospital emergency department in 30 min to 1 h, 43% reached within 30 min, and 5% came after 1 h. Moreover, 74% and 82% of the patients had hypoxia and hypotension on arrival to the hospital emergency department, and 87% were intubated and put on mechanical ventilation.

In this study, 34.8% of the patients had a survival period of 1–3 days, and 30.4% lived for >3 days. In a study by Sane et al., deaths were delayed ranging from 9 h to 72 d [6]. Kumar reported the shortest survival period of 15 h, whereas in the present study, 8.7% of the patients survived up to 6 h [10.] According to Harish et al., the longest survival period was 7 and 14 days [11].

Moreover, Boots et al. observed that 22% had a GCS of 3 at the scene, and 32% required cardiopulmonary resuscitation at the scene by bystanders, ambulance, or paramedics. Where an ambulance was used (73%), the response time was <10 min, and 43% required intubation, which was mainly performed in hospital [5].

Hypoxic encephalopathy was the most common cause of death (43.5%), followed by aspiration pneumonia (26.1%). Infection/septicemia and asphyxia were the causes of death in 8.7% and 4.3% of the cases, respectively. In eight cases, death was attributed to a combination of pathology, i.e., hypoxic encephalopathy with aspiration pneumonia (4.3%)

and hypoxic encephalopathy with infection (13%). Constriction of the neck by ligature causes vascular obstruction of the neck vessels and cerebral hypoxia resulting in hypoxic encephalopathy. Boots, Sane, Swapan Debbarma, and Nithin et al. have also reported hypoxic encephalopathy as the leading cause of delayed death in nonjudicial hanging [5,6,9,12].

CONCLUSION

The outcome in near-hanging events depends both on the circumstances of hanging and clinical parameters. The type of hanging, duration of suspension, falling height, time taken to reach the hospital, and whether life support was given at the scene are some of the factors that determine survival. Hypoxia, hypotension, and poor neurological status on

hospital arrival are clinical predictors of fatal outcomes. All near-hanging cases irrespective of the clinical status should be provided with prompt emergency services and aggressive intensive care to reduce mortality.

ADDITIONAL INFORMATION

Funding source. This study was not supported by any external sources of funding.

Competing interests. The authors declare that they have no competing interests.

Authors' contribution. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

REFERENCES

1. Karanth S, Nayyar V. What influences outcome of patients with suicidal hanging. *J Assoc Physicians India*. 2005;(53):853–856.
2. Suicides in India. Accidental Deaths & Suicides in India. National Crime Records Bureau. Ministry of Home Affairs [03.03.2022]. 2020. Available from: <http://ncrb.nic.in>. Accessed: 15.11.2023.
3. Kodikara S. Attempted suicidal hanging an uncomplicated recovery. *Am J Forensic Med Pathol*. 2012;33(4):317–318. doi: 10.1097/PAF.0b013e3182443585
4. Rao D. An autopsy study of death due to Suicidal Hanging, 264 cases. *Egypt J Forensic Sci*. 2016;20(3):248–254. doi: 10.1016/j.ejfs.2015.01.004
5. Boots RJ, Joyce C, Mullany DV, et al. Near-hanging as presenting to hospitals in Queensland: Recommendations for practice. *Anaesth Intensive Care*. 2006;34(6):736–745. doi: 10.1177/0310057X0603400610
6. Sane MR, Mugadlimath AB, Zine KU, et al. Course of near-hanging victims succumbed to death: A seven year study. *J Clin Diagnostic Res*. 2015;9(3):HC01–HC03. doi: 10.7860/JCDR/2015/11189.5647
7. Rao BS. A Post-mortem study of deaths due to hanging reported to RIMS, Adilabad. *Eur J Molecul Clin Med*. 2020;7(11): 8809–8815.
8. Jayaprakash S, Sreekumari K. Pattern of injuries to neck structures in hanging-an autopsy study. *Am J Forensic Med Pathol*. 2012;33(4):395–399. doi: 10.1097/PAF.0b013e3182662761
9. Debbarma S, Deka SJ. Study of delayed death in hanging. *Indian J Forens Commun Med*. 2016;3(4):280–283.
10. Kumar V. Delayed hanging death: A case report. *J Pak Med Assoc*. 2007;57(1):39–41.
11. Harish D, Kumar A, Sirohiwal BL, Dikshit PC. Delayed death in hanging: Case reports. *J Forensic Med Toxicol*. 1994;(9):48–50.
12. Nithin MD, Manjunatha B, Kumar GN, Sasidharan S. Delayed death in hanging. *J Forensic Res*. 2011;4(S1):1. doi: 10.4172/2157-7145.S1-001

СПИСОК ЛИТЕРАТУРЫ

1. Karanth S., Nayyar V. What influences outcome of patients with suicidal hanging // *J Assoc Physicians India*. 2005. N 53. P. 853–856.
2. Suicides in India. Accidental Deaths & Suicides in India. National Crime Records Bureau. Ministry of Home Affairs [03.03.2022]. 2020. Режим доступа: <http://ncrb.nic.in>. Дата обращения: 15.11.2023.
3. Kodikara S. Attempted suicidal hanging an uncomplicated recovery // *Am J Forensic Med Pathol*. 2012. Vol. 33, N 4. P. 317–318. doi: 10.1097/PAF.0b013e3182443585
4. Rao D. An autopsy study of death due to Suicidal Hanging, 264 cases // *Egypt J Forensic Sci*. 2016. Vol. 20 N 3. P. 248–254. doi: 10.1016/j.ejfs.2015.01.004
5. Boots R.J., Joyce C., Mullany D.V., et al. Near-hanging as presenting to hospitals in Queensland: Recommendations for practice // *Anaesth Intensive Care*. 2006. Vol. 34, N 6. P. 736–745. doi: 10.1177/0310057X0603400610
6. Sane M.R., Mugadlimath A.B., Zine K.U., et al. Course of near-hanging victims succumbed to death: A seven year study // *J Clin Diagnostic Res*. 2015. Vol. 9, N 3. P. HC01–HC03. doi: 10.7860/JCDR/2015/11189.5647
7. Rao B.S. A Post-mortem study of deaths due to hanging reported to RIMS, Adilabad // *Eur J Molecul Clin Med*. 2020. Vol. 7, N 11. P. 8809–8815.
8. Jayaprakash S., Sreekumari K. Pattern of injuries to neck structures in hanging-an autopsy study // *Am J Forensic Med Pathol*. 2012. Vol. 33, N 4. P. 395–399. doi: 10.1097/PAF.0b013e3182662761
9. Debbarma S., Deka S.J. Study of delayed death in hanging // *Indian J Forens Commun Med*. 2016. Vol. 3, N 4. P. 280–283.
10. Kumar V. Delayed hanging death: A case report // *J Pak Med Assoc*. 2007. Vol. 57, N 1. P. 39–41.
11. Harish D., Kumar A., Sirohiwal B.L., Dikshit P.C. Delayed death in hanging: Case reports // *J Forensic Med Toxicol*. 1994. Vol. 9. P. 48–50.
12. Nithin M.D., Manjunatha B., Kumar G.N., Sasidharan S. Delayed death in hanging // *J Forensic Res*. 2011. Vol. 4, N S1. P. 1. doi: 10.4172/2157-7145.S1-001

AUTHORS' INFO

*** Jayanth S. Hosahally**, MD, Associate Professor;
address: Dept of Forensic Medicine, Dr. Chandramma
Dayananda Sagar Institute of Medical
Education & Research, DSU, Deverakaggalahalli,
Ramanagara Dt, Karnataka, 562112, India;
ORCID: 0000-0001-5209-1133;
e-mail: veejay02@gmail.com

Girish Chandra Y.P., MD, Professor;
ORCID: 0000-0002-5446-8114;
e-mail: girishchandra14@gmail.com

Basappa S. Hugar, MD, Professor;
ORCID: 0000-0002-4470-0549;
e-mail: bshugar2007@gmail.com

ОБ АВТОРАХ

*** Jayanth S. Hosahally**, доцент;
адрес: Кафедра судебной медицины, Институт медицинского
образования и исследований доктора Чандраммы Даянанды
Сагара, DSU, Деверакаггалахалли, Раманагара, округ
Карнатака, 562112, Индия;
ORCID: 0000-0001-5209-1133;
e-mail: veejay02@gmail.com

Girish Chandra Y.P., профессор;
ORCID: 0000-0002-5446-8114;
e-mail: girishchandra14@gmail.com

Basappa S. Hugar, профессор;
ORCID: 0000-0002-4470-0549;
e-mail: bshugar2007@gmail.com

* Corresponding author / Автор, ответственный за переписку

Validation of Kannada Version of the Amsterdam Preoperative Anxiety and Information Scale (APAIS)

Review began 06/06/2024

Review ended 06/18/2024

Published 06/29/2024

© Copyright 2024

Srinivasaiah et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

DOI: 10.7759/cureus.63486

Madhu Srinivasaiah¹, Nandini Mysore Gopalswamy¹, Harini Krishna¹, Venkatesh Murthy Kallur Thimmarayappa¹

¹. Anesthesiology, Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research, Kanakapura, IND

Corresponding author: Harini Krishna, harini.anesthesia@gmail.com

Abstract

Background and aim: Preoperative anxiety is a complex and subjective phenomenon, most commonly observed in patients posted for elective surgery. The Amsterdam Preoperative Anxiety Information Scale (APAIS) has been widely used in preoperative settings to measure anxiety quickly. This study aimed to translate the APAIS into Kannada and to evaluate its psychometric properties.

Method: The study involved forward and backward translation of APAIS into Kannada followed by a cognitive interview of 10 patients by clinical psychologist to confirm the correct translation. The translated version was then administered to 240 patients who were posted for elective surgery along with the Visual Analogue Scale for Anxiety (VAS-A). Reliability and internal consistency were assessed by calculating Cronbach's alpha. Construct validity was assessed by principal component analysis and confirmatory factor analysis. Criteria validity was assessed by evaluating the correlation between APAIS and VAS-A.

Result: The Kannada-translated version of APAIS was completed by 224 patients posted for elective surgery. Cronbach's alpha was 0.82 and 0.83 for anxiety and need for information items, respectively. Root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI) were 0.07, 0.98, and 0.96, respectively, for three-factor model, indicating it to be best fit for Kannada version of APAIS.

Conclusion: The Kannada version of APAIS is a valid and reliable tool for measuring preoperative anxiety in patients undergoing elective surgery.

Categories: Psychology, Anesthesiology, Quality Improvement

Keywords: apais, kannada, validity, translation, preoperative anxiety

Introduction

Anxiety is one of the most commonly observed psychological manifestations of the patients posted for surgery. Preoperative anxiety is observed in about 11-80% of surgical patients [1,2]. Preoperative anxiety can lead to negative consequences like difficult venous access, increased requirement of intraoperative anesthetics, exaggerated postoperative pain, postoperative nausea and vomiting, prolonged hospital stay, and associated morbidity [3-5].

Preoperative anxiety is a subjective phenomenon and is influenced by various factors, which makes it difficult to assess objectively [6,7]. Several instruments are being used for measuring preoperative anxiety like the Spielberger State-Trait Anxiety Inventory (STAI), Hospital Anxiety and Depression (HAD) scale, Visual Analogue Scale for Anxiety (VAS-A), etc. In clinical psychology and psychiatry, STAI is used most frequently [8]. It is also used more often for assessing preoperative anxiety and is considered as gold standard [9]. However, in a clinical setting, especially in preoperative framework, the use of STAI is associated with an increase in time consumption. Another disadvantage is that the inventory is copyright-restricted and has to be purchased for regular use.

The Amsterdam Preoperative Anxiety and Information Scale (APAIS) is a freely available self-report questionnaire developed to assess preoperative anxiety. APAIS comprises six items, two items on anxiety about anesthesia, two on anxiety about surgery, and two related to the need for information. Each item is addressed by patients on a five-point Likert scale, with 1 being "not at all worrying" to 5 as "extremely worrying." APAIS was first developed in Dutch and has been validated in surgical patients [10]. The anxiety score of APAIS had shown a high correlation with STAI-state (0.74) in Dutch patients posted for surgery. The APAIS has been subsequently translated and validated in English, Japanese, German, French, Italian, Spanish, Chinese, and Portuguese [11-18].

The prevalence of preoperative anxiety in India is unknown; however, few studies indicate it to be around 30-50% [6,19]. In majority of these studies, no validated inventory was used for measuring preoperative

How to cite this article

Srinivasaiah M, Mysore Gopalswamy N, Krishna H, et al. (June 29, 2024) Validation of Kannada Version of the Amsterdam Preoperative Anxiety and Information Scale (APAIS). Cureus 16(6): e63486. DOI 10.7759/cureus.63486

anxiety. Kannada, an official language of Karnataka state of India, is used by around 64 million people across the world. The purpose of this study is to translate the APAIS into Kannada and to evaluate its psychometric properties.

Materials And Methods

The study was initiated after approval from the institutional ethics committee and was registered in the clinical trial registry of India. The study was conducted in accordance with the principles laid down in the Declaration of Helsinki. Patients were enrolled in the study after obtaining written informed consent in Kannada language. Patients posted for emergency surgeries, cesarean section, patients with a history of substance dependence/abuse, patients on anti-psychotropic medication, and patients with known psychiatric disorders were excluded. Patients posted for elective surgery with age >18 years and able to read and understand Kannada were included in the study.

The APAIS tool has six items, if we consider respondent to item ratio of 30:1, a sample size of 180 would be sufficient for the validation study. However in order to account for missed data and to have a fair sample, a sample size of 240 was considered for our study [20].

Patients posted for surgery underwent routine pre-anesthetic check-ups in OPD as per routine practice. During pre-anesthetic check-ups, patients deemed fit for surgery were accepted for surgery and those patients requiring optimization of comorbid conditions were advised accordingly. During this visit, patients were given necessary information regarding anesthesia as per routine practice by a concerned anesthesiologist. A list of patients deemed fit for surgery was generated a day prior to surgery.

On the day prior to surgery, the anesthesiologist made a visit to the respective ward, eligible subjects were explained about the aim of the study, and written informed consent was obtained. During the consultation with anesthesiologist, socio-demographic data and other clinical data that assess patients' fitness for surgery were collected. Patients were then provided the APAIS inventory followed by VAS-A. In VAS-A, patients were asked to express their anxiety on a scale of 0-100 mm with 0 indicating no anxiety and 100 indicating severe anxiety [21].

The scale

The APAIS is a self-administered questionnaire comprising six questions, two questions on anxiety related to anesthesia, two on anxiety related to surgery, and two on the need for information. The answers are recorded on a five-point Likert scale from 1 (not at all worrying) to 5 (extremely worrying). The scores of the anxiety subscales range from four to 20 and the need for information ranges from two to 10. A higher score is associated with more anxiety. In the study by Moerman et al, the cutoff for anxiety was a total anxiety scale score of eleven [10].

Validation process

The process of validation is comprised of two steps. The first step was to develop a Kannada version of APAIS that is semantically equivalent to the original version of APAIS. The second step involved the evaluation of psychometric properties of the Kannada version.

After obtaining authorization for the translation of APAIS to Kannada from the authors of original scale, forward translation was done by a bilingual senior anesthesiologist. This was reviewed by an expert followed by back translation by an independent translator. After the finalization of translated version, the instrument was administered to 10 surgical adult patients who underwent cognitive interview by a senior clinical psychologist to obtain an equivalent translated scale in Kannada.

To check if the Kannada version would maintain similar factor structure as in previous studies and to evaluate internal validity, confirmatory factor analysis was done. Bartlett's test of sphericity and Kaiser-Meyer-Olkin measure of sampling adequacy were done to check if factor analysis could be performed on the data. Two-factor model as described in the original APAIS and the three-factor model as described in French APAIS validation were evaluated [10,14]. The root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI) were used to check the adequacy of model. A CFI and TLI >0.9 and RMSEA <0.08 indicate a satisfactory fit of the data. Cronbach's alpha was calculated to check for reliability and internal consistency.

Non-parametric Spearman's correlation was used to determine the correlation between APAIS scores and VAS on anxiety. Mean scale scores were compared by student t-test. A p-value of <0.05 was considered significant. Statistical analysis was done by using Jamovi computer software version 2.3 (Sydney, Australia: The Jamovi Project 2024) and IBM SPSS statistics version 20.0 (Armonk, NY: IBM Corp.) for Windows.

Results

Process of translation

The Kannada version of APAIS did not show any mismatches when back translated to English by a different bilingual health professional (table in the appendix). Cognitive interviews with 10 participants did not require rephrasing of the translated versions.

Characteristics of study subjects

The study included 240 subjects posted for elective surgery, of which 16 forms were incomplete and hence excluded from the final analysis. The characteristics of subjects are presented in Table 1. Subjects were categorized based on education status into Category A - primary education (20.98%), Category B - high school (33.03%), and Category C - above high school (45.98%).

Variables		Category A (primary)	Category B (high school)	Category C (above high school)
Gender	Male	18 (8%)	20 (8.9%)	43 (19.2%)
	Female	29 (12.9%)	54 (24.10%)	60 (26.8%)
ASA	I	30 (13.4%)	54 (24.1%)	81 (36.2%)
	II	17 (7.6%)	20 (8.9%)	22 (9.8%)
Comorbid illness	Present	17 (7.6%)	20 (8.9%)	22 (9.8%)
	Absent	30 (13.4%)	54 (24.1%)	81 (36.2%)
Previous surgery	Yes	27 (12%)	25 (11.2%)	37 (16.5%)
	No	20 (8.9%)	49 (21.9%)	66 (29.5%)
General surgery		25 (11.2%)	33 (14.7%)	48 (21.4%)
Obstetrics and gynecology		11 (4.9%)	28 (12.5%)	32 (14.3%)
Orthopedics		8 (3.6%)	9 (4%)	18 (8%)
Otorhinolaryngology		3 (1.3%)	4 (1.8%)	5 (2.2%)

TABLE 1: Characteristics of the patients.

ASA: American Society of Anesthesiologists

Reliability and validity of APAIS Kannada version

Tests of Reliability and Internal Consistency

The internal consistency reliability was high. The Cronbach’s alpha for all items was 0.82 for anxiety-related items (AQ1, AQ2, AQ4, and AQ6), and for desire for information was 0.83.

Construct Validity

Bartlett’s test of sphericity (chi-square=0.559 and p<0.001) and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy 0.77 indicated that the data sample is adequate for factor analysis. A principal component analysis with varimax rotation revealed two factors, which accounted for 72.19% of variance. The communalities, factor loadings, and eigenvalue are shown in Table 2. Overall, inter-item correlations were good for APAIS items with weakest correlation between item six and item one.

Factors	Items	Factor loading	Eigen value	Variance	Total variance
Factor 1	I am worried about anesthesia	0.79	3.311	55.19%	72.19%
	The anesthesia is constantly on my mind	0.86			
	I am worried about the procedure	0.85			
	The procedure is constantly on my mind	0.84			
Factor 2	I would like to know as much as possible about the anesthesia	0.88	1.02	16.99%	
	I would like to know as much as possible about the procedure	0.90			

TABLE 2: Factor structure, eigenvalue, and percent of variance in a two-factor model.

Test for Dimensionality

Confirmatory factor analysis was done by evaluating two-factor model (as described in the original version) and three-factor model (as described in the French APAIS validation). The RMSEA, CFI, and TLI of both models are given in Table 3. The three-factor model was the best fit for the data.

Models and items	Two-factor model	Three-factor model
Chi-square p-value	<0.001	0.04
CFI	0.95	0.98
TLI	0.92	0.96
RMSEA	0.11	0.07

TABLE 3: Confirmatory factor analysis.

CFI: comparative fit index; RMSEA: root mean square error of approximation; TLI: Tucker-Lewis index

Tests of Concurrent or External Validity

The APAIS global anxiety score was compared with VAS-A. The mean anxiety score significantly correlated with VAS-A with $r=0.504$ and $p=0.001$.

Anxiety and Need for Information

The anxiety comprised four questions, two questions on anxiety about anesthesia and two questions on anxiety about surgery. As three-factor model was the best fit for our data, we compared means of anxiety about anesthesia, anxiety about surgery, and need for information based on gender or comorbid condition or previous history of surgery. There was no significant difference across groups (Table 4).

Variables	Anxiety about anesthesia	p-Value	Anxiety about surgery	p-Value	Need for information	p-Value
Gender (n)						
Male (81)	2.96±1.04	0.15	2.88±1.51	0.09	3.80±1.97	0.69
Female (143)	3.17±1.07		3.80±1.68		3.91±1.95	
Comorbidity (n)						
Present (59)	3.14±0.94	0.71	3.36±1.84	0.19	4.03±2.19	0.46
Absent (165)	3.08±1.05		3.03±1.54		3.81±1.86	
History of previous surgery (n)						
Yes (88)	3.11±1.01	0.82	3.14±1.69	0.86	3.90±2.07	0.82
No (135)	3.08±1.03		3.10±1.59		3.84±1.87	

TABLE 4: Comparison of means of anxiety and need for information in a three-factor model based on gender, history of comorbidity, and previous surgery.

Discussion

This study aimed to translate and validate APAIS for use in the Kannada-speaking population. The forward translation and backward translation were done by two independent individuals who were expert researchers proficient in both languages and cultures. Similar to the original study, principal component analysis with varimax rotation revealed two factors. The factor loadings were >0.79, indicating that items one, two, four, and five were related to anxiety, and items three and six were related to need for information.

The Kannada version of APAIS showed high reliability with Cronbach’s alpha >0.80 for anxiety and need for information scale similar to the original and other validation studies [10-18]. In contrast to validation in Chinese, German, Turkish, and original studies, confirmatory factor analysis suggested a three-dimensional model as the best fit for the Kannada version [10,13,17,22]. Our study results were similar to the French translation (CFI of 1.0) and Portuguese translation (CFI: 0.970 and TLI: 0.926). The RMSEA is an index that is responsive to sample size and complexity and a value of <0.05 is considered good and between 0.05 and 0.08 is considered acceptable [23,24]. In our study, a value of 0.07 indicated a fair fit of three-dimensional model as compared to two-dimensional model. This is similar to findings in French and Portuguese validation studies [14,18]. To have a more holistic view of the goodness of fit, it is recommended to use multiple fit indices which would account for sample size, model complexity, and various other considerations in a particular study [24].

The hypothesis that females are more anxious than males, or patients with a previous history of surgery would be less anxious was evaluated in our study and showed no significant difference. This is in contrast to findings in the original study and might be due to the skewed distribution of groups, cultural differences, or paternalistic type of doctor-patient relationship.

One of the limitations of our study is that we did not compare APAIS to other anxiety tools as we do not have a valid tool to measure preoperative anxiety in Kannada and also there is enough evidence supporting APAIS as a preoperative anxiety tool. However, we compared it with VAS-A which showed a moderate level of correlation. Also, the variability observed in our study could be due to the inclusion of patients posted for major and minor surgeries, posted under general anesthesia or regional anesthesia. Further studies considering these factors will probably give more insight into the level of anxiety prior to surgery.

Conclusions

The results of our study indicate that the Kannada version of the APAIS is valid and reliable. This translated version of APAIS with a three-dimensional structure can be valuable in measuring preoperative anxiety in patients undergoing elective surgeries. In this era of digitalization and readily available information, it has become a very important tool in assessing preoperative anxiety. The Kannada version of APAIS which is a simple, brief, and quick screening inventory, can further be used to estimate the prevalence of preoperative anxiety. Thus, this helps in planning appropriate interventions to alleviate anxiety, which finally would improve patient satisfaction and outcome of surgery.

Appendices

S. no.	Items (English)	Items (Kannada)
1	I am worried about the anesthetic	
2	The anesthetic is on my mind continually	
3	I would like to know as much as possible about the anesthetic	
4	I am worried about the procedure	
5	The procedure is on my mind continually	
6	I would like to know as much as possible about the procedure	

TABLE 5: List of six APAIS items.

APAIS: Amsterdam Preoperative Anxiety Information Scale

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Acquisition, analysis, or interpretation of data: Nandini Mysore Gopalswamy, Madhu Srinivasaiah, Harini Krishna

Drafting of the manuscript: Nandini Mysore Gopalswamy, Madhu Srinivasaiah, Harini Krishna

Critical review of the manuscript for important intellectual content: Nandini Mysore Gopalswamy, Madhu Srinivasaiah, Harini Krishna, Venkatesh Murthy Kallur Thimmarayappa

Concept and design: Madhu Srinivasaiah, Venkatesh Murthy Kallur Thimmarayappa

Supervision: Madhu Srinivasaiah

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. Institutional Ethics Committee of Dr. Chandramma Dayananda Sagar Institute of Medical Education and Research (CDSIMER) issued approval #CDSIMER/MR/0008/IEC/2021. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Acknowledgements

The authors would like to acknowledge Dr. Moerman N for giving permission and guidance in the translation and validation process of the manuscript.

References

1. Maranets I, Kain ZN: Preoperative anxiety and intraoperative anesthetic requirements . Anesth Analg. 1999, 89:1346-51. [10.1097/00000539-199912000-00003](https://doi.org/10.1097/00000539-199912000-00003)
2. Bansal T, Joon A: A comparative study to assess preoperative anxiety in obstetric patients undergoing elective or emergency cesarean section. Anaesth Pain Intensive Care. 2019, 20:25-30.
3. Nigussie S, Belachew T, Wolancho W: Predictors of preoperative anxiety among surgical patients in Jimma University Specialized Teaching Hospital, South Western Ethiopia. BMC Surg. 2014, 14:[10.1186/1471-2482-14-67](https://doi.org/10.1186/1471-2482-14-67)
4. Almalki MS, Hakami OA, Al-Amri AM: Assessment of preoperative anxiety among patients undergoing elective surgery. Egypt J Hosp Med. 2017, 69:2329-33. [10.12816/0041537](https://doi.org/10.12816/0041537)
5. Pearson S, Maddern GJ, Fitridge R: The role of pre-operative state-anxiety in the determination of intra-operative neuroendocrine responses and recovery. Br J Health Psychol. 2005, 10:299-310.

- 10.1348/135910705X26957
6. Vadhanan P, Tripaty DK, Balakrishnan K: Pre-operative anxiety amongst patients in a tertiary care hospital in India - a prevalence study. *J Soc Anesthesiol Nepal*. 2017, 4:5-10. [10.3126/jsan.v4i1.17377](#)
7. Dhungana M, Limbu R, Shrestha M: Assessment of pre-operative anxiety among patients in selected hospitals of Rupandehi, Nepal. *J Psychiatrists' Association Nepal*. 2019, 8:28-32. [10.3126/jpan.v8i1.26333](#)
8. Kvaal K, Ulstein I, Nordhus IH, Engedal K: The Spielberger State-Trait Anxiety Inventory (STAI): the state scale in detecting mental disorders in geriatric patients. *Int J Geriatr Psychiatry*. 2005, 20:629-34. [10.1002/gps.1330](#)
9. Zemła AJ, Nowicka-Sauer K, Jarmoszewicz K, Wera K, Batkiewicz S, Pietrzykowska M: Measures of preoperative anxiety. *Anesthesiol Intensive Ther*. 2019, 51:64-9. [10.5603/AIT.2019.0013](#)
10. Moerman N, van Dam FS, Muller MJ, Oosting H: The Amsterdam Preoperative Anxiety and Information Scale (APAIS). *Anesth Analg*. 1996, 82:445-51. [10.1097/00000539-199603000-00002](#)
11. Boker A, Brownell L, Donen N: The Amsterdam preoperative anxiety and information scale provides a simple and reliable measure of preoperative anxiety. *Can J Anaesth*. 2002, 49:792-8. [10.1007/BF03017410](#)
12. Nishimori M, Moerman N, Fukuhara S, van Dam FS, Muller MJ, Hanaoka K, Yamada Y: Translation and validation of the Amsterdam preoperative anxiety and information scale (APAIS) for use in Japan. *Qual Life Res*. 2002, 11:361-4. [10.1023/a:1015561129899](#)
13. Berth H, Petrowski K, Balck F: The Amsterdam Preoperative Anxiety and Information Scale (APAIS) - the first trial of a German version. *Psychosoc Med*. 2007, 4:
14. Maurice-Szamburski A, Loundou A, Capdevila X, Bruder N, Auquier P: Validation of the French version of the Amsterdam preoperative anxiety and information scale (APAIS). *Health Qual Life Outcomes*. 2013, 11:[10.1186/1477-7525-11-166](#)
15. Buonanno P, Laiola A, Palumbo C, Spinelli G, Terminiello V, Servillo G: Italian validation of the Amsterdam Preoperative Anxiety and Information Scale. *Minerva Anesthesiol*. 2017, 83:705-11. [10.23736/S0375-9393.16.11675-X](#)
16. Vergara-Romero M, Morales-Asencio JM, Morales-Fernández A, Canca-Sanchez JC, Rivas-Ruiz F, Reinaldo-Lapuerta JA: Validation of the Spanish version of the Amsterdam Preoperative Anxiety and Information Scale (APAIS). *Health Qual Life Outcomes*. 2017, 15: [10.1186/s12955-017-0695-8](#)
17. Wu H, Zhao X, Chu S, Xu F, Song J, Ma Z, Gu X: Validation of the Chinese version of the Amsterdam Preoperative Anxiety and Information Scale (APAIS). *Health Qual Life Outcomes*. 2020, 18: [10.1186/s12955-020-01294-3](#)
18. Maurício S, Rebêlo I, Madeira C, Resende F, Esteves S: Validation of the Portuguese version of Amsterdam Preoperative Anxiety and Information Scale (APAIS). *Health Qual Life Outcomes*. 2021, 19: [10.1186/s12955-021-01736-6](#)
19. Bansal T, Joon A: Preoperative anxiety-an important but neglected issue: a narrative review . *Indian Anaesth Forum*. 2016, 17:37-42. [10.4103/0973-0311.195955](#)
20. Tsang S, Royse CF, Terkawi AS: Guidelines for developing, translating, and validating a questionnaire in perioperative and pain medicine. *Saudi J Anaesth*. 2017, 11:80-9. [10.4103/sja.SJA_203_17](#)
21. Abend R, Dan O, Maoz K, Raz S, Bar-Haim Y: Reliability, validity and sensitivity of a computerized visual analog scale measuring state anxiety. *J Behav Ther Exp Psychiatry*. 2014, 45:447-53. [10.1016/j.jbtep.2014.06.004](#)
22. Çetinkaya F, Kavuran E, Ünal Aslan KS: Validity and reliability of the Amsterdam Preoperative Anxiety and Information Scale in the Turkish population. *Turk J Med Sci*. 2019, 49:178-83. [10.3906/sag-1806-84](#)
23. Li-tze H, Bentler PM: Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct Equ Modeling*. 1999, 6:1-55. [10.1080/10705519909540118](#)
24. Alavi M, Visentin DC, Thapa DK, Hunt GE, Watson R, Cleary M: Chi-square for model fit in confirmatory factor analysis. *J Adv Nurs*. 2020, 76:2209-11. [10.1111/jan.14399](#)

ORIGINAL RESEARCH

A study on Clinical profile of cases of schizophrenia

¹Dr. Vajipeyajula Anupama, ²Dr. Furkhan Ali, ³Dr. Sharbandh Raj

¹Assistant Professor, Department of Psychiatry, CDSIMER, Bengaluru, Karnataka, India

²Consultant Psychiatrist, NIMHANS, Bangalore, Karnataka, India

³Professor, Department of Psychiatry, SVS Medical College, Mahabubnagar, Telangana, India

Corresponding Author

Dr. Furkhan Ali

Consultant Psychiatrist, NIMHANS, Bangalore, Karnataka, India

Received: 02Sept, 2023

Accepted: 25Sept, 2023

ABSTRACT

As extrapyramidal side effects of typical antipsychotics compelled clinicians to move towards the atypical ones, these newer, so-called novel agents have brought with them a gamut of adversities, the various metabolic side effects. The study will include 120 patients, both indoor and outdoor, suffering from schizophrenia, diagnosed using the ICD-10 criteria. The patients will be grouped into three categories, i.e. control group and two study groups, control group having 30 patients and study groups with 45 patients each. The average weight gains in the three drug groups show a mean of 61.8 in the Haloperidol group with a mean average increase of 2.9 kgs over a period of 18 months, as compared to mean increases in weight with Olanzapine being 14.6 kgs and for Risperidone 10.9 kgs. All the three groups have significant p-values (<0.0001) for increase in weight over the 18 month period.

Keywords: Schizophrenia, Risperidone, Olanzapine

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

INTRODUCTION

Old is the existence of psychosis and varied are its presentations. Efforts to understand this enigma, as well as to treat the sufferer have been puzzling humanity since time as old as the problem itself. So far, trials have been done with innumerable options including a number of pharmacological agents starting from those of ancient days through typical antipsychotics to atypical ones in later times. But problems came hand-in-glove with each of these options. As extrapyramidal side effects of typical antipsychotics compelled clinicians to move towards the atypical ones, these newer, so-called novel agents have brought with them a gamut of adversities, the various metabolic side effects.¹

Prior to 1952, there was no generally applicable, effective pharmacological treatment of psychotic illness. In the early 1920s, sleep treatment with barbiturates was introduced. Insulin coma therapy was introduced by Manfred Sakel in 1927. Prefrontal lobotomy was proposed as a treatment for serious mental illnesses by Egas Moniz in 1935. The use of frontal lobotomy was common prior to the introduction of effective antipsychotics. Psychosurgery was abandoned as a treatment for schizophrenia after the introduction of effective antipsychotic medications. Convulsive therapies were

developed after it was observed that some patients improved after a seizure. Drugs such as camphor and pentylenetetrazole were used initially to induce seizures but were abandoned after Ugo Cerletti and Lucio Bini proposed the use of electroconvulsive therapy in 1937.^{2,3}

The first effective antipsychotic medications were probably derived from extracts of the rauwolfia plant. Reserpine, the most potent of the rauwolfia alkaloids, was isolated in India in 1931 by Drs. Salimuzzaman Siddiqui and Rafat Hussain Siddiqui. Almost around the same time Drs. Gananath Sen and Kartick Chandra Bose reported its effective use in treatment of psychosis.⁴

The discovery of chlorpromazine in the early 1950s by Charpentier may be the most important single contribution to the treatment of psychiatric illness. Laborit, a surgeon in Paris, noticed that administering chlorpromazine to patients prior to surgery resulted in an unusual state in which they seemed less anxious regarding the procedure. In 1952 he convinced Jean Delay and Pierre Deniker and other psychiatrists to administer chlorpromazine to psychotic and excited patients. Chlorpromazine was effective in reducing hallucinations and delusions as well as excitement. It also caused adverse effects that resembled Parkinsonism.⁵

Subsequently, thioridazine, fluphenazine, haloperidol and other first generation antipsychotics were developed. All of these agents used to act through the same Dopamine D2 receptor blockade, and though they differed in their potency and their adverse effect profiles, they differed little in terms of effectiveness.⁶ Clozapine, the first effective antipsychotic with negligible extrapyramidal side effects was discovered in 1958 and first studied in the 1960s. Risperidone, olanzapine, quetiapine, ziprasidone and other agents discovered subsequently with affinity for both dopamine and serotonin receptors exhibited minimal extrapyramidal side effects. These newer agents came to be known as the second-generation antipsychotics and gradually replaced largely older drugs as the standard treatments for psychoses.^{7,8}

METHODOLOGY

INCLUSION CRITERIA

1. Adult males/females of age between 18 and 60 years, who are cases of schizophrenia diagnosed as per the ICD-10 criteria.
2. Only physically active patients will be included (patients are considered to be physically active if they regularly engaged in an aerobic type of activity at least twice per week for 20 min; these activities included walking, jogging, swimming or garden/yard work).

EXCLUSION CRITERIA

1. Patients who had received prior antipsychotic medication in the last 6 months.
2. Patients having any of the five features of metabolic syndrome, patients having any type of cardiovascular disorder, whether under treatment or not, and known patients of diabetes (even if having fasting blood sugar controlled below 110 mg/dl by any diabetic medication) will be excluded.
3. Patients with history of co-morbid substance abuse, pregnant patients, patients having family history of diabetes and patients having co-morbid chronic medical illness will also be excluded.

PROCEDURE

All new persons attending out-patient department with the diagnosis of first episode drug naive schizophrenia as per ICD-10 diagnostic criteria. Metabolic parameters like BMI, Waist/Hip ratio, Lipid Profile, Fasting blood sugars, and Blood Pressure will be taken before onset of drug treatment and after 18 months.

The study will include 120 patients, both indoor and outdoor, suffering from schizophrenia, diagnosed using the ICD-10 criteria. The patients will be grouped into three categories, i.e. control group and two study groups., control group having 30 patients and study groups with 45 patients each.

Thirty patients will be given conventional antipsychotics and 90 will be given second-generation antipsychotics, including risperidone and olanzapine.

RESULTS

Table 1: Age distribution of Haloperidol group

Age (in Years)	No. of Subjects	Percentage%
19 to 27	9	30.00
28 to 37	6	20.00
38 to 47	6	20.00
48 to 57	5	16.67
58 to 66	4	13.33
Total	30	100.00

Table 2: Age distribution of Olanzapine group

Age (in Years)	No. of Subjects	Percentage%
18 to 26	17	40.48
27 to 35	11	26.19
36 to 44	2	4.76
45 to 53	6	14.29
54 to 62	4	9.52
63 to 71	2	4.76
Total	42	100.00

Table 3: Age distribution of Risperidone group

Age (in Years)	No. of Subjects	Percentage
19 to 27	14	34.15
28 to 36	6	14.63
37 to 45	7	17.07
46 to 54	7	17.07
55 to 63	0	0.00
64 to 71	7	17.07

Total	41	100.00

The gender distribution in three groups, haloperidol with 33.4% females and 66.4% males; olanzapine with 52.4% females and 47.6% males; risperidone with 41.5% females and 58.5% males. The p value for

gender distribution is $p = 0.262$. Statistically not significant, implying that there is no gender bias in the sample collection.

Table 4: The association between genders for the drugs haloperidol, olanzapine and risperidone

Gender	Male	Female	Total	P-value
Haloperidol	20	10	30	0.262
Olanzapine	20	22	42	
Risperidone	24	17	41	
Total	64	49	113	

Socioeconomic status was classified into lower, middle and upper and the distribution amongst

the groups was statistically not significant with a p value, $p = 0.237$.

Table 5: Association between socio drug groups economic statuses for the three

Socio-economic status	Lower	Middle	Upper	Total	P-value
Haloperidol	18	10	2	30	0.237
Olanzapine	16	20	6	42	
Risperidone	14	22	5	41	
Total	48	52	13	113	

Table 6: Comparison between baseline and After 18 months for the parameter weight (in Kgs) among the groups Haloperidol, Olanzapine and Risperidone.

Groups	Minimum	Maximum	Mean	Sd	P-value
Hal - bl	45	78	58.87	9.73	<0.0001
Hal- a18m	46	89	61.8	11.45	
Ol -bl	47	76	59.05	7.77	
Ol- a18m	53	94	73.62	9.43	<0.0001
Res -bl	50	79	60.88	7.43	<0.0001
Res- a18m	53	93	71.83	8.82	

Table 7: Comparison between baseline and After 18 months for the parameter BMI among the groups Haloperidol, Olanzapine and Risperidone.

Groups	Minimum	Maximum	Mean	Sd	P-value
Hal -bl	18	27.6	20.96	2.44	<0.0001
Hal- a18m	18.4	32	22.02	3.35	
Ol -bl	16.6	26.9	21.54	2.21	
Ol- a18m	19.4	33.3	26.91	3.07	<0.0001
Res -bl	19.1	27.6	22.75	2.03	<0.0001
Res- a18m	20.1	33.2	26.92	3.12	

DISCUSSION

Comparison between the metabolic derangements starting from parameters weight and BMI to changes in blood pressures all show significant changes in both the atypical drugs Olanzapine and Risperidone. The derangements in inter-group comparisons between Olanzapine (26%) and Risperidone (22%) again show greater derangements with Olanzapine comparatively for overall development of Metabolic syndrome.⁹

The average weight gains in the three drug groups show a mean of 61.8 in the Haloperidol group with a mean average increase of 2.9 kgs over a period of 18 months, as compared to mean increases in weight with Olanzapine being 14.6 kgs and for Risperidone 10.9

kgs. All the three groups have significant p-values (<0.0001) for increase in weight over the 18 month period. Previous studies on antipsychotic use leading to weight gain show rapid increases in weight within the first few months of initiating therapy with atypical drugs, that may not reach a plateau even after 1 year of treatment. In one prospective, double blind study, olanzapine was found to increase weight twice as that of Risperidone.¹⁰

Mean changes in BMI over the 18 months period is also significant with a p-value <0.0001, for all the three drug groups, more so again for the atypicals compared to haloperidol. Previous similar studies show large amounts of intra-abdominal fat have been found to be associated with adverse metabolic

consequences. Limited data suggest that in humans, most of the weight gained is fat. One study found that people with schizophrenia have more than three times as much intra-abdominal fat as controls matched for age, gender and lifestyle and that 6 months of treatment with either olanzapine or risperidone, although increased body mass index, did not significantly increase visceral fat stores.^{11,12}

rabbits. Archives of International Pharmacodynamics and Therapy, 128, 82-88.

CONCLUSION

Atypical antipsychotic drugs both risperidone and olanzapine cause significant rise in weight and body mass index.

REFERENCES

1. Wu, R.R., Zhao, J.P., Liu, Z.N., Zhai, J.G., Guo, X.F. (2006) Effects of typical and atypical antipsychotics on glucose-insulin homeostasis and lipid metabolism in first-episode schizophrenia. *Psychopharmacology*, 186(4), 572-578.
2. Shen, S.W., Reaven, G.M., Farquhar, J.W. (1970) Comparison of impedance to insulin-mediated glucose uptake in normal subjects and in subjects with latent diabetes. *Journal of Clinical Investigation*, 49, 2151-2160.
3. Bergman, R.N., Ader, M. (2005) Atypical Antipsychotics and Glucose Homeostasis. *Journal of Clinical Psychiatry*, 66, 504-514.
4. Weyer, C., Hanson, K., Bogardus, C., *et al.* (2000) Long-term changes in insulin action and insulin secretion associated with gain, loss, regain and maintenance of body weight. *Diabetologia*, 43, 36-46.
5. Melkersson, K.I., Dahl, M.L. (2003) Relationship between levels of insulin or triglycerides and serum concentrations of the atypical antipsychotics clozapine and olanzapine in patients on treatment with therapeutic doses. *Psychopharmacology*, 170, 157-166.
6. Baptista, T., Lacruz, A., Angeles, F., *et al.* (2001) Endocrine and metabolic abnormalities involved in obesity associated with typical antipsychotic drug administration. *Pharmacopsychiatry*, 34, 223-231.
7. DeFronzo, R.A. (1997). Pathogenesis of type 2 diabetes: metabolic and molecular implications for identifying diabetes genes. *Diabetes-metabolism reviews*, 5, 177-269.
8. Selke, G., Fucetola, R., Cooper, B.P. (2000) Atypical antipsychotic-induced differences in glucose regulation in schizophrenia independent of differences in adiposity. *Social Neurosciences Abstract*, 26, 275.
9. Dwyer, D.S., Liu, Y., Bradley, R.J. (1999) Dopamine receptor antagonists modulate glucose uptake in rat pheochromocytoma (PC12) cells. *Neuroscience Letters*, 274, 151-154.
10. Erle, G., Basso, M., Federspil, G. (1977) Effect of chlorpromazine on blood glucose and plasma insulin in man. *European Journal of Clinical Pharmacology*, 11, 15-18.
11. Sato, S., Katayama, K., Kakemi, M. (1988) A kinetic study of chlorpromazine on the hyperglycemic response in rats, 2: effect of chlorpromazine on plasma glucose. *Journal of Pharmacobiodynamics*, 11, 492-503.
12. Gupta, S.K., Patel, M.A., Joseph, A.D. (1960) Effect of chlorpromazine and epinephrine on blood-sugar of

“A COMPARATIVE STUDY BETWEEN FNAC AND EXCISION BIOPSY IN THE DIAGNOSIS OF LYMPH NODE DISEASE IN A.J. INSTITUTE OF MEDICAL SCIENCES-MANGALORE”

Dr Suhas S Kumar¹, Dr K Karthikeyan², Dr Manisha Narayana³, Dr Akshai C K⁴

¹Asst Prof Department Of General Surgery, St Johns Medical College Hospital

²Asst Prof Department Of General Surgery St Johns Medical College Hospital

³assistant Professor, SABVMCRI

⁴Asst Prof Department Of General Surgery St Johns Medical College Hospital

Corresponding Author: Dr Akshai C K

Abstract

Introduction: Accurate and timely diagnosis of lymph node pathology is crucial for appropriate management and prognostication. This study aimed to compare the diagnostic accuracy of fine-needle aspiration cytology (FNAC) and excision biopsy in the diagnosis of various lymph node diseases.

Materials and Methods: A total of 250 patients with lymphadenopathy underwent FNAC and excision biopsy at a tertiary care center between September 2013 and September 2015. The diagnostic performance of FNAC was evaluated using sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Results: Tuberculosis lymphadenitis (TBLN) was the most common diagnosis, accounting for 41.6% of cases on FNAC and 46% on excision biopsy. FNAC had a sensitivity of 90.4% and a PPV of 100% in the diagnosis of TBLN. For metastatic carcinoma, FNAC demonstrated a sensitivity of 84.2%, a specificity of 98.71%, a PPV of 97.56%, and an NPV of 91.07%. The overall sensitivity of FNAC in the diagnosis of lymph node diseases was 83.6%, with a PPV of 100%.

Conclusion: FNAC exhibited excellent diagnostic accuracy in the evaluation of TBLN and metastatic carcinoma, supporting its use as a reliable, minimally invasive, and cost-effective first-line investigation in the management of lymphadenopathy. While excision biopsy remains the gold standard, the high diagnostic performance of FNAC, as demonstrated in this study, highlights its clinical utility in guiding further diagnostic and treatment decisions.

Keywords: Fine-needle aspiration cytology, Excision biopsy, Lymph node disease, Tuberculosis lymphadenitis, Metastatic carcinoma, Diagnostic accuracy

INTRODUCTION

Lymph node disease is a common presentation in clinical practice, with a wide range of underlying etiologies, ranging from benign reactive processes to malignant conditions [1]. Accurate and timely diagnosis of lymph node pathology is crucial for appropriate management and prognostication. Two commonly employed diagnostic modalities are fine-needle aspiration cytology (FNAC) and excision biopsy [2]. While FNAC is a minimally invasive and cost-effective procedure, excision biopsy is considered the gold standard for definitive diagnosis [3].

FNAC is a widely used technique that involves the aspiration of cellular material from a palpable lymph node using a fine-gauge needle [4]. The aspirated material is then prepared and examined under a microscope by a cytopathologist. FNAC is a relatively simple procedure that can be performed in an outpatient setting and provides rapid results [5]. It has been reported to have a high diagnostic accuracy, with sensitivity and specificity rates ranging from 67% to 97% and 80% to 100%, respectively, in the diagnosis of lymph node diseases [6,7].

On the other hand, excision biopsy involves the surgical removal of the entire lymph node or a portion of it for histopathological examination [8]. This technique allows for a comprehensive assessment of the lymph node architecture and the underlying pathology, which can be crucial in certain conditions, such as lymphoma, where the architectural patterns are essential for diagnosis [9]. Excision biopsy is considered the gold standard for the diagnosis of lymph node diseases, with a reported diagnostic accuracy of up to 98% [10].

While both FNAC and excision biopsy are well-established diagnostic modalities, there is an ongoing debate about their comparative performance in the diagnosis of lymph node diseases [11]. Several studies have attempted to assess the diagnostic accuracy, reliability, and cost-effectiveness of these two techniques, with varying results [12,13]. Some studies have reported comparable performance between FNAC and excision biopsy, while others have suggested that excision biopsy may be superior in certain clinical scenarios [14,15].

Aims and Objectives

The main aim of this study was to compare the accuracy of FNAC in providing an early diagnosis as compared to that of excision biopsy and to prove that it is a rapid, easy, and dependable method of diagnosis in cases of lymph node disease.

MATERIALS AND METHODS

Fine needle aspiration cytology was carried out on 250 patients with significantly palpable lymph nodes. The majority of the aspirates were from enlarged cervical lymph nodes, with the remaining taken from the axillary, inguinal, and palpable abdominal lymph nodes. This procedure was performed on patients in both the inpatient and outpatient departments of AJ Institute of Medical Sciences, Kuntikana, Mangalore, from October 2013 to September 2015.

The inclusion criteria for the study were patients of all ages, sex, or occupation who were diagnosed with a lymph node disease in the outpatient and inpatient departments, and had their diagnosis confirmed by performing both FNAC and excision biopsy. The exclusion criteria were patients where only FNAC was done without excision biopsy, and those where an adequate aspirate smear was not obtained.

After obtaining proper clinical history and other relevant clinical data, the patients were subjected to FNAC, and the same patients were subsequently subjected to excision biopsy on a later date. The results of the two diagnostic modalities were then compared and analyzed.

The technique of performing FNAC involved obtaining written consent, using no local anesthesia as the procedure is minimally painful, positioning the patient lying down, and performing a minimum of two needle passes to obtain the aspirate. The aspirated material was then placed on glass slides, one for air-dried Diff-Quik staining and the other for spray-fixed Papanicolaou staining. In the case of bloody aspirates, the procedure was modified to address the issue.

RESULTS

The current study was conducted to evaluate and compare the diagnostic accuracy of fine-needle aspiration cytology (FNAC) and excision biopsy in the diagnosis of lymph node diseases. The study included a total of 250 patients with lymphadenopathy (cervical, axillary, and inguinal) who underwent both FNAC and excision biopsy for histopathological confirmation between September 2013 and September 2015 at the AJ Institute of Medical Sciences and Research Centre, Kuntikana, Mangalore. All patients were enrolled in the study based on the specified inclusion and exclusion criteria.

The age distribution of the study population ranged from 5 years to 86 years, with a mean age of 38.98 years. The majority of the patients were in the 20-30 years (21.2%) and 30-40 years (17.6%) age groups (Table 1). The gender distribution showed a predominance of male patients, with 149 (59.6%) males and 101 (40.4%) females (Table 2).

An in-depth analysis of the FNAC findings across different age groups revealed that tuberculosis lymphadenitis (TBLN) was the most common diagnosis, accounting for 104 (41.6%) cases (Table 3). The majority of TBLN cases were observed in the 20-40 years age range, with the highest proportion in the 20-30 years age group (36 cases, 67.9%). Metastatic carcinoma, which included metastatic squamous cell carcinoma (MSCC), metastatic adenocarcinoma (MADC), and metastatic undifferentiated carcinoma (MIDC), was more prevalent in patients older than 40 years, with a total of 82 (32.8%) cases. Non-Hodgkin's lymphoma (NHL) was diagnosed in 9 (3.6%) patients across the study population.

The results of the excision biopsy findings showed a similar pattern, with TBLN being the most common diagnosis, accounting for 115 (46%) cases (Table 4). The majority of TBLN patients were in the 10-40 years age group, with the highest proportion in the 20-30 years age range (41 cases, 77.4%). Metastatic carcinoma was diagnosed in 95 (38%) patients,

predominantly in the 30-60 years age group, with the highest prevalence in the 50-60 years age range (21 cases, 48.8%). NHL was diagnosed in 24 (9.6%) patients, with the majority of cases occurring in the 20-40 years age group.

The comparative analysis of FNAC and excision biopsy findings, presented in Table 5, revealed that TBLN was diagnosed with an impressive accuracy of 90.4% by FNAC. Metastatic carcinoma (MSCC, MADC, MIDC) was diagnosed with a remarkably high accuracy of 95.9% by FNAC, demonstrating the reliability of this minimally invasive technique in the diagnosis of malignant lymph node lesions.

The sensitivity of FNAC in the diagnosis of TBLN was 90.4%, and the positive predictive value was 100% (Table 6). These results highlight the excellent performance of FNAC in accurately identifying tuberculosis lymphadenitis, which is a common and clinically significant lymph node disease. For the diagnosis of metastatic carcinoma, the sensitivity of FNAC was 84.2%, the specificity was 98.71%, the positive predictive value was 97.56%, and the negative predictive value was 91.07% (Table 7). These statistical measures further corroborate the high diagnostic accuracy of FNAC in the detection of metastatic lymph node involvement.

The percentage distribution of TB and non-TB cases based on FNAC findings across different age groups (Table 8) showed that the overall proportion of TBLN cases was 41.6%, with the highest prevalence in the 20-30 years age group (67.9%). This finding is consistent with the epidemiological patterns of tuberculosis in the region, highlighting the importance of considering TBLN as a potential diagnosis, particularly in younger individuals presenting with lymphadenopathy.

The overall sensitivity of FNAC in the diagnosis of lymph node diseases was 83.6%, and the positive predictive value was 100% (Table 9). These results demonstrate the high diagnostic accuracy of FNAC as a reliable and minimally invasive tool in the evaluation of lymph node pathologies, compared to the gold standard of excision biopsy.

In summary, the findings of this study underscore the significant diagnostic value of FNAC in the diagnosis of various lymph node diseases, particularly TBLN and metastatic carcinoma. The high sensitivity, specificity, and predictive values observed for FNAC in this study highlight its utility as a rapid, cost-effective, and minimally invasive technique for the initial evaluation of lymphadenopathy. These results support the use of FNAC as a reliable first-line investigation in the management of patients presenting with lymph node diseases, with the potential to guide further diagnostic and treatment decisions.

Table 1: Age Incidence

Age in years	Frequency	Percent	Valid Percent	Cumulative Percent
<10	13	5.2	5.2	5.2
10 -20	30	12.0	12.0	17.2
20-30	53	21.2	21.2	38.4
30-40	44	17.6	17.6	56.0
40-50	38	15.2	15.2	71.2
50-60	43	17.2	17.2	88.4
60-70	19	7.6	7.6	96.0
>70	10	4.0	4.0	100.0
Total	250	100.0	100.0	

Table 2: Sex Incidence

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
MALE	149	59.6	59.6	59.6
FEMALE	101	40.4	40.4	100.0
Total	250	100.0	100.0	

Table 3: Age-wise Distribution According to Diagnosis Based on FNAC

AGE GROUP	FNAC	Total
	RH	TBLN
<10	5	7
10 -20	8	19
20-30	10	36
30-40	8	19
40-50	7	10
50-60	4	9
60-70	3	2
>70	0	2
Total	45	104

Table 4: Age-wise Distribution According to Diagnosis Based on Excision Biopsy

AGE GROUP	EXCISION BIOPSY	Total
	RH	TBLN
<10	4	8
10 -20	3	23
20-30	3	41
30-40	0	19
40-50	0	11
50-60	1	9
60-70	0	2
>70	0	2
Total	11	115

Table 5: FNAC versus Histopathology

FNAC Diagnosis	Excision Biopsy Diagnosis							
	RH	TBLN	NHL	MSCC	MADC	MIDC	NSCL	
RH	11 (24.4%)	6 (13.3%)	13 (28.9%)	2 (4.4%)	8 (17.8%)	5 (11.1%)	0 (0.0%)	45 (100.0%)
	100.0%	5.2%	54.2%	4.1%	36.4%	20.8%	0.0%	18.0%
TBLN	0 (0.0%)	104 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	104 (100.0%)
	0.0%	90.4%	0.0%	0.0%	0.0%	0.0%	0.0%	41.6%
NHL	0 (0.0%)	0 (0.0%)	9 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	9 (100.0%)
	0.0%	0.0%	37.5%	0.0%	0.0%	0.0%	0.0%	3.6%
MSCC	0 (0.0%)	0 (0.0%)	0 (0.0%)	47 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	47 (100.0%)
	0.0%	0.0%	0.0%	95.9%	0.0%	0.0%	0.0%	18.8%
MADC	0 (0.0%)	0 (0.0%)	1 (6.7%)	0 (0.0%)	14 (93.3%)	0 (0.0%)	0 (0.0%)	15 (100.0%)
	0.0%	0.0%	4.2%	0.0%	63.6%	0.0%	0.0%	6.0%
MIDC	0 (0.0%)	0 (0.0%)	1 (5.0%)	0 (0.0%)	0 (0.0%)	19 (95.0%)	0 (0.0%)	20 (100.0%)
	0.0%	0.0%	4.2%	0.0%	0.0%	79.2%	0.0%	8.0%
NSCL	0 (0.0%)	5 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (50.0%)	10 (100.0%)

FNAC Diagnosis	Excision Biopsy Diagnosis							
	0.0%	4.3%	0.0%	0.0%	0.0%	0.0%	100.0%	4.0%
Total	11 (4.4%)	115 (46.0%)	24 (9.6%)	49 (19.6%)	22 (8.8%)	24 (9.6%)	5 (2.0%)	250 (100.0%)
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 6: Results of TBLN

Test	HPR Positive	HPR Negative	Total
FNAC Positive	104	0	104
FNAC Negative	11	0	11
Total	115	0	115

Table 7: Result of Metastatic Carcinoma

Test	HPR Positive	HPR Negative	Total
FNAC Positive	80	2	82
FNAC Negative	15	153	168
Total	95	155	250

Table 8: Percentage Distribution TB and Non TB Cases

AGE GROUP	FNAC - TB	FNAC - NON-TB	TOTAL
<10	7 (53.8%)	6 (46.2%)	13
10-20	19 (63.3%)	11 (36.7%)	30
20-30	36 (67.9%)	17 (32.1%)	53
30-40	19 (43.2%)	25 (56.8%)	44
40-50	10 (26.3%)	28 (73.7%)	38
50-60	9 (20.9%)	34 (79.1%)	43
60-70	2 (10.5%)	17 (89.5%)	19
>70	2 (20.0%)	8 (80.0%)	10
TOTAL	104 (41.6%)	146 (58.4%)	250

Table 9: Overall Diagnostic Accuracy of FNAC

Test	HPR Positive	HPR Negative	Total
FNAC Positive	209	0	209
FNAC Negative	41	0	41
Total	250	0	250

DISCUSSION

The present study aimed to compare the diagnostic accuracy of fine-needle aspiration cytology (FNAC) and excision biopsy in the diagnosis of various lymph node diseases, with a particular focus on tuberculosis lymphadenitis (TBLN) and metastatic carcinoma. The findings of this study demonstrate the high diagnostic performance of FNAC, corroborating the existing evidence in the literature.

In the current study, TBLN was the most common lymph node disease, accounting for 41.6% of the cases based on FNAC and 46% based on excision biopsy. This is consistent with the observations made in other studies conducted in regions with a high prevalence of tuberculosis. For instance, a study by Koo et al. [16] reported that TBLN constituted 66.7% of the cases in their cohort, while Nasuti et al. [17] found that TBLN accounted for 43.9% of the lymph node lesions. The high incidence of TBLN in the present study underscores the importance of considering tuberculosis as a common etiology of lymphadenopathy, particularly in endemic regions.

The diagnostic accuracy of FNAC in the diagnosis of TBLN was found to be remarkably high, with a sensitivity of 90.4% and a positive predictive value of 100%. These results are consistent with the findings reported in the literature. Kholová and Ludvíková [18] conducted a systematic review and meta-analysis of studies evaluating the performance of FNAC in the diagnosis of TBLN, reporting a pooled sensitivity of 93% and a specificity of 96%. Similarly, Koo et al. [16] reported a sensitivity of 96.7% and a specificity of 100% for FNAC in the diagnosis of TBLN. These findings emphasize the reliability of FNAC as a first-line investigation in the evaluation of suspected tuberculous lymphadenitis, with the potential to guide prompt initiation of appropriate treatment.

In the diagnosis of metastatic carcinoma, the current study found that FNAC had a high sensitivity of 84.2%, a specificity of 98.71%, a positive predictive value of 97.56%, and a negative predictive value of 91.07%. These results are in line with the findings reported in the literature. Roskell and Buley [19] conducted a review of the diagnostic accuracy of FNAC in the evaluation of lymph node lesions and reported a sensitivity of 83-98% and a specificity of 93-100% for the detection of metastatic carcinoma. Similarly, Nasuti et al. [20] reported a sensitivity of 92.4% and a specificity of 100% for FNAC in the diagnosis of metastatic lymph node diseases. These studies highlight the substantial diagnostic value of FNAC in the identification of metastatic lymphadenopathy, which is crucial for appropriate staging and management of malignancies.

It is important to note that while FNAC demonstrated excellent performance in the diagnosis of TBLN and metastatic carcinoma, it had a lower accuracy in the diagnosis of other lymph node pathologies, such as reactive hyperplasia and non-Hodgkin's lymphoma. This is consistent with the findings reported in the literature, where FNAC has been shown to have lower diagnostic accuracy in differentiating between reactive and neoplastic lymph node lesions, particularly in the context of lymphoma [21,22]. In such cases, the architectural and immunohistochemical evaluation provided by excision biopsy remains the gold standard for accurate diagnosis and management.

The strengths of this study include the large sample size, the inclusion of patients from both inpatient and outpatient settings, and the comprehensive comparison of FNAC and excision biopsy findings. However, the study was conducted at a single tertiary care center, which may limit the generalizability of the results. Additionally, the study did not evaluate the impact of FNAC on patient management and clinical outcomes, which could be an area for future research.

The findings of the present study highlight the significant diagnostic value of FNAC in the evaluation of lymph node diseases, particularly TBLN and metastatic carcinoma. The high sensitivity, specificity, and predictive values observed for FNAC in this study support its use as a reliable, minimally invasive, and cost-effective first-line investigation in the management of patients presenting with lymphadenopathy. While excision biopsy remains the gold standard for definitive diagnosis, the results of this study suggest that FNAC can play a crucial role in guiding further diagnostic and treatment decisions, especially in resource-constrained settings.

CONCLUSION

The findings of this comprehensive study underscore the significant diagnostic value of fine-needle aspiration cytology (FNAC) in the evaluation of various lymph node diseases, particularly tuberculosis lymphadenitis (TBLN) and metastatic carcinoma. The study demonstrated that FNAC had a remarkably high sensitivity of 90.4% and a positive predictive value of 100% in the diagnosis of TBLN, corroborating the existing evidence in the literature. Similarly, for the detection of metastatic carcinoma, FNAC exhibited a sensitivity of 84.2%, a specificity of 98.71%, a positive predictive value of 97.56%, and a negative predictive value of 91.07%, further highlighting its reliability as a minimally invasive and cost-effective diagnostic tool.

While FNAC showed excellent performance in the diagnosis of TBLN and metastatic carcinoma, its accuracy was lower in the differentiation of reactive and neoplastic lymph node lesions, particularly in the context of lymphoma. In such cases, the architectural and immunohistochemical evaluation provided by excision biopsy remains the gold standard for accurate diagnosis and management.

Overall, the findings of this study support the use of FNAC as a reliable first-line investigation in the evaluation of lymphadenopathy, with the potential to guide further

diagnostic and treatment decisions, especially in resource-constrained settings. The high diagnostic accuracy of FNAC, as demonstrated in this study, underscores its clinical utility and reinforces its role as a valuable diagnostic tool in the comprehensive management of patients presenting with lymph node diseases.

REFERENCES:

1. Hoang MP, Gupta R, Jungbluth AA, Lau SK, Monabati A. Immunohistochemical diagnosis of lymph node diseases. *Expert Rev Mol Diagn.* 2019;19(4):329-340. doi:10.1080/14737159.2019.1593724
2. Orell SR, Sterrett GF. Orell and Sterrett's Fine Needle Aspiration Cytology. 5th ed. Churchill Livingstone; 2012.
3. Almeida Silvani CM, Carneiro Monteiro ML, Carvalho Nicolau G, Marcelo Soares Teixeira L. Diagnostic accuracy of fine-needle aspiration cytology compared to surgical excisional biopsy in the diagnosis of lymph node malignancies. *Rev Col Bras Cir.* 2017;44(6):595-600. doi:10.1590/0100-6991e-20171593
4. Kholová I, Ludvíková M. Thyroid gland fine-needle aspiration biopsy: different sampling techniques and their possible impact on the specimen adequacy. *Acta Cytol.* 2014;58(6):532-546. doi:10.1159/000369352
5. Tan LHC. Fine needle aspiration biopsy of lymph nodes. *J Clin Pathol.* 2013;66(10):828-836. doi:10.1136/jclinpath-2013-201559
6. Koo V, Lioe TF, Spence RA. Fine needle aspiration cytology (FNAC) in the diagnosis of granulomatous lymphadenitis. *Ulster Med J.* 2006;75(1):59-64.
7. Nasuti JF, Mehrotra R, Gupta PK. Diagnostic value of fine-needle aspiration in superficial lymphadenopathy: a study of 376 cases. *Diagn Cytopathol.* 2001;25(6):351-355. doi:10.1002/dc.2117
8. Rajini T, Vinaya Kumar Potu B, Gorantla VR, et al. Lymph node excision biopsy: a review of the literature. *Int J Anat Var.* 2010;3:42-45.
9. Ioachim HL, Medeiros LJ. Ioachim's Lymph Node Pathology. 4th ed. Lippincott Williams & Wilkins; 2008.
10. Baruah P, Saikia UN, Dutta A, et al. Diagnostic accuracy of excision biopsy in lymph node diseases. *J Clin Diagn Res.* 2016;10(3):EC01-EC04. doi:10.7860/JCDR/2016/18088.7360
11. Lioe TF, Elliott H, Allen DC, Spence RA. The role of fine needle aspiration cytology (FNAC) in the diagnosis of lymphoma. *J Clin Pathol.* 1999;52(9):648-653. doi:10.1136/jcp.52.9.648
12. Nasuti JF, Gupta PK, Baloch ZW. Diagnostic value and cost-effectiveness of on-site evaluation of fine-needle aspiration specimens: review of 5,688 cases. *Diagn Cytopathol.* 2002;27(1):1-4. doi:10.1002/dc.10131
13. Roskell DE, Buley ID. Fine needle aspiration cytology in cancer diagnosis. *BMJ.* 2004;329(7463):461-462. doi:10.1136/bmj.329.7463.461
14. Annam V, Arakeri SU, Premalatha CS, Rao RS. Comparison of the diagnostic accuracy of fine-needle aspiration cytology and excision biopsy of lymph node lesions. *J Cytol.* 2009;26(4):127-131. doi:10.4103/0970-9371.59378

15. Kumarasinghe MP, Lau SK, Pang SC, Nallusamy R. Fine needle aspiration cytology in lymphadenopathy: is it useful as a first-line investigation? *Malays J Pathol.* 2015;37(1):9-15.
16. Koo V, Lioe TF, Spence RA. Fine needle aspiration cytology (FNAC) in the diagnosis of granulomatous lymphadenitis. *Ulster Med J.* 2006;75(1):59-64.
17. Nasuti JF, Mehrotra R, Gupta PK. Diagnostic value of fine-needle aspiration in superficial lymphadenopathy: a study of 376 cases. *Diagn Cytopathol.* 2001;25(6):351-355. doi:10.1002/dc.2117
18. Kholová I, Ludvíková M. Thyroid gland fine-needle aspiration biopsy: different sampling techniques and their possible impact on the specimen adequacy. *Acta Cytol.* 2014;58(6):532-546. doi:10.1159/000369352
19. Roskell DE, Buley ID. Fine needle aspiration cytology in cancer diagnosis. *BMJ.* 2004;329(7463):461-462. doi:10.1136/bmj.329.7463.461
20. Nasuti JF, Gupta PK, Baloch ZW. Diagnostic value and cost-effectiveness of on-site evaluation of fine-needle aspiration specimens: review of 5,688 cases. *Diagn Cytopathol.* 2002;27(1):1-4. doi:10.1002/dc.10131
21. Lioe TF, Elliott H, Allen DC, Spence RA. The role of fine needle aspiration cytology (FNAC) in the diagnosis of lymphoma. *J Clin Pathol.* 1999;52(9):648-653. doi:10.1136/jcp.52.9.648
22. Annam V, Arakeri SU, Premalatha CS, Rao RS. Comparison of the diagnostic accuracy of fine-needle aspiration cytology and excision biopsy of lymph node lesions. *J Cytol.* 2009;26(4):127-131. doi:10.4103/0970-9371.59378

Original research article**The emergence of metabolic syndrome due to second-generation antipsychotics as compared with conventional (typical) antipsychotics****¹Dr. Vajipeyajula Anupama, ²Dr. Neeraj Raj B, ³Dr. Furkhan Ali**¹Assistant Professor, Department of Psychiatry, CDSIMER, Bengaluru, Karnataka, India²Assistant Professor, Department of Psychiatry, CDSIMER, Bengaluru, Karnataka, India³Consultant Psychiatrist, NIMHANS, Bangalore, Karnataka, India**Corresponding Author:**

Dr. Vijay Raj N

Abstract

Persons with schizophrenia are reported to be more likely to die from cardiovascular illness than those in the general population, and are at a greater risk of developing obesity, diabetes type 2, hypertension and dyslipidemias. Trials have been done with innumerable options including a number of pharmacological agents starting from those of ancient days through typical antipsychotics to atypical ones in later times. But problems came hand-in-glove with each of these options. As extrapyramidal side effects of typical antipsychotics compelled clinicians to move towards the atypical ones, these newer, so-called novel agents have brought with them a gamut of adversities, the various metabolic side effects.

The study includes 120 patients, both indoor and outdoor, suffering from schizophrenia, diagnosed using the ICD-10 criteria. The patients were grouped into three categories, i.e. control group and two study groups, control group having 30 patients and study groups with 45 patients each.

Thirty patients were given conventional antipsychotics and 90 were given second-generation antipsychotics, including risperidone and olanzapine.

At the end of 18 months it was observed that a significant number of subjects developed metabolic syndrome in both the atypical drugs, Olanzapine and Risperidone (p-value <0.0001). Comparatively the incidence was more in Olanzapine (26%) than Risperidone (22%), with higher increases especially in weight, fasting blood sugars and lipid profile changes in the subjects treated with Olanzapine. The same random sample showed little changes in the parameters when treated with conventional antipsychotic Haloperidol. Thus, even though there was a lesser incidence of extra- pyramidal symptoms with atypical antipsychotics, it should be borne in mind that the incidence of metabolic syndrome adds to the cardiovascular risk of patients with Schizophrenia and the need to tailor a drug based on patient profile is always the better option.

Keywords: Metabolic syndrome, Second-generation antipsychotics, conventional antipsychotics

Introduction

Antipsychotic medications, the mainstay for the treatment of psychoses, are also widely used in many other psychiatric conditions. For people who respond well, antipsychotics can mean the difference between leading an engaged, fulfilling community life and being severely disabled ^[1]. The first generation antipsychotics are effective in treating positive symptoms of psychosis, such as hallucinations and delusions. However, first generation antipsychotics do not adequately alleviate many other common and important aspects of psychosis, such as negative symptoms. In addition, all first generation antipsychotics can produce significant extrapyramidal side effects at clinically effective doses, which include dystonic reactions, drug-induced Parkinsonism, akathisia, and tardive dyskinesia. These side effects can make treatment intolerable for some people leading to subjective distress, diminished function, stigma, and non-adherence ^[2].

The effort to find more effective medications with fewer and less severe side effects led to the development of second-generation antipsychotics, often referred to as the “atypical antipsychotics”.

Since the introduction of second-generation antipsychotics, these agents have been widely prescribed for the management of patients with schizophrenia. The increasing use of second generation antipsychotics is in part due to the evidence suggesting its beneficial effects on positive symptoms, negative symptoms and cognition in schizophrenia, combined with a lower propensity for extrapyramidal symptoms or tardive dyskinesia compared to first generation antipsychotics. The improved tolerability of the atypical agents compared to the typical agents and the emerging data suggesting improved psychiatric outcomes, has led the clinicians to begin prescribing these agents widely. But now, a few decades after the first atypical antipsychotic came in scenario, researchers and clinicians have gradually come to realize that while extrapyramidal symptoms and tardive dyskinesia occur less commonly with atypical agents, these

medications may present a different set of adverse effects than typical agents. Of particular concern are the metabolic side effects of glucose intolerance, new-onset type 2 diabetes mellitus, weight gain and hypertriglyceridemia^[3, 4].

Methodology

Inclusion Criteria

1. Adult males/females of age between 18 and 60 years, who are cases of schizophrenia diagnosed as per the ICD-10 criteria.
2. Only physically active patients will be included (patients are considered to be physically active if they regularly engaged in an aerobic type of activity at least twice per week for 20 min; these activities included walking, jogging, swimming or garden/yard work).

Exclusion Criteria

1. Patients who had received prior antipsychotic medication in the last 6 months.
2. Patients having any of the five features of metabolic syndrome, patients having any type of cardiovascular disorder, whether under treatment or not, and known patients of diabetes (even if having fasting blood sugar controlled below 110 mg/dl by any diabetic medication) will be excluded.
3. Patients with history of co-morbid substance abuse, pregnant patients, patients having family history of diabetes and patients having co-morbid chronic medical illness will also be excluded.

Procedure

All new persons attending out- patient department with the diagnosis of first episode drug naive schizophrenia as per ICD-10 diagnostic criteria. Metabolic parameters like BMI, Waist/Hip ratio, Lipid Profile, Fasting blood sugars, and Blood Pressure will be taken before onset of drug treatment and after 18 months.

The study will include 120 patients, both indoor and outdoor, suffering from schizophrenia, diagnosed using the ICD-10 criteria. The patients will be grouped into three categories, i.e. control group and two study groups, control group having 30 patients and study groups with 45 patients each.

Thirty patients will be given conventional antipsychotics and 90 will be given second-generation antipsychotics, including risperidone and olanzapine.

Results

Table 1: Comparison between baseline and After 18 months for the parameter Triglyceride's among the groups Haloperidol, Olanzapine and Risperidone.

Groups	Minimum	Maximum	Mean	SD	P-value
Hal –BL	122	187	144.9	13.9	
Hal- A18M	137	211	153.6	18.1	<0.0001
OL – BL	129	181	153.5	12.69	
OL- A18M	136	247	178.7	29.3	<0.0001
Res – BL	129	187	149.5	15.05	
Res- A18M	136	234	173.2	25.4	<0.0001

Table 2: Comparison between baseline and After 18 months for the parameter High-density Lipoprotein (HDL) among the groups Haloperidol, Olanzapine and Risperidone.

Groups	Minimum	Maximum	Mean	SD	P-value
Hal –BL	45	61	51.4	4.18	
Hal- A18M	33	56	44.8	5.62	<0.0001
OL – BL	40	66	51.9	5.3	
OL- A18M	34	61	45.9	7	<0.0001
Res – BL	42	60	51.5	4.73	
Res- A18M	34	56	45.9	5.27	<0.0001

Table 3: Comparison between baseline and After 18 months for the parameter Fasting blood sugars among the groups Haloperidol, Olanzapine and Risperidone.

Groups	Minimum	Maximum	Mean	Sd	P-value
Hal –BL	67	123	89.6	13.02	
Hal- A18M	71	167	96.5	21.78	0.001
OL – BL	70	121	95.9	14.11	
OL- A18M	77	203	117.6	28.62	<0.0001
Res – BL	74	123	98.2	12.09	
Res- A18M	74	171	112.2	24.63	<0.0001

Table 4: Comparison between baseline and After 18 months for the parameter Systolic blood pressure among the

groups Haloperidol, Olanzapine and Risperidone.

Groups	Minimum	Maximum	Mean	SD	P-value
Hal –BL	90	130	116	10.03	
Hal- A18M	90	150	119.2	12.67	<0.0001
OL – BL	90	135	115.6	10.43	
OL- A18M	90	170	129	17.58	<0.0001
Res – BL	100	135	115.6	9.37	
Res- A18M	100	155	126.1	15.55	<0.0001

Table 5: Comparison between baseline and After 18 months for the parameter Diastolic blood pressure among the groups Haloperidol, Olanzapine and Risperidone.

Groups	Minimum	Maximum	Mean	SD	P-value
Hal –BL	60	90	78.9	7.51	
Hal- a18m	70	100	80.7	7.4	<0.0001
OL – BL	60	95	78.1	8.04	
OL- a18m	60	110	85.3	10	<0.0001
Res – BL	70	90	78.9	6.57	
Res- a18m	70	100	83.6	7.68	<0.0001

Table 6: Comparison among the groups Haloperidol, Olanzapine and Risperidone to the incidence of Metabolic Syndrome.

Group	Yes	No	P value
Haloperidol	2 (6.7%)	28 (93.3%)	<0.0001
Olanzapine	11 (26.2%)	31(73.8%)	<0.0001
Risperidone	9 (22%)	32 (78%)	<0.0001

Discussion

In one study, the prevalence of metabolic syndrome in patients hospitalized with bipolar disorder (56%) was dramatically higher than the prevalence observed in community samples (25%).The magnitude of comorbid metabolic disorders correlated positively with the severity of the mood disorder.

The role of antipsychotic medications in the development of diabetes and other pre-diabetic states remains controversial. As per some authors, attributable risk is low and traditional risk factors most probably account for much of the diabetes seen in schizophrenia populations. But in the recent literature, Type 2 diabetes mellitus has received significant attention; in part related to the association with atypical antipsychotic therapy, and concern over long-term health burden in patients with schizophrenia, especially the marked increase in cardiovascular disease risk ^[5].

Non-prospective studies suggest that atypical antipsychotic medications can cause diabetes mellitus and other metabolic effects in some patients. However, retrospective studies cannot quantify this risk or determine whether it varies between drugs and how it compares with recognised risk factors such as race, increasing age and obesity. These important clinical questions can only be answered by well-designed prospective studies that take into account potential confounders. Clozapine and olanzapine causes more derangements, risperidone and quetiapine to the moderate extent. Ziprazidone, Aripiprazole have doubtful liabilities ^[6].

The current study is one of few studies done in first episode drug naive persons to eliminate the disease effect and very few studies were done in these populations.

At the end of 18 months in metabolic derangements, there are no differences among gender, educational status, marital status, religion, and occupation.

Of the 2 persons who developed metabolic syndrome, in the Haloperidol group, it was more due to the illness and sedentary lifestyle pattern than that can be attributed to the drug's effects. There was no strict adherence to physical activity and dietary regimens in these two patients.

The p value for this group, as depicted shows a significant p-value (<0.0001) for the Null hypothesis, ie., there is significance for not progressing to metabolic syndrome for the drug Haloperidol. Studies to compare between typical and atypical drugs showing no metabolic derangements with typical antipsychotics were conducted by Sernyak and Newcomer *et al.* But the studies had potential bias in using healthy controls, as schizophrenic patients proved to have propensity for glucose dysregulation, in earlier studies ^[7, 8].

Incidence was comparatively higher with the drug Olanzapine (26%) compared to that of Risperidone (22%). The incidence was statistically significant with a p-value <0.0001. Comparison for the incidence in relation to gender was non-significant in all the three drug groups Haloperidol (p-value 1.000), Olanzapine (p-value 0.298) and Risperidone (p- value 0.128), implying that there was no gender bias in collecting the sample.

The incidence of metabolic syndrome in comparison to the socio- economic statuses revealed that the lower socio- economic group had no to minimal incidence of metabolic syndrome in the Haloperidol group with a significant p-value 0.034, supportive of the NULL hypothesis. Noteworthy is that two subjects out of the 30 in control group treated with Haloperidol, have developed metabolic syndrome at the end of 18 months, while the majority of patients did not. These two subjects were observed and closely followed up throughout the duration of study and the incidence of metabolic syndrome was more due to the disease, Schizophrenia itself than to consider it the effects of the drug as these patients were not strictly adhering to the advised physical activity and dietary restrictions. Similar findings were previously documented about the inherent risk of Schizophrenics to develop cardio-vascular complications and metabolic risks during the course of their illness ^[9, 10].

Psychiatric disorders can be a risk factor for, as well as a complication of, diabetes. Diabetes is highly prevalent among the schizophrenia population. The prevalence of this disorder in patients with schizophrenia is approximately 10–15%, or twice that of the general population. The reasons for it are likely to be multi factorial. It has been found that first-episode, drug-naïve patients with schizophrenia have impaired fasting glucose tolerance, more insulin resistance and higher levels of plasma glucose, insulin, and cortisol than healthy comparison subjects. A stress model of schizophrenia can explain the tendency of people with this disorder to develop disturbance in glucose homeostasis. Numerous studies report over activation of the HPA (Hypothalamo-Pituitary- Adrenal) axis with attenuated feedback inhibition and increased cortisol output. Such a biological vulnerability would render individuals even more susceptible to the negative effects of poor dietary pattern and lack of exercise which lead to weight gain and dyslipidaemia ^[11, 12].

The same when assessed for the incidence of metabolic syndrome in the subjects treated with the atypical drugs Olanzapine and Risperidone (pie charts 6 to 9), it was observed that there was significant rise in the middle in upper echelons compared to the lower. The p-values for Olanzapine were 1.26 and for haloperidol 0.0007 for the same in this study.

Conclusion

- Significant difference between the two study groups Olanzapine (26%) and Risperidone (22%) show, among the second generations, risperidone may be considered as a safer alternative when it comes to changes in metabolic profile.
- Haloperidol has little to no risk for metabolic risk factors when compared to the atypical drugs in the study.
- Atypical antipsychotic drugs both risperidone and olanzapine cause significant rise in plasma glucose, triglycerides, HDL cholesterol.

References

1. Sakel M. The methodical use of hypoglycemia in the treatment of psychoses. Reproduced in: Am J Psychiatry (1994). 1927;151(6):240-247.
2. Meduna LJ. Die Konvulsionstherapie der Schizophrenie. Halle, Germany. In: Fink, M. (1984) Meduna and the origins of convulsive therapy. American Journal of Psychiatry. 1937;141:1034-1041.
3. Cerletti U. L'Elettroshock. RivistaSperimentale di Frenatria, I, 209- 310. In: Endler, N.S. (1988) The origins of electroconvulsive therapy. Convulsive Therapy. 1940;4:5-23.
4. Kane JM Marder SR. Schizophrenia: somatic treatmen. In: Sadock, B.J. and Sadock, V.A. (Eds.). Comprehensive Textbook of Psychiatry. Philadelphia: Lippincott Williams & Wilkins. 2005, 1467-1468.
5. Jeste DV, Klausner M, Brecher M, Clyde C, Jones R. The ARCS Study Group, (1997) A clinical evaluation of risperidone in the treatment of schizophrenia: a 10-week, open-label, multicenter trial involving 945 patients. Psychopharmacology. 2005;131:239-247.
6. Dolder CR, Jeste DV. Incidence of tardive dyskinesia with typical versus atypical antipsychotics in very high risk patients. Biological Psychiatry. 2003;53:1142-1145.
7. Sernyak MJ, Leslie DL, Alarcon RD, Losonczy MF, Rosenheck R. Association of diabetes mellitus with use of atypical neuroleptics in the treatment of schizophrenia. American Journal of Psychiatry. 2002;159:561-566.
8. Newcomer JW, Haupt DW, Fucetola R, Angela K, Melson AK, Schweiger JA, *et al.* Abnormalities in glucose regulation during antipsychotic treatment of schizophrenia. Archives of General Psychiatry. 2002;59:337-345
9. Lieberman JA. Metabolic changes associated with antipsychotic use. Primary Care Companion Journal of Clinical Psychiatry. 2004;6(2):8-13.
10. Oliver D. A prospective study of impairment in glucose control caused by clozapine without changes in insulin resistance. American Journal of Psychiatry. 2004;161:361-363
11. Henderson DC. Schizophrenia and Comorbid Metabolic Disorders. Journal of Clinical Psychiatry. 2005;66(6):11-20.

12. Newcomer JW. Second-generation (atypical) antipsychotics and metabolic effects: a comprehensive literature review. CNS Drugs. 2005;19(1):1-93.

Original research article

Correlation of the clinical parameters with severity of delirium in patients with alcohol related disorder

¹Dr. Sadananjali, ²Dr. Anantha Kalyan, ³Dr. Furkhan Ali

¹ Assistant Professor, Department of Biochemistry, Gadag Institute of Medical sciences, Karnataka, India

² Assistant Professor, Department of Psychiatry, Basaveswara medical college, Chitradurga, Karnataka, India

³ Consultant Psychiatrist, NIMHANS, Bangalore, Karnataka, India

Corresponding Author:

Dr. Vajipeyajula Anupama

Abstract

Among the more intense withdrawal conditions that can be seen in conjunction with autonomic hyperactivity, the most dramatic is delirium tremens (DT). While there is some disagreement about the optimal definition of this condition, most studies agree that in addition to evidence of severe autonomic dysfunction patients must show some level of confusion or disorientation, often accompanied by illusions, hallucinations and agitation. Consecutive sampling was done to select the study subjects. All patients who attended or referred to the department of psychiatry with alcohol related disorders as per ICD-10 were included in the study. Mean score of SADQ-C which is an indicator of severity of alcohol dependence in DT group was 31.45 (sd=6.31) and in Non-DT group 27.88 (sd=5.31). Mean of total CIWA-Ar Score Day 1 of admission which indicated the severity of withdrawal symptoms was 34.30 (sd =6.31) in DT group and 19.41 (sd =4.07) in non DT group. Mean days of recovery from withdrawal state was 4.36 days (sd=0.83) in DT group and 2.45 days (sd=0.56) in non DT group.

Keywords: Clinical parameters, Delirium, Alcohol related disorder

Introduction

Around 10% of alcohol-dependent individuals are likely to develop more severe withdrawal syndromes at some time in their lives. These potentially dangerous conditions include a combination of marked autonomic hyperactivity such as increase in blood pressure, pulse, respiratory and heart rate, along with an elevated body temperature, sweating and severe tremors. Among the more intense withdrawal conditions that can be seen in conjunction with autonomic hyperactivity, the most dramatic is delirium tremens (DT). While there is some disagreement about the optimal definition of this condition, most studies agree that in addition to evidence of severe autonomic dysfunction patients must show some level of confusion or disorientation, often accompanied by illusions, hallucinations and agitation. The withdrawal phenomena appear to relate primarily to a history of repeated heavy exposure to alcohol followed by relative or absolute abstinence and are not just the outcome of poor nutrition or organ damage ^[1, 2].

Studies have demonstrated that the usual alcohol withdrawal or abstinence syndrome is relatively mild. In an evaluation of 487 hospitalized alcohol-dependent individuals, only 10.6% demonstrated withdrawal syndromes judged to be severe enough to require medications. Several investigations have indicated that the alcohol withdrawal syndrome is usually mild enough to be treated on an outpatient basis ^[3].

One study of 1024 patients undergoing evaluation for outpatient detoxification identified only 90 cases (8%) who demonstrated severe syndromes requiring hospitalization. This type of severe withdrawal syndrome begins within the first several days of withdrawal, peaks in intensity between days three and four and is likely to markedly improve over a 72-hour period ^[4]. Complicated alcohol withdrawal is the one with occurrence of seizures or delirium tremens on sudden reduction or stoppage of alcohol consumption. Complications related to alcohol withdrawal account for a significant demand in healthcare resources and are associated with an increase in morbidity and mortality ^[5, 6].

Methodology

Source of data

142 out of 150 patients with alcohol related problems were recruited as per ICD-10, those who had attended or referred to the department of psychiatry.

Type of study

A prospective cross sectional study design.

Sampling procedure

Consecutive sampling was done to select the study subjects. All patients who attended or referred to the

department of psychiatry with alcohol related disorders as per ICD-10 were included in the study.

Inclusion criteria

Adult patients more than 18yrs of age who had attended or referred to the Department of Psychiatry for alcohol related problems as per ICD-10.

Exclusion criteria

- Clinical evidence of other significant primary psychiatric illness other than alcohol related disorders were excluded. These include dementia due to any cause, schizophrenia, bipolar affective disorders and major depressive disorders.
- Other substance use disorders like benzodiazepine dependence syndrome, opioid dependence syndrome and cannabis dependence syndrome, except for nicotine dependence syndrome Delirium primarily due to other causes like neuro-infections, head injury (head injury resulting in intracranial bleed or significant oedema), hepatic encephalopathy, metabolic causes like hyponatremia, hypoglycemia and systemic causes like septicemia.

Methods of collection of data

Consecutively referred patients with alcohol related problems to the Department of Psychiatry, who fulfilled the inclusion criteria were included in the study. A total of 150 cases were assessed and 142 cases were included for the final analysis. All the patients were assessed on the day of referral or admission and appropriate scales were used to collect the data.

Results

Table 1: Clinical Variables of Patients with Delirium Tremens (DT) when compared with Non-DT patients

Variable	Delirium Tremens N=31	Non- Delirium Tremens N=111	p value
Age at first drink (mean/sd)	22.7 (2.7)	22.6 (3.3)	0.943
Age at dependence pattern (mean/sd)	33.1 (2.5)	32.7 (4.0)	0.577
Amount (mean / sd)	15.0 (1.9)	12.0 (2.5)	<0.0001
Duration of alcohol use in years(Dependence pattern) (mean/ sd)	10.7 (6.1)	9.8 (5.9) N=106	0.466
Time of onset of any withdrawal symptoms (mean / sd)	21.2 (6.3)	23.3 (13.8)	0.410
Pulse rate per minute (mean / sd)	88.6 (8.6)	92.9 (11.9)	0.065
Systolic Blood Pressure (mean / sd)	126.5 (6.0)	128.3 (8.1)	0.233
Diastolic Blood Pressure (mean/sd)	83.7 (6.9)	82.9 (6.9)	0.581
Score of SADQ-C (median/IQR)	34 (35.5 to 32)	28 (30 to 21) N=106	<0.0001
Total CIWA-Ar Score-Day 1 (median/IQR)	32 (35 to 29)	20 (24.75 to 17.25) N=82	<0.0001
Recovery from withdrawal state (Days) (mean / sd)	3.9 (0.6)	1.8 (0.6)	<0.0001
Family history of alcoholism (N/ %)	17 (54.83)	50 (45.05)	0.3366
Past history of Seizures (N/ %)	8 (25.80)	9 (8.11)	0.0075
Past history of Delirium (N/ %)	4 (12.90)	0 (0)	0.0001
Past history of Delirium Tremens (N/ %)	8 (25.80)	2 (1.80)	<0.0001.

Age at first drink and onset of alcohol use in dependence pattern was similar in both DT and the non-DT group. The mean years of alcohol use in the dependence pattern though slightly more in the DT group (10.7 years) was not statistically different with that of non-DT group. The total amount alcohol used on a daily basis was statistically significant in cases with DT, when compared with that of non DT. Case with DT were using a mean of 15 units of alcohol on daily basis, when compared to 12 units of alcohol among non-DT group.

The time of onset of any withdrawal symptom was earlier in cases of DT when compared with that of non DT cases by two hours, which was not statistically significant. The mean time of onset of any withdrawal symptom was around 21 hours after the last drink by the patient. There was a marginal increase in the systolic and diastolic blood pressure, and decrease in pulse rate among the cases of DT, though it did not reach statistical significance.

Past history of seizure was found in 9 (27.3%) cases in DT group and 10 (8.3%) in non DT group. Past history of delirium was found 4 (12.1%) cases in DT group and was not found in non-DT group. Past history of DT was found in 8 (25.8%) cases and in 1(0.8%) in non DT group. Pressssence of past history of seizure, delirium and DT was significantly more in cases of DT when compared with that of non-DT cases.

Family history of alcohol use was present in half of the cases with DT, which was not different from that of non-DT cases.

Mean score of SADQ-C which is an indicator of severity of alcohol dependence in DT group was 31.45

(sd=6.31) and in Non-DT group 27.88 (sd=5.31). Mean of total CIWA-Ar Score Day 1 of admission which indicated the severity of withdrawal symptoms was 34.30 (sd =6.31) in DT group and 19.41 (sd =4.07) in non DT group. Mean days of recovery from withdrawal state was 4.36 days (sd=0.83) in DT group and 2.45 days (sd=0.56) in non DT group. All the above were significantly higher in patients with DT when compared with non-DT cases reaching statistical significance ($p<0.01$).

Table 2: Correlation analysis of variables in patients with alcohol withdrawal symptoms

Clinical variables	Severity of Withdrawal Symptoms		
	CIWA- Ar total score on Day 1 of admission (r / p)	DRS Severity Score on Day 1 of admission (r / p)	Duration of withdrawal symptoms in days (r / p)
Age	0.30(*)	0.09	0.06
	0.10	0.630	0.748
Duration of alcohol use	0.501	0.228	0.088
(dependence pattern)	0.004	0.217	0.638
Amount of alcohol use (IU)	0.24 0.194	0.30	0.657
SADQ-C total Score	<0.0001	0.228	-0.199

Correlation analysis was performed to look at the variables which influenced the outcome in the form of occurrence of severe alcohol withdrawal symptoms. The significant variables were daily amount of alcohol use, severity score on SADQ-C, which correlated positively with severity of alcohol withdrawal symptoms on CIWA- Ar on the first day of admission and also was positively correlated with longer duration of recovery from withdrawal symptoms. Severity of delirium in DT cases was seen to be positively correlated with that of total score of SADQ-C.

The clinical variables that best differentiated between the DT and the non DT group were those that showed significance in correlation analyses. Variables included daily amount of alcohol in units, seizures in the current admission, past history of DT, total score of SADQ-C and total CIWA-Ar Score-Day 1 of admission. Finally the variables which were significant were the presence of seizure in the current admission and the total score of CIWA-Ar on day 1 of admission.

Discussion

This is a bit different from findings in our study and the possible causes may be due to the methodological issues like a prospective study with consecutive sampling and the study population was hospital based which is an indication of the severe form of alcohol dependence syndrome^[7].

Mortality rate from DT has been reported as high as 20% in earlier studies. However, with appropriate detection and prompt treatment, mortality has reduced and currently the mortality from DT ranges from 1 to 5%. In our study we did not find any mortality in DT group, which might be attributed to proper use of medication, good hydration, correction of electrolytes, adequate supplementation of vitamins like thiamin, Vitamin B12 etc., at an appropriate time. There is a possibility of exclusion of cases of DT with severe medical co morbidity, which may be another reason why the mortality was absent in the current sample. Improved survival rates might be attributed to careful use of benzodiazepines, more meticulous attention to fluids, vitamins, nutrition and correction of electrolytes and acid-base disturbances^[8].

The clinical profile of DT as assessed by using DRS-R-98 revealed hyperactive type of delirium with autonomic hyperactivity, tremulousness, agitation and half of the patients reported hallucinations. These findings are in tune with the earlier studies that DT is due to hyperactive state of the brain secondary to abrupt cessation of GABA receptor agonist like alcohol, while there is also activation of Glutamatergic activities. A recent study by Grover *et al* (2013) reveals the similar clinical profile delirium in Cases of DT^[9].

While comparing the clinical and socio-demographic variables in patients with DT with those who did not develop DT, there was no significance in terms of age of the patients, background and education. When clinical variables were evaluated across the groups, DT patients showed no difference in terms of age of onset of alcohol, duration of alcohol use and age at dependence of alcohol use. Some studies have shown that earlier onset and longer duration of alcohol use was associated with more severe withdrawal symptoms. The total amount of alcohol use by the patients was significantly higher in patients with DT along with the severity of alcohol dependence as indicated by the SADQ-C score. Patients with DT required more days to recover from withdrawal symptoms when compared to the non DT group which is an indication of severe alcohol dependence. The presence of past episodes of seizures, delirium and DT was significantly higher in cases with DT when compared with that of non DT group. This has been reported in the previous studies and it has been hypothesized that kindling process occurs as that in recurrent seizure.

Family studies using the FIGS instrument revealed that presence of alcohol use with significant impairment and presence of psychosis was higher in cases with DT. There is high heritability for alcohol dependence syndrome and also for the severe complications as shown by earlier studies^[10].

Investigation revealed impairment in the liver functions like presence of hepatitis and fatty liver changes

on sonography, which is an indicator of recent and acute damage to the liver. It may also explain the higher occurrence of DT in the group, as hepatic derangement itself can cause delirium^[11].

When the severity of withdrawal symptoms was assessed using CIWA-Ar score, it showed high positive correlation with that of severity of alcohol use in the form of score on SADQ-C and the total amount of alcohol use^[12].

The predictors of DT in the current sample showed, presence of withdrawal seizures and high scores of CIWA-Ar on the first day after discontinuation. This finding is similar to that in the earlier studies and has significant clinical implications.

Conclusion

A Median score of SADQ-C which is an indicator of severity of alcohol dependence in DT group was 34 (IQR 35.5 to 32) and in Non-DT group 28 (IQR 30 to 21). Median of total CIWA-Ar Score Day 1 of admission indicated the severity of withdrawal symptoms was 32 (IQR 35 to 29) in DT group and 20 (IQR 24.75 to 17.25) in non DT group. Mean days of recovery from withdrawal state was 3.9 days (sd=0.6) in DT group and 1.8 days (sd=0.6) in non DT group. All the above were significantly higher in patients with DT when compared to non-DT cases ($p<0.05$).

References

1. Hayashida M, Alterman AI, McLellan AT, O'Brien CP, Ptmnix JJ, Volpicelu JR, *et al.* Comparative effectiveness and costs of inpatient and outpatient detoxification of patients with mild-to-moderate alcohol withdrawal syndrome, *Nete England Journal of Medicine*. 1989;320:356-8.
2. Schuckit MA, Tipp JE, Reich T, Hesselbrock VM, Bucholz KK. The histories of withdrawal convulsions and delirium tremens in 1648 alcohol-dependent subjects. *Addiction*. 1995;90:1335-47.
3. Whitfield CL, Thompson G, Lamb A, Spencer V, Pfeifer M, Browning- Ferrando M, *et al.* Detoxification of 1,024 alcoholic patients without psychoactive drugs. *JAMA*. 1978;239:1409-10.
4. Ferguson JA, Suelzer CJ, Eckert GJ, Zhou XH, Dittus RS. Risk factors for delirium tremens development. *J Gen Intern Med*. 1996;1:410-4.
5. Lerner WD, Fallon HJ. The alcohol withdrawal syndrome. *N Engl J Med*. 1985;313:951-2.
6. Palmstierna T. A model for predicting alcohol withdrawal delirium. *Psychiatr Serv*. 2001;52:820-3.
7. Pearson S. Observations on the brain fever: delirium tremens. *Edinberg Medical Surgical Journal*. 1813;9:6.
8. Stern TA, Gross AF, Stern TW, Nejad SH, Maldonado JR. Current approaches to the recognition and treatment of alcohol withdrawal and delirium tremens:- old wine in new bottles or new wine in old bottles. *Prim Care Companion J Clin Psychiatry*. 2010;12:1-15.
9. Shaw GK, Waller S, Latham CJ, Dunn G, Thomson AD. The detoxification experience of alcoholic in-patients and predictors of outcome. *Alcohol Alcohol*. 1998;33:291-303.
10. Mayo-Smith MF, Beecher LH, Fischer TL, Gorelick DA, Guillaume JL, Hill A, *et al.* Management of alcohol withdrawal delirium. *Arch Intern Med*. 2004;164:1405-12.
11. Koch-Weser J, Sellers EM, Kalant H. Alcohol intoxication and withdrawal. *N Engl J Med*. 1976;294:757-62.
12. Victor M. Alcohol withdrawal seizures: An Overview. In: R, P. (ed.) *Alcohol and Seizures*. New York: Davis; c1990.

Original research article

The socio-demographic variables with severity of delirium in patients with alcohol related disorders

¹Dr. Vijay Raj N, ²Dr. Vajipeyajula Anupama, ³Dr. Sadananjali

¹Professor, Department of Psychiatry, Karwar institute of medical sciences, Karnataka, India

²Assistant Professor, Department of Psychiatry, CDSIMER, Bengaluru, Karnataka, India

³Assistant Professor, Department of Biochemistry, Gadag Institute of Medical sciences, Karnataka, India

Corresponding Author:

Dr. Neeraj Raj B

Abstract

Alcohol dependence is a chronic and relapsing condition and due to its relapsing nature leads to multiple withdrawal states. Withdrawal syndrome is an important and characteristic feature of alcohol dependence and needs clinical attention and management. Consecutively referred patients with alcohol related problems to the Department of Psychiatry, who fulfilled the inclusion criteria were included in the study. A total of 150 cases were assessed and 142 cases were included for the final analysis. All the patients were assessed on the day of referral or admission and appropriate scales were used to collect the data. Mean age of DT group being 43.8 (sd= 6.8) and in Non-DT group being 41.9 (sd=8.7). There was no statistical difference in the mean age, in both the groups. 15 (48.4%) patients were males while 16(58.6%) were female in DT group while 66 (59.5%) were male and 46 (44.2%) female in Non-DT group. Cases with DT were similar in terms of domicile (urban and rural), occupation (unskilled, semiskilled, skilled) and there was no statistical significance in DT and Non-DT group.

Keywords: Socio-demographic variables, Severity of delirium, Alcohol related disorders

Introduction

The prevalence of alcohol use related problems vary across the population. The rates elicited indicate that the largest proportion of alcohol users do not develop those clinical disorders. Screening questionnaires such as CAGE, a four-item instrument which rates the probability of alcoholism have identified around 20% of the adult population as probable alcohol misusers ^[1]. More stringent procedures, which apply full diagnostic criteria, yield point prevalence rates ranging from 5.4 to 7.4 percent, depending on whether the clinical disorder surveyed is strictly alcohol dependence or any form of harmful drinking (i.e. dependence plus alcohol abuse). The rates for men are about double those for women. In India a study conducted by revealed overall substance use prevalence of 6.9/1000 with urban and rural rates of 5.8 and 7.3/1000 respectively. Rates among men and women were 11.9% and 1.7% respectively. A study in southern rural India showed that 14.2% of population surveyed had hazardous alcohol use on the AUDIT. A similar study in the tertiary hospital revealed that 17.6% admitted patients had hazardous alcohol use ^[2, 3].

Alcohol dependence is a chronic and relapsing condition and due to its relapsing nature leads to multiple withdrawal states. Withdrawal syndrome is an important and characteristic feature of alcohol dependence and needs clinical attention and management. Alcohol has a general central nervous system depressant effect and in view of adapting to this there is increased excitability of nerve cells through different mechanisms. When alcohol is eliminated from body during abstinence this compensatory increased excitability remains for several days and may present clinically in different forms ranging from mild tremors to delirium tremens and death ^[4].

Methodology**Source of data**

142 out of 150 patients with alcohol related problems were recruited as per ICD-10, those who had attended or referred to the department of psychiatry.

Type of study

A prospective cross sectional study design.

Sampling procedure

Consecutive sampling was done to select the study subjects. All patients who attended or referred to the department of psychiatry with alcohol related disorders as per ICD-10 were included in the study.

Inclusion criteria

Adult patients more than 18yrs of age who had attended or referred to the Department of Psychiatry for alcohol related problems as per ICD-10.

Exclusion criteria

- Clinical evidence of other significant primary psychiatric illness other than alcohol related disorders were excluded. These include dementia due to any cause, schizophrenia, bipolar affective disorders and major depressive disorders.
- Other substance use disorders like benzodiazepine dependence syndrome, opioid dependence syndrome and cannabis dependence syndrome, except for nicotine dependence syndrome Delirium primarily due to other causes like neuro-infections, head injury (head injury resulting in intracranial bleed or significant oedema), hepatic encephalopathy, metabolic causes like hyponatremia, hypoglycemia and systemic causes like septicemia.

Methods of collection of data

Consecutively referred patients with alcohol related problems to the Department of Psychiatry, who fulfilled the inclusion criteria were included in the study. A total of 150 cases were assessed and 142 cases were included for the final analysis. All the patients were assessed on the day of referral or admission and appropriate scales were used to collect the data.

Results

Table 1: Comparison of Socio-demographic profile in Delirium Tremens (DT) patients when compared with Non-DT patients:

Variable	Delirium Tremens N=31	Non- Delirium Tremens N=111	p value
Age in years(mean/sd)	43.8 (6.8)	41.9 (8.7)	0.279
Gender n (%)			
Male	15 (48.4%)	66 (59.5%)	
Female	16 (58.6%)	45 (40.5%)	
Domicile n (%)			
Urban	17 (54.8%)	65 (55.8%)	
Rural	14 (45.2%)	46 (44.2%)	
Occupation n (%)			
Unskilled	6 (19.4%)	10 (9%)	
Semiskilled	16 (51.6%)	63 (56.8%)	
Skilled	9 (29%)	38 (34.2%)	

Mean age of DT group being 43.8 (sd= 6.8) and in Non-DT group being 41.9 (sd=8.7). There was no statistical difference in the mean age, in both the groups. 15 (48.4%) patients were males while 16 (58.6%) were female in DT group while 66 (59.5%) were male and 46 (44.2%) female in Non-DT group. Cases with DT were similar in terms of domicile (urban and rural), occupation (unskilled, semiskilled, skilled) and there was no statistical significance in DT and Non-DT group

Table 2: Family History using FIGS in patients with Delirium Tremens (DT) when compared with Non-DT patients

Any one adopted in family	0 (0)	2 (1.80)	0.45
Family history of problem with nerves or emotions	2 (6.45)	2 (1.80)	0.17
Family history of Depression	1 (3.22)	3 (2.70)	0.09
Family history of Suicide	2 (6.45)	5 (4.50)	0.66
Family history of Mania	0 (0)	2 (1.80)	0.45
Family history of Psychosis	2 (6.45)	0 (0)	0.007
Family history of alcohol or drug use problems (health, family, job or police).	18 (58.06)	54 (48.65)	0.35
Family history of any one hospitalized for psychiatric or drug or alcohol problems	4 (12.90)	24 (21.62)	0.28
Family history of CNS Disorder	1 (3.22)	5 (4.50)	0.76

Family history was evaluated in detail using the Family interview for genetic studies (FIGS) in all the cases. There was family history of alcoholism in half of the total sample, which was not different among the DT and non DT cases. There were higher rates of problems due to alcohol use, presence of family history of psychosis in the DT group when compared to that of non DT.

Discussion

Alcohol dependence leads to various physical, psychological and social problems. Since many centuries studies about the alcohol dependence and its complications like DT were reported^[5]. DT is characterized by short lived, but occasionally life threatening toxic confusional state with accompanying somatic disturbances. It is usually a consequence of absolute or relative withdrawal of alcohol in severely

dependent users with a long history of use. There is a great variation in occurrence of DT between studies ranging from 1% up to 33%. Previous studies showed that DT is preceded by withdrawal seizures and also associated with significant changes in the laboratory parameters such as AST, ALP, GGT, platelets, serum electrolytes etc. Historically mortality rate from delirium tremens has been reported as high as 20%. However, with appropriate detection and prompt treatment, mortality has reduced and currently the mortality from DT ranges from 1 to 5% ^[6].

In view of the above findings, DT is one of the common presentation of severe alcohol withdrawal state and a cause of morbidity and mortality. The studies have shown varying prevalence rates and the associated clinical correlates with DT. There has been very few studies on the prevalence of DT from the Indian subcontinent and which have been retrospective in nature ^[7]. Also the clinical characteristics and profile of withdrawal symptoms from our set of population may be varying compared to the western literature. Hence our study is aimed at evaluating the prevalence and clinical correlates of DT in patients with alcohol dependence syndrome from a general hospital setup. With long-term alcohol consumption, receptors in the brain undergo adaptive changes in an attempt to maintain homeostasis. The important neurotransmitter system involved in AWS are gamma-aminobutyric acid (GABA) and glutamate ^[8]. The symptoms of withdrawal represent a phase in the alcohol-induced cycle of neuronal inhibition and excitation. Research has demonstrated that short-term (i.e., acute) administration of alcohol can alter the release of chemical messengers (i.e., neurotransmitters) from neurons and can disrupt the function of proteins in neuronal membranes, including receptor proteins which bind to neurotransmitters and ion channels through which ions (e.g., sodium or calcium) enter the cell.

Following repeated intake of alcohol, the brain attempts to restore normal functioning through adaptations (i.e., tolerance) that reduce alcohol's initial perturbing effects. Long-term exposure to alcohol can lead to physical dependence, in which neuronal adaptations to alcohol become sufficiently pronounced in that the brain requires the continued presence of alcohol to function normally. When a person stops a prolonged drinking session, the adaptations that developed to offset alcohol's initial inhibitory actions are unopposed, resulting in a rebound hyper- excitability or withdrawal syndrome ^[9, 10].

Conclusion

There was no statistical difference in the mean age, in both the groups. 15(48.4%) patients were males while 16(58.6%) were female in DT group while 66 (59.5%) were male and 46(44.2%) female in Non-DT group. Cases with DT were similar in terms of domicile (urban and rural), occupation (unskilled, semiskilled, skilled) and there was no statistical significance in DT and Non-DT group.

References

1. Nordstrom G, Berglund M. Delirium tremens: a prospective long-term follow-up. *J Stud Alcohol*. 1988;49:178-85.
2. Hemmingsen R, Kramp P, Rafaelsen OJ. Delirium tremens and related clinical states, *Acta Psychiatrica Scandinavica*. 1979;59:337-69.
3. Kramp P, Ronsted P, Hansen T. Barbitol and diazepam plasma levels during treatment of delirium tremens, *Acta Psychiatrica Scandinavica*. 1979;59:263- 75.
4. Pycha R, Miller C, Barnas C, Hummer M, Stuppäck C, Whitworth A, *et al*. Intravenous (lunitrazepam in the treatment of alcohol withdrawal delirium, *AkohoUsm: Clinical and Experimental Research*. 1993;17:753-7.
5. Tonnesen E. Delirium tremens and hypokalaemia. *Lancet*. 1982;2:97.
6. Isbell H, Fraser HF, Wdcler A, Belleville RE, Elsenman AJ. An experimentiU study of the etiology of "rum fits" and delirium tremens. *Journal of Studies of Alcohol*. 1955;16:1-33.
7. Salum I. Delirium Tremens and Certain Other Acute Sequels of Alcohol Abuse (Copenhagen, Munksgaard). *Acta Psychiatr Scand Suppl*. 1972;235:1- 145.
8. Sellers EM, Sltlivan JT, Somer G, Sykora K. Characterization of DSM-III-R criteria for tmcomplicated alcohol withdrawal provides an empirical basis for DSM-IV, *Archives of General Psychiatry*. 1991;48:442-7.
9. Benzer DC. Qualification of the alcohol withdrawal syndrome in 487 alcoholic patients. *Journal of Substance Abuse Treatment*. 1990;7:117-23.
10. Feldman DJ, Pattison EM, Sijbell LS. Outpatient alcohol detoxification: initial findings on 564 patients, *American Journal of Psychiatry*. 1975;132:407-12.

Across-sectional study of opinion about mental illness among undergraduate medical students with and without exposure to the psychiatry clinical rotation/postings during their undergraduate training

B. Neeraj Raj¹, B. K. Shivakumar², H. R. Vinay²

¹Department of Psychiatry, Dr. Chandramma Dayananda Sagar Medical Education and Research, Ramanagara, Karnataka, India, ²Department of Psychiatry, Adichunchanagiri Medical College and Research Center, B G Nagara, Mandya, Karnataka, India

ABSTRACT

Background: A positive attitude toward mental illness is a prerequisite for the provision of holistic care. Thus, a study was undertaken to know the opinion about mental illness among medical students with and without exposure to the psychiatry clinical rotation/postings during their undergraduate training.

Materials and Methods: This is a descriptive, cross-sectional study conducted at Adichunchanagiri Institute of Medical Sciences (AIMS), Karnataka. The sample comprised medical undergraduate students with and without exposure to psychiatry clinical postings, respectively. Self-administered socio-demographic and opinion about mental illness (OMI) questionnaires were used to collect the data.

Result: Medical undergraduates from 1st and 2nd years who were unexposed to psychiatry and students from 3rd and 4th years who had exposure to psychiatry constituted about 52.17% ($n = 252$) and 47.83% ($n = 231$) of the overall sample size. A positive opinion toward mental illness was seen across various subsections of OMI questionnaire, especially in students who had attended psychiatry clinical posting.

Conclusion: Opinions can change based on one's experiences. A positive opinion toward mental illness was seen across medical undergraduate students who had completed psychiatry clinical postings in our study. The study provides valuable insights across various domains or areas wherein a teacher can focus and adjust the teaching methodologies accordingly. In the long run, it might have a positive influence on medical students to understand mental disorders, diagnose them, and manage patients with mental illness.

Key words: Attitude, beliefs, medical undergraduates, mental illness, opinion, psychiatric illness, psychiatry

Address for correspondence: Dr. B. Neeraj Raj, Department of Psychiatry, Dr. Chandramma Dayananda Sagar Medical Education and Research, Devarakaggalahalli, Harohalli, Kanakapura Road, Ramanagara - 562 112, Karnataka, India. E-mail: neerajraj20dec@gmail.com

Submitted: 10-Feb-2023, **Revised:** 05-Jun-2023,

Accepted: 12-Jul-2023, **Published:** 07-Aug-2023

Access this article online	
Website: https://journals.lww.com/indianjpsychiatry	Quick Response Code 
DOI: 10.4103/indianjpsychiatry.indianjpsychiatry_87_23	

INTRODUCTION

Mental illnesses are a major public health problem around the world.^[1] Not only do they affect a person's quality of life, but

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Raj BN, Shivakumar BK, Vinay HR. A cross-sectional study of opinion about mental illness among undergraduate medical students with and without exposure to the psychiatry clinical rotation/postings during their undergraduate training. Indian J Psychiatry 2023;65:853-61.

it also makes them vulnerable to stigma and discrimination in the eyes of society.^[2-4] A favorable attitude, belief, and opinion toward mental disorders are desired and expected when providing mental healthcare services. According to Dyduch and Grzywa,^[5] person's profession, frequency of contact with mentally ill persons, personal experience, level of mental health literacy, education level, culture-related factors, overall value orientation, age, and gender are the most relevant factors, which influence the perception of the people suffering from mental disorders. Bhugra^[6] and Jorm *et al.*^[7] report that education and awareness of mental illnesses by itself may increase the chances of developing stigma.

Patients improve significantly more with caring professionals. Thus, the opinion about mental disorders among medical professionals becomes important because they are going to be involved in the care of such patients either directly or indirectly. This is more so among medical undergraduate students who may even consider taking up psychiatry as a career.^[8] Few clerkship studies have found that the students would often feel overwhelmed,^[9] stressed^[10] and uncomfortable^[11] while providing care to such patients. Some would feel that mentally ill patients have a poor prognosis^[12] and working with them is dangerous,^[13] disturbing, and emotionally draining, and overwhelming.^[14]

Most of the studies that have been done among healthcare students have explored the attitude toward psychiatry.^[9] Studies that have been done to know the belief/perception/opinion toward mental illnesses among medical undergraduate students in general have revealed mixed results.^[9,15,16] While some of the studies have reported that knowledge and compassion reduce stigma leading to a more favorable attitude, others have been neutral to negative reports with worsening opinion toward persons with mental illness, especially after exposure to psychiatry.^[9,15,16]

Thus, this study was undertaken among medical undergraduate students at Adichunchanagiri Institute of Medical Sciences (AIMS) wherein students have had fair exposure either directly or indirectly to mental health-related topics through various forms of competitions such as quiz, role plays, skits, awareness programs at Community Health center/Primary Health Center, debates, clay modeling, art and paintings, and mimes, right from the beginning of their journey into Bachelor of surgery and Bachelor of Medicine (MBBS). We wanted to do this study on our students with a hypothesis that our medical undergraduate students exposed to psychiatry after having completed their clinical rotatory postings would exhibit a favorable opinion toward persons with mental illness. As per our knowledge and literature review, no such studies have been done in the Mandya district region of Karnataka. Furthermore, we wanted to know how the non-Competency

Based Medical Education (CBME) batch of medical students fared with regard to their opinion toward mental illness after clinical exposure to psychiatry.

Methodology

Aims

This study aimed to study the opinion about mental illness among medical undergraduate students who have and who have not completed their rotatory psychiatry clinical postings.

Objective

1. To study the opinion about mental illness among medical undergraduate students who have completed their rotatory psychiatry clinical postings.
2. To study the opinion about mental illness among medical undergraduate students who have not completed their rotatory psychiatry clinical postings.
3. To compare the opinion about mental illness among medical undergraduate students who have and who have not completed their rotatory psychiatry clinical postings.

MATERIALS AND METHODS

Study design

This is a descriptive, cross-sectional study.

Study site

The study was conducted at AIMS and Research Center, a constituent college of Adichunchanagiri University, a tertiary care hospital catering predominantly to rural population in Karnataka, South India.

Sample/study participants

The sample comprised medical undergraduate students from all four professional phases of MBBS who were studying in the institute. The medical exposed group consisted of medical undergraduate students who had completed their rotatory psychiatry clinical postings.

Sample size

Most of the studies that have been done on medical students/ doctors with regard to attitude toward mental illness had a proportion of knowledge from as low as 45% to as high as 75%.^[17,18] In our study, we have taken the estimated proportion of knowledge regarding mental health problems as 75%, with 95% confidence level, and 5% margin of error. Accordingly, the sample size was calculated [$n = (z\alpha/2)^2 P(1 - p)/d^2$]. With the addition of a 10% contingency for nonresponse, the final sample size we arrived at was 320.

Sampling technique

The sample was selected through non-probability convenient sampling technique. Data were collected batch-wise in their classrooms during their lecture class hours with prior permission. In the introduction, the

primary author explained briefly the nature and the purpose of the study. A written informed consent was taken from all study participants based on the inclusion–exclusion criteria. Then, they were asked to fill in a specially constructed semi-structured pro forma along with a standardized self-answering questionnaire called “opinion about mental illness.” They could complete both questionnaires in about 20 to 30 min. Data collection tools contained no identifying information (such as name, address, and mobile number) and therefore kept the individual responses confidential.

The yearly intake of MBBS students is 150 at AIMS. The sample comprised medical undergraduate students from all four professional phases of MBBS who were studying in the institute. The total number of consenting participants was 524; of which, 41 were excluded from the analysis due to the following reasons: 38 of them were incomplete responses, one had a family history of mental illness (depression) and had taken treatment for depression, and two were on treatment for anxiety and depression.

Study period

The study was conducted between January 2019 and March 2019. Ethical clearance was obtained from the Institute's Ethics Committee.

Inclusion criteria

1. Medical undergraduate students providing informed consent.
2. Medical undergraduate students with more than 75% attendance during their completion of clinical postings.

Exclusion criteria

1. Medical undergraduate students having first- or second-degree relatives with a current psychiatric disorder.
2. Medical undergraduate students undergoing treatment for mental health problems.
3. Medical undergraduate students who were absent on the day when the OMI questionnaire was administered.
4. Incomplete filling of the questionnaire by the medical undergraduate students.

Tools of assessment

1. **Semi-structured pro forma:** - It contained socio-demographic details such as name, age, gender, year of education, residential background, family, and personal history of psychiatric illnesses and treatment.
2. **Opinion about mental illness (OMI) questionnaire:**^[19-25] - The OMI scale was originally developed by Cohen and Struening^[19] in 1959 to assess the attitudes of healthcare personnel toward mental illness. Responses to the items on the OMI scale reflect their opinions and attitudes about the etiology, treatment, and prognosis of mental illness. Construct validation of the OMI was

done using a pool of 200 items that were analyzed by more than 8000 people experienced in mental health, and a final form of the 51-item scale was derived from extensive factor analysis. The instrument covers five dimensions namely as follows:

- A. **Authoritarianism:** - It includes authoritarian submission and anti-intraception. It reveals a view of people with mental illness as an inferior class requiring coercive handling and also indicates a belief that people with mental illness are inferior to normal individuals. Questions in OMI that indicate authoritarianism include Q1, Q6, Q9, Q11, Q16, Q21, Q39, Q43, Q46, and Q48.
- B. **Benevolence:** - It reflects an orientation toward care in general. Questions in OMI that indicate benevolence include Q2, Q12, Q17, Q18, Q22, Q26, Q27, Q32, Q34, Q36, Q37, Q40, Q47, and Q49.
- C. **Mental hygiene ideology:** - It reflects the positive orientation, which embodies the beliefs of the mental health worker and the tenets of the mental hygiene movement. Questions in OMI that indicate mental hygiene ideology include Q3, Q13, Q23, Q28, Q31, Q33, Q38, Q44, and Q50.
- D. **Social restrictiveness:** - It explores the belief that people with mental illness constitute a threat to society, particularly to the family, and must therefore be restricted in their functioning during hospitalization and afterward. Questions in OMI that indicate social restrictiveness include Q4, Q7, Q8, Q14, Q24, Q29, Q41, Q42, Q45, and Q51.
- E. **Interpersonal etiology:** - It is an area that reflects the belief that mental illness arises from interpersonal experience, especially deprivation of parental love during childhood. Questions in OMI that indicate social restrictiveness include Q5, Q10, Q15, Q20, Q25, Q30, and Q35.

The OMI scale has been chosen in this study because it has satisfactory psychometric properties and due to its long history of usage in different populations. The scale was quoted from Shaw *et al.*^[20] The validity and reliability of the scale were established.^[21] Agrawal,^[22] Kurian,^[23] and Shyamanta Das^[24,25] have used it in the Indian population.

Statistical analysis

Nominal data were analyzed using descriptive statistics. They were expressed as frequencies and percentages. The Chi-square test was used to find out significant differences between the groups (medical undergraduate students exposed vs unexposed). A statistical significance was assumed at $P < 0.05$.

RESULTS

Of 483, 252 (52.17%) were undergraduate students who had not attended psychiatry clinical postings and 231 (47.83%)

had attended psychiatry clinical postings. The mean age of the overall sample is 19.2359. The mean age of the students attending and not attending psychiatry clinical postings was 19.03 (standard deviation [SD]: 1.08) years and 21.14 (SD: 0.99) years, respectively ($P < 0.001$). The minimum age was 18 years, and the maximum age was 24. There was no statistically significant difference in other socio-demographic characteristics [Table 1]. Men constituted 42.86% of the sample. 91.72% of the sample were Hindus. 76.4% of the sample was from the nuclear family, and 10.35% were from a joint family background. 71.22% of the sample was from an urban background.

DISCUSSION

Attitude is a relatively enduring system of evaluative, affective reactions based upon and reflecting the evaluative concepts or beliefs, which have been learned about the characteristics of a social object or class of social objects.^[24] Belief is defined as the “emotional acceptance of a proposition or doctrine on what one considers to be adequate ground.”^[25] Opinion is defined as “a belief that one holds to be without emotional commitment or desire, and to be open to reevaluation since the evidence is not affirmed to be convincing. Opinions are verbalizable, while attitudes are sometimes mediated by nonverbal processes or are “unconscious.” Opinions are responses, while attitudes are response predispositions.^[24,25] Thus, in this study we chose to understand the opinion of medical undergraduate students toward mental illness and see whether there was a change in their opinion after exposure to psychiatry clinical postings.

In this study, students scored less on authoritarianism and social restrictiveness and more on benevolence, mental hygiene, and interpersonal etiology of the OMI questionnaire. Overall undergraduate medical students showed positive opinion toward mental illness across various subsections of OMI scale, and this was noted more in undergraduate students who have attended psychiatry clinical posting.

Authoritarianism [Table 2]

Students were not sure and disagreed with Q6. This could be due to a lack of skill set to assess mental state examination, which usually tries to learn during their internship. Most of the students were not sure about Q9. This could be secondary to an inner sense that people need to apply a problem-solving approach and should not shy away from difficulties. Although the majority disagreed with Q16 that “People would not become mentally ill if they avoided bad thoughts” (total $N = 484$, 38.51% vs 32.92%) ($P \leq 0.00001^*$), few of them were not sure (28.57%). 43.3% of students who had no exposure to psychiatry had agreed with the opinion. The majority agreed to Q21 that “People with mental illness should never be treated in the same hospital as people with physical illness,” and this was seen more in the students without exposure to psychiatry (total $N = 484$, 43.27% vs 34.58%) ($n = 252$, 44.2% vs $n = 231$, 33.3%) ($P \leq 0.00001^*$). This could be due to the disturbed behaviors of patients observed in an acute setting. Students might have interpreted it as dangerous and could account for the view that the public need to be protected. Most of the students were not sure (43.89%) and disagreed (33.75%) to Q43 ($P = 0.0321^*$). Students disagreed that “Sometimes mental illness is punishment for bad deeds” (total $N = 484$,

Table 1: Socio-demographic data of the sample (n=483)

Variable groups	Total (n=483)		Medical unexposed (n=252)		Medical exposed (n=231)		P
	Frequency	%	Frequency	%	Frequency	%	
Age group							
17-20	287	59.42	230	91.27	57	24.68	
21-25	196	40.60	22	8.73	174	75.32	
Gender							
Male	207	42.86	113	44.84	94	40.7	$\chi^2=0.85, P=0.36$
Female	276	57.14	139	55.16	137	59.3	
Religion							
Hindu	443	91.72	239	94.84	204	100	
Muslim	24	4.97	11	4.36	13	5.6	
Christian	14	2.89	2	0.79	12	5.2	
Others	3	0.62	0	0	3	1.3	
MBBS							
1 st year	137	28.36	137	54.36	-	-	
2 nd year	115	23.81	115	45.63	-	-	
3 rd year	104	21.53	-	-	104	45.02	
4 th year	127	26.29	-	-	127	54.97	
Family Type							
Nuclear	369	76.40	189	75.0	180	77.92	$\chi^2=3.29, P=0.19$
Extended Nuclear	64	13.25	31	12.30	33	14.29	
Joint	50	10.35	32	12.70	18	7.79	
Place							
Rural	139	28.78	64	25.40	75	32.5	$\chi^2=2.94, P=0.09$
Urban	344	71.22	188	74.60	156	67.5	

Table 2: OMI showing “Authoritarianism” among medical students who were unexposed and those who were exposed

OMI	Total (n=483)		Medical unexposed (n=252)		Medical exposed (n=231)		P
	Frequency	%	Frequency	%	Frequency	%	
Agree	239	49.48	114	45.24	125	54.1	$\chi^2=5.6029$
Disagree	111	22.98	68	26.98	43	18.6	$P=0.06077$
Not sure	133	27.54	70	27.78	63	27.3	
Agree	127	26.29	67	26.6	60	26.0	$\chi^2=0.539$
Disagree	184	38.1	99	39.3	85	36.8	$P=0.7637$
Not sure	172	35.61	86	34.1	86	37.2	
Agree	165	34.16	86	34.12	79	34.2	$\chi^2=0.0714$
Disagree	88	12.22	47	18.65	41	17.7	$P=0.9649$
Not sure	230	47.62	119	47.22	111	48.1	
Agree	259	53.62	130	51.6	129	55.8	$\chi^2=1.8327$
Disagree	104	21.53	53	21.0	51	22.1	$P=0.4000$
Not sure	120	24.84	69	27.4	51	22.1	
Agree	159	32.92	109	43.3	50	21.6	$\chi^2=25.6690$
Disagree	186	38.51	84	33.3	102	44.2	$P\leq 0.00001^*$
Not sure	138	28.57	59	23.3	79	34.2	
Agree	209	43.27	136	54.0	73	31.6	$\chi^2=25.9197$
Disagree	167	34.58	66	26.2	101	43.7	$P\leq 0.00001^*$
Not sure	107	22.15	50	19.8	57	24.7	
Agree	236	48.86	118	47.0	118	51.1	$\chi^2=2.7308$
Disagree	100	20.7	49	19.5	51	22.1	$P=0.2553$
Not sure	147	30.43	85	33.73	62	26.8	
Agree	108	22.36	68	27.1	40	17.3	$\chi^2=6.875$
Disagree	163	33.75	77	30.7	86	37.2	$P=0.0321^*$
Not sure	212	43.89	107	42.46	105	45.5	
Agree	82	16.98	62	24.7	20	8.7	$\chi^2=27.6566$
Disagree	279	57.76	121	48.2	158	68.4	$P\leq 0.00001^*$
Not sure	122	25.26	69	27.38	53	22.9	
Agree	350	72.46	189	75.3	161	69.7	$\chi^2=3.0724$
Disagree	62	12.84	26	10.4	36	15.6	$P=0.2152$
Not sure	71	14.70	37	14.68	34	14.7	

57.76%) ($n = 252$, 48.2% vs $n = 231$, 68.4%) ($P \leq 0.00001^*$). 25.26% of the students were not sure. Students' opinion with regard to Q39 did not change because most of the neurobiological basis for psychiatric illness is polygenic in nature.

Benevolence [Table 3]

Medical students on an overall agree to Q2 that “Mental illness is like any other illness” (total $N = 484$, 60.45% vs 29.40%) ($P \leq 0.0001^*$) and disagreed with Q32 ($P = 0.0454^*$). Students disagreed with Q34 that “If a patient in a mental hospital attack someone, he should be punished so he doesn't do it again” (total $N = 484$, 66.67% vs 10.35%) ($P = 0.0001^*$). No clear consensus was noted among the students with the statement, “The law should allow a woman to divorce her husband as soon as he has been confined in a mental hospital with a severe mental illness” (total $N = 484$, 26.92% agree vs 38.51% disagree vs 34.58 not sure) ($P = 0.00006$) ($n = 252$, 19.5% agree vs 46.6% disagree vs 34.39% are not sure) ($n = 231$, 35.1% agree vs 29.9% disagree vs 35.93% are not sure). This could be due to lesser knowledge of the forensic aspect of psychiatry, which is usually focused with respect to postgraduate students. However, it is worthwhile to know that such aspects do matter in cementing a perception of the person with mental illness in society. Students disagreed with Q40 ($N = 484$,

73.91%) and with Q49 (“There is little that can be done for patients in a mental hospital except to see that they are comfortable and well fed”; $P \leq 0.00001^*$). Students agreed to the Q36 and Q47, which is a divergence in thinking, which reflects those students at one end might have felt that in the wards the people with mental illness could not enjoy the same amount of freedom as other patients in the hospital do but at the same time might have felt that people tend to ask discharge and try to abscond, thereby the inner sense to have a high fence and more guards in every hospital. This also points to the fact that a deeper integration of human rights in our clinical practice and its education is required.

Mental hygiene ideology [Table 4]

The majority of medical students changed their opinion to Q28 (“Our mental hospitals seem more like prisons than like places where mentally ill people can be cared for”; $P \leq 0.00001^*$). This perception could be an experience, which students might have got from having seen an asylum or through media. Most of the students agreed with Q3, but undergraduates exposed to psychiatry felt otherwise. The majority of the students were not sure to Q50. This could be because of the longer hospital stay of a few patients who were severely ill and some patients who might have been violent during the postings and needed restraints.

Table 3: OMI showing “Benevolence” among medical students who were unexposed and those who were exposed

OMI	Total (n=483)		Medical unexposed (n=252)		Medical exposed (n=231)		P
	Frequency	%	Frequency	%	Frequency	%	
Agree	292	60.45	130	51.59	162	70.12	$\chi^2=18.5302$
Disagree	142	29.40	94	37.30	48	20.78	$P=0.0001^*$
Not sure	49	10.14	28	11.11	21	9.09	
Agree	434	89.85	229	90.87	205	88.74	$\chi^2=0.6586$
Disagree	12	2.48	6	2.38	6	2.60	$P=0.7194$
Not sure	37	7.66	17	6.75	20	8.66	
Agree	328	67.91	174	69	154	66.7	$\chi^2=0.3168$
Disagree	52	10.76	26	10.3	26	11.3	$P=0.8535$
Not sure	103	21.32	52	20.6	51	22.1	
Agree	317	65.63	156	61.9	161	69.7	$\chi^2=3.9566$
Disagree	51	10.56	32	12.7	19	8.20	$P=0.1383$
Not sure	115	23.81	64	25.40	51	22.10	
Agree	414	85.71	215	85.3	199	86.1	$\chi^2=0.1401$
Disagree	29	6.00	15	6.0	14	6.1	$P=0.9324$
Not sure	40	8.28	22	8.70	18	7.80	
Agree	51	10.56	32	12.7	19	8.2	$\chi^2=3.1149$
Disagree	288	59.62	143	56.7	145	62.8	$P=0.2106$
Not sure	144	29.81	77	30.83	67	29.0	
Agree	386	79.92	207	82.1	179	77.5	$\chi^2=0.1672$
Disagree	27	5.59	13	5.2	14	6.1	$P=0.4333$
Not sure	70	14.49	32	12.7	38	16.5	
Agree	38	7.87	25	9.9	13	5.6	$\chi^2=6.1833$
Disagree	401	83.02	199	79	202	87.4	$P=0.0454^*$
Not sure	44	9.11	28	11.1	16	6.90	
Agree	50	10.35	38	15.1	12	5.2	$\chi^2=22.397$
Disagree	322	66.67	145	57.5	177	76.6	$P=0.0001^*$
Not sure	111	22.98	69	27.4	42	18.20	
Agree	243	50.31	137	54.2	106	45.9	$\chi^2=3.6953$
Disagree	127	26.29	59	23.5	68	29.4	$P=0.1576$
Not sure	113	23.40	56	22.53	57	24.70	
Agree	130	26.92	49	19.5	81	35.1	$\chi^2=19.5376$
Disagree	186	38.51	117	46.6	69	29.9	$P=0.00006^*$
Not sure	167	34.58	86	34.39	81	35.93	
Agree	53	10.97	35	13.9	18	7.8	$\chi^2=10.1344$
Disagree	357	73.91	171	68.1	186	80.5	$P=0.0063^*$
Not sure	73	15.11	46	18.58	27	12.55	
Agree	416	86.13	212	84.5	204	88.3	$\chi^2=5.4655$
Disagree	30	6.21	14	5.6	16	6.9	$P=0.0650$
Not sure	37	7.66	26	10.67	11	5.63	
Agree	141	29.19	99	39.4	42	18.2	$\chi^2=30.6954$
Disagree	229	47.41	93	37.1	136	58.9	$P\leq 0.00001^*$
Not sure	113	23.40	60	24.11	53	23.81	

Social restrictiveness [Table 5]

Majority of the students disagreed that “Although patients discharged from mental hospitals may seem all right, they should not be allowed to marry” ($N = 483$, 60.25% vs 9.11%) ($P = 0.001^*$). Students disagreed that “The small children of patients in mental hospitals should not be allowed to visit them” ($N = 483$, 54.24% vs 21.12%) ($P = 0.0168^*$). The number of students who agreed that “Anyone who is in a hospital for a mental illness should not be allowed to vote” increased. This could be the fact that students did not have awareness about the rights of persons with disabilities and also highlights the importance of imparting knowledge about the same among undergraduates.

INTERPERSONAL ETIOLOGY [TABLE 6]

Students exposed to psychiatry agreed more when compared to unexposed that “Mental patients come from homes where the parents took little interest in their children” ($n = 231$, 49.4% vs 15.6%) ($P \leq 0.00001^*$). Most of the students were not sure “If the children of mentally ill parents were raised by normal parents, they would probably not become mentally ill” ($N = 483$, 39.96% not sure; 29.81% disagreed) ($P = 0.01993^*$). Most of the students agree that “The mental illness of many people is caused by the separation or divorce of their parents during childhood” ($N = 483$, 59.42% vs 12.84%) ($P = 0.0003^*$).

Table 4: OMI showing “Mental Hygiene” among medical students who were unexposed and those who were exposed

OMI	Total (n=483)		Medical unexposed (n=252)		Medical exposed (n=231)		P
	Frequency	%	Frequency	%	Frequency	%	
Agree	242	50.10	125	49.60	117	50.6	$\chi^2=0.0985$
Disagree	85	17.60	44	17.46	41	17.7	$P=0.9519$
Not sure	156	32.30	83	32.94	73	31.6	
Agree	192	39.75	101	40.1	91	39.4	$\chi^2=0.6147$
Disagree	65	13.46	31	12.3	34	14.7	$P=0.7354$
Not sure	226	46.79	120	47.6	106	45.9	
Agree	332	68.74	165	65.7	167	72.3	$\chi^2=3.6511$
Disagree	32	6.62	21	8.4	11	4.8	$P=0.1611$
Not sure	119	24.63	66	26.19	53	22.9	
Agree	237	49.07	162	64.3	75	32.5	$\chi^2=51.237$
Disagree	115	23.81	36	14.3	79	34.2	$P\leq 0.00001^*$
Not sure	131	27.12	54	21.4	77	33.3	
Agree	28	5.80	20	7.9	08	3.5	$\chi^2=4.4353$
Disagree	411	85.09	210	83.3	201	87.0	$P=0.1089$
Not sure	44	9.11	22	8.7	22	9.5	
Agree	243	50.31	124	49.2	119	51.5	$\chi^2=1.0909$
Disagree	119	24.64	67	26.6	52	22.5	$P=0.5795$
Not sure	121	25.05	61	24.2	60	26.0	
Agree	315	65.22	148	58.73	167	72.3	$\chi^2=9.7793$
Disagree	52	10.77	32	12.70	20	8.7	$P=0.0075^*$
Not sure	116	24.02	72	28.57	44	19.0	
Agree	166	34.37	87	34.52	79	34.2	$\chi^2=0.0073$
Disagree	106	21.95	55	21.82	51	22.1	$P=0.9963$
Not sure	211	43.69	110	43.65	101	43.7	
Agree	119	24.64	75	29.76	44	19.05	$\chi^2=7.5936$
Disagree	124	25.67	62	24.60	62	26.8	$P=0.022442^*$
Not sure	240	49.69	115	45.63	125	54.1	

Our results were similar to other studies that had shown that the stigmatizing views change when students start psychiatry clinical postings and during clinical clerkships in psychiatry.^[9,16]

Similar studies have been attempted with various study population namely the general public,^[26,27] students from medical,^[15,16] and paramedical profession,^[28,29] nonpsychiatric doctors,^[30] and from students from other professions.^[8,30,31] A study examined the effects of (i) education (which replaces myths about mental illness with accurate conceptions); (ii) contact (which challenges public attitudes about mental illness through direct interactions with persons who have these disorders); and (iii) protest (which seeks to suppress stigmatizing attitudes about mental illness) for changing stigmatizing attitudes about schizophrenia and other severe mental illnesses among 152 randomly selected college students.^[32] The researchers found that contact stimulated more positive changes than education alone. Other research also provided strong evidence that contact with the mentally ill reduced stigmatized attitudes among the general population.^[33] Another study explored the factors, which might influence the willingness of teenage students to address mental health concerns: Results suggested that reducing stigma through mental health education is crucial.^[34] Furthermore, outreach programs that are designed to enhance college students' help-seeking attitudes and intentions and to reduce stigmas were

effective in increasing participants' positive attitudes toward counseling and decreasing their self-stigma associated with counseling immediately after the program.^[35]

There were few studies that show that psychiatry course could not improve attitudes of the medical students and some studies say that attitude can deteriorate over time as students continue with their studies and internship. Poor awareness, lack of proper exposure, and training in psychiatry may be postulated as probable reason.^[16,36] Medical undergraduate students at AIMS have shown a lot of interest in psychiatry by participating in national and state-level psychiatry quiz activities regularly over a decade and also by attending clinical postings regularly. It is likely that the interest aroused in psychiatry may be the reason that the present study shows a more positive opinion about mental illness among undergraduate medical students.^[37]

To influence student's attitude toward psychiatry, Manohari *et al.* suggested to keep clinical posting parallel to the theory classes with a focus to prepare undergraduate medical students to practice psychiatry at the primary care level.^[38] Lyons Z *et al.* suggested embedding and integrating anti-stigma training throughout the curriculum.^[39] It is to be seen how the competency-based curriculum in psychiatry (in accordance with Miller's pyramid of clinical competence) would impact the opinion about mental illness in students as it is more student centric in approach

Table 5: OMI showing “Social Restrictiveness” among medical students who were unexposed and those who were exposed

OMI	Total (n=483)		Medical unexposed (n=252)		Medical exposed (n=231)		P
	Frequency	%	Frequency	%	Frequency	%	
Agree	44	9.11	28	11.11	16	6.9	$\chi^2=18.1094$
Disagree	291	60.25	168	66.67	123	53.2	$P=0.0001^*$
Not sure	148	30.64	56	22.22	92	39.8	
Agree	257	53.21	124	49.2	133	57.6	$\chi^2=4.1866$
Disagree	103	21.32	55	21.8	48	20.8	$P=0.1233$
Not sure	123	25.47	73	29	50	21.6	
Agree	165	34.16	86	34.1	79	34.2	$\chi^2=0.7843$
Disagree	89	18.43	50	19.8	39	16.9	$P=0.6756$
Not sure	229	47.41	116	46.0	113	48.9	
Agree	105	21.12	67	26.6	38	16.5	$\chi^2=8.1704$
Disagree	262	54.24	124	49.2	138	59.7	$P=0.0168^*$
Not sure	116	24.02	61	24.2	55	23.8	
Agree	64	13.25	32	12.7	32	13.9	$\chi^2=3.6214$
Disagree	280	57.97	156	61.9	124	53.7	$P=0.1635$
Not sure	139	28.78	64	25.4	75	32.5	
Agree	145	30.02	68	27.0	77	33.3	$\chi^2=2.6967$
Disagree	184	38.10	103	40.9	81	35.1	$P=0.2597$
Not sure	154	31.88	81	32.1	73	31.6	
Agree	90	18.63	54	21.43	36	15.6	$\chi^2=3.8622$
Disagree	131	27.12	61	24.21	70	30.3	$P=0.1449$
Not sure	262	54.24	137	54.37	125	54.1	
Agree	162	33.54	144	57.14	118	51.1	$\chi^2=5.5506$
Disagree	86	17.8	35	13.89	51	22.1	$P=0.0623$
Not sure	135	27.95	73	28.97	62	26.8	
Agree	255	52.79	129	51.19	126	54.5	$\chi^2=0.6649$
Disagree	94	19.46	52	20.63	42	18.2	$P=0.7171$
Not sure	134	27.74	71	28.17	63	27.3	
Agree	79	16.36	45	17.86	34	14.7	$\chi^2=1.0372$
Disagree	164	33.95	82	32.54	82	35.5	$P=0.5953$
Not sure	240	49.69	125	49.60	115	49.8	

Table 6: OMI showing “Interpersonal Etiology” among medical students who were unexposed and those who were exposed

OMI	Total (n=483)		Medical unexposed (n=252)		Medical exposed (n=231)		P
	Frequency	%	Frequency	%	Frequency	%	
Agree	255	52.79	124	49.2	131	56.7	$\chi^2=8.2652$
Disagree	116	24.02	74	29.4	42	18.2	$P=0.1604$
Not sure	112	23.19	54	21.4	58	25.1	
Agree	277	57.35	144	57.1	133	57.6	$\chi^2=1.2733$
Disagree	84	17.39	48	19.0	36	15.6	$P=0.5290$
Not sure	122	25.26	60	23.8	62	26.8	
Agree	81	16.77	36	14.3	45	19.5	$\chi^2=3.3707$
Disagree	264	54.66	137	54.4	127	55.0	$P=0.1854$
Not sure	138	28.57	79	31.3	59	25.5	
Agree	187	38.72	73	29.0	114	49.4	$\chi^2=3.28527$
Disagree	128	26.50	92	36.5	36	15.6	$P\leq 0.00001^*$
Not sure	168	34.78	87	34.5	81	35.1	
Agree	146	30.23	88	34.9	58	25.1	$\chi^2=7.8311$
Disagree	144	29.81	77	30.6	67	29.0	$P=0.01993^*$
Not sure	193	39.96	87	34.5	106	45.9	
Agree	287	59.42	131	52.0	156	67.5	$\chi^2=16.3587$
Disagree	62	12.84	45	17.9	17	7.4	$P=0.0003^*$
Not sure	134	27.74	76	30.2	58	25.1	
Agree	78	16.15	46	18.3	32	13.9	$\chi^2=1.9415$
Disagree	213	44.10	106	42.1	107	46.3	$P=0.3788$
Not sure	192	39.75	100	39.7	92	39.8	

with formative assessments, interactive way of teaching the theory using small group teaching methodology and audiovisual aids. Most of the competencies are from the knowledge domain, and a few are from the skill and attitude and ethics domains.^[40] Ultimately, it is the quality of the teaching, enthusiasm of the clinical teachers, the holistic approach, and scientific basis of psychiatry, which would influence the students' attitudes toward psychiatry.^[41]

Limitations

The cross-sectional descriptive design and convenient sampling from a single university need to be considered before the generalization of results.

Future implications

The perception and attitude and thereby beliefs and opinion can change based on one's experiences. Early clinical exposure and structured psychiatry training would definitely improve opinion and attitude toward mental illness. Long prospective studies/longitudinal studies and multicentric studies need to be considered with a larger sample size to assess the impact of the current curriculum of psychiatry across various colleges.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Demyttenaere K, Bruffaerts R, Posada-Villa J, Gasquet I, Kovess V; Prevalence, severity, and unmet need for treatment of mental disorders in the World Health Organization World Mental Health Surveys, *et al.* Prevalence, severity, and unmet need for treatment of mental disorders in the World Health Organization World Mental Health Surveys. *JAMA* 2004;291:2581-90.
- Huxley CJ, Atherton H, Watkins JA, Griffiths F. Digital communication between clinician and patient and the impact on marginalised groups: A realist review in general practice. *Br J Gen Pract* 2015;65:e813-21.
- Pepin R, Segal DL, Coolidge FL. Intrinsic and extrinsic barriers to mental health care among community-dwelling younger and older adults. *Aging Ment Health* 2009;13:769-77.
- Batra S, Baker RA, Wang T, Forma F, DiBiasi F, Peters-Strickland T. Digital health technology for use in patients with serious mental illness: A systematic review of the literature. *Med Devices (Auckl)* 2017;10:237-51.
- Dyduch A, Grzywa A. Stigma and related factors basing on mental illness stigma. *Pol Merkur Lekarski* 2009;26:263-7.
- Bhugra D. Attitudes towards mental illness. A review of the literature. *Acta Psychiatr Scand* 1989;80:1-12.
- Jorm AF, Korten AE, Jacomb PA, Rodgers B, Pollitt P, Christensen H, *et al.* Helpfulness of interventions for mental disorders: Beliefs of health professionals compared with the general public. *Br J Psychiatry* 1997;171:233-7.
- Vijayalakshmi P, Reddy D, Math SB, Thimmaiah R. Attitudes of undergraduates towards mental illness: A comparison between nursing and business management students in India. *S Afr J Psychiatr* 2013;19:66-74.
- Lyons Z. Impact of the psychiatry clerkship on medical student attitudes towards psychiatry and to psychiatry as a career. *Acad Psychiatry* 2014;38:35-42.
- Cutler JL, Alspector SL, Harding KJ, Wright LL, Graham MJ. Medical students' perceptions of psychiatry as a career choice. *Acad Psychiatry* 2006;30:144-9.
- Budd S, Kelley R, Day R, Variend H, Dogra N. Student attitudes to psychiatry and their clinical placements. *Med Teach* 2011;33:e586-92.
- Curtis-Barton M, Eagles J. Factors that discourage medical students from pursuing a career in psychiatry. *Psych* 2011;35:425-9.
- Malhi GS, Parker GB, Parker K, Kirkby KC, Boyce P, Yellowlees P, *et al.* Shrinking away from psychiatry? A survey of Australian medical students' interest in psychiatry. *Aust N Z J Psychiatry* 2002;36:416-23.
- Pessar LF, Pristach CA, Leonard KE. What troubles clerks in psychiatry? A strategy to explore the question. *Acad Psychiatry* 2008;32:194-8.
- Gulati P, Das S, Chavan BS. Impact of psychiatry training on attitude of medical students toward mental illness and psychiatry. *Indian J Psychiatry* 2014;56:271-7.
- Poreddi V, Thimmaiah R, Math SB. Attitudes toward people with mental illness among medical students. *J Neurosci Rural Pract* 2015;6:349-54.
- Kihumuro RB, Kaggwa MM, Kintu TM, Nakandi RM, Muwanga DR, Muganzi DJ, *et al.* Knowledge, attitude and perceptions of medical students towards mental health in a university in Uganda. *BMC Med Educ* 2022;22:730.
- Sujaritha V, Partheeban M, Thiviya T, Sowmiya M. Attitude towards mental illness among doctors and nurses in a tertiary care centre, Pondicherry, India. *Int J Res Med Sci* 2017;5:3059-64.
- Cohen J, Struening EL. Opinions about mental illness in the personnel of two large mental hospitals. *J Abnorm Soc Psychol* 1962;64:349-60.
- Shaw ME, Wright JM. Scales for the Measurement of Attitudes. New York: McGraw-Hill; 1967.
- Costin F, Kerr WD. The effect of an abnormal psychology course on students' attitudes toward mental illness. *J Educ Psychol* 1962;53:214.
- Agrawal SM. Attitude of relatives towards mental illness. *J Clinical Psychiatry India* 1982;6:122-6.
- Kurian C. A sociological study of schizophrenic patients in Goa (Doctoral dissertation, Goa University).
- Das S, Phookun HR. Knowledge, attitude, perception and belief (KAPB) of patients' relatives towards mental illness: Association with clinical and sociodemographic characteristics. *Delhi Psychiatry J* 2013;16:98-109.
- Das S, Phookun HR. Knowledge, attitude, perception and belief (KAPB) of patients' relatives towards mental illness: A cross-sectional study. *Delhi Psychiatry J* 2014;17:48-59.
- Corrigan PW, Green A, Lundin R, Kubiak MA, Penn DL. Familiarity with and social distance from people who have serious mental illness. *Psychiatr Serv* 2001;52:953-8.
- Prabhu GG, Raghuram A, Verma N, Maridass AC. Public attitudes towards mental illness: A review. *Nimhans Journal* 1984;2:1-4.
- Poreddi V, Thimmaiah R, Pashupu DR, Ramachandra, Badamath S. Undergraduate nursing students' attitudes towards mental illness: Implications for specific academic education. *Indian J Psychol Med* 2014;36:368-72.
- Sreeraj VS, Parija S, Uvais NA, Mohanty S, Kumar S. Indian nursing students' attitudes toward mental illness and persons with mental illness. *Ind Psychiatry J* 2017;26:223-7.
- Kumar MV, Macharapu R, Reddy PK, Babu S. Attitude toward mental illness among medical students and nonpsychiatric doctors. *Arch Ment Health* 2019; 20:9-13.
- Todor I. Opinions about mental illness. *Procedia Soc Behav Sci* 2013 Jul 3; 82:209-14.
- Corrigan PW, River LP, Lundin RK, Penn DL, Uphoff-Wasowski K, Campion J, *et al.* Three strategies for changing attributions about severe mental illness. *Schizophr Bull* 2001;27:187-95.
- Alexander LA, Link BG. The impact of contact on stigmatizing attitudes towards people with mental illness. *J Ment Health* 2003;12:271-89.
- Chandra A, Minkowitz CS. Factors that influence mental health stigma among 8th grade adolescents. *J Youth Adolescence* 2007;36:763-74. [<http://dx.doi.org/10.1007/s10964-006-9091-0>]
- Blocher W. Effectiveness of an outreach program designed to enhance college students' help-seeking attitudes, intentions, and to reduce stigmas. Graduate Thesis. Ames, Iowa: Iowa State University, 2011.
- Baxter H, Singh SP, Standen P, Duggan C. The attitudes of 'tomorrow's doctors' towards mental illness and psychiatry: Changes during the final undergraduate year. *Med Educ* 2001;35:381-3.
- Kishor M, Vinay HR. Innovative ways and customizing psychiatry training for undergraduates. *Indian J Psychiatry* 2015;57:431-3.
- Manohari SM, Johnson PR, Galgali RB. How to teach psychiatry to medical undergraduates in India? A model. *Indian J Psychol Med* 2013;35:23-8.
- Lyons Z, Janca A. Impact of a psychiatry clerkship on stigma, attitudes towards psychiatry, and psychiatry as a career choice. *BMC Med Educ* 2015;15:34.
- Pernenkil V. Competency-based psychiatric education for Indian medical undergraduates. *Arch Ment Health* 2019;20:1-2.
- Lampe L, Coulston C, Walter G, Malhi G. Familiarity breeds respect: Attitudes of medical students towards psychiatry following a clinical attachment. *Australas Psychiatry* 2010;18:348-53.

A Study on Flex patriates Behaviour in International Assignments Among Information Technology Sector Employees

^[1] Shruti Khemshetty ^[2] Dr. Roohi Kursheed Khan.S,

^[1] Research Scholar

Dayananda Sagar University

^[2] Associate Professor & BBA Program Manager,

School of Commerce & Management Studies, Dayananda Sagar University

Abstract

There are certain changes that are observed in the global workforce. It was seen that Flexpatriate's behaviour is one of the modern trends in the workforce. Therefore, the study has aimed towards analysing Flexpatriates behaviour in International assignments among Information Technology Sector Employees. The term Flexpatriates is relatively new thus people are not familiar with the term. Hence, secondary data was considered for the empirical analysis. In addition, a qualitative method of analysis was employed in order to deliver reliable results. It was observed that there are certain behavioural traits associated with the Flexpatriates. For instance, it was noted that globalization is a major factor that prompts such behaviour in employees. In addition, it was noted that the quality of work for international assignments is impacted by Flexpatriate's behaviour of employees. The prime reason for that was contemplated to be the work-life balance of such Flexpatriates behaviour. Moreover, it was noted that skills and adaptability for information technology employees are some of the major criteria of such employees that impact the quality of international assignments.

Keywords: *Flexpatriates behaviour, International assignments, Global IT employees, Adaptability of Flexpatriates employee, benefits of Flexpatriates behaviour.*

1. Introduction

Flexpatriates is considered a modern world word that describes an employee who lives and works from another country. However, such an employee works for a firm or business that is situated in a different country. The term Flexpatriates gained popularity in the initial years of the 21st century in order to describe the growing number of workers who were traveling abroad but weren't relocating permanently [1]. The term has gained popularity over time and along with that international assignments are managed with such employees. Therefore, the study has focused on Flexpatriates behaviour in International assignments among Information Technology Sector Employees [2]. Moreover, different factors related to Flexpatriate's behaviour are discussed in the study. There are certain factors associated with the management of global assignments [3]. Therefore, elements of the global assignment are coherently discussed in the study.

Figure 1 of the empirical analysis is associated with the factors of global assignments management. In order to analyse flexpatriates behaviour in International assignments among Information Technology Sector Employees it is essential to analyse such factors [4]. It can be contemplated that having cooperation among different factors is essential for the stability of a global project [5]. Thus, the study has further discussed relevant challenges and their possible solutions in the study.



Fig 1: Factors associated with global assignments
(Source: Influenced by 5)

2. Objective

- To discuss the factors related to Flexpatriate's behaviour
- To identify the elements associated with international assignments
- To analyse the impact of Flexpatriates employees in the IT sector
- To evaluate the benefits of Flexpatriates employees for international assignments

3. Literature/Background survey

3.1 Importance of flexpatriates behaviour for countering poly contextual environments

Globalization has presented new challenges along the way. Further during the time of COVID remote working facilities were streamlined [6]. Moreover, skills and talents were more valued than in contemporary educational backgrounds. Thus, in the situation of globalization companies are required to compete globally and penetrate new markets [7]. However, there were certain challenges that hindered the process, especially in times of economic crisis and significant unemployment issues of global project management. Moreover, these factors contribute to hiring issues such as attracting localized talent and developing a culturally sophisticated workforce [8]. Additionally, globally savvy business leaders were facing issues with the requirement of diversification of skills.

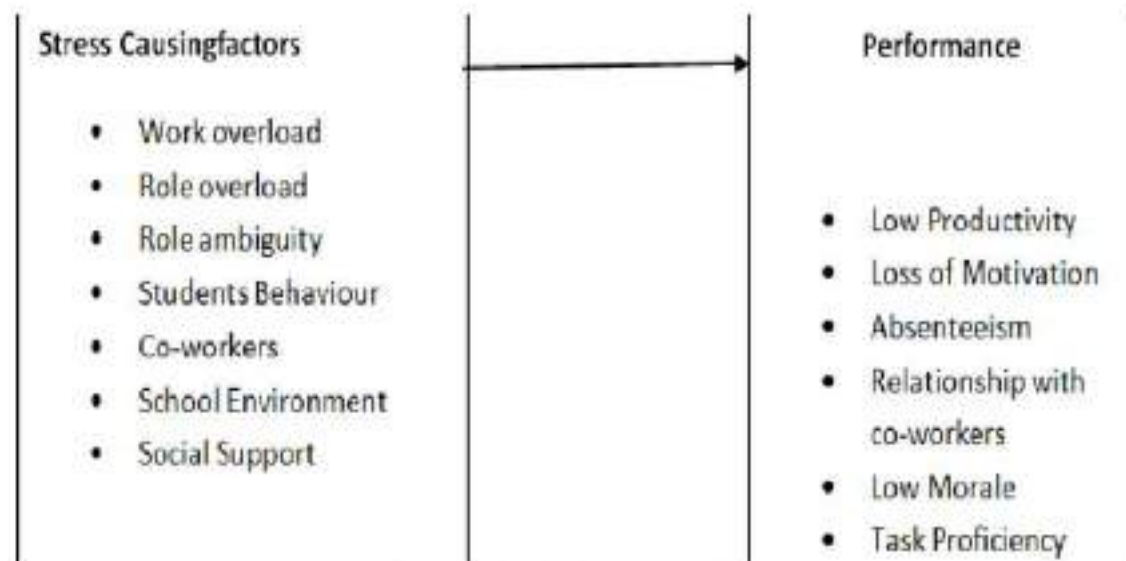


Fig 2: Factors that impact Productivity
(Source: Influenced by 10)

In the above image, all the factors related to the factors that impact the phenomenon are presented. It can be seen that factors such as workload and role ambiguity can be a major contributor to the performance of an employee [9]. Further, such factors can lead to low morale of the employee and impact the performance. Therefore, in order to address these personnel issues, and to increase productivity Flexpatriate's behaviour in International assignments can be beneficial. Furthermore, an increasing range of alternate overseas assignments is being employed in addition to traditional long-term expatriation [10]. Moreover, such factors could be used to describe people who are extremely adaptive and versatile when it comes to operating in a variety of cross-cultural or international environments. Therefore, it can be contemplated that such a productive impact on the business can improve the business in different manners. People who can concurrently traverse several cultural, social, or professional contexts are said to be in "poly-contextual environments" [11]. Hence it can be understood that flexpatriates behaviour plays a crucial role in countering polycontextual environments in a business. Additionally, skilled employment can be beneficial for the improvement of the corporate culture.

3.2 Factors of flexpatriates behaviour:

At the time of analyzing past literature, it was noted that there are certain factors associated with the flexpatriates behaviour. Moreover, such behaviour was related to different skills and realizations of the employees. Such as cultural sensitivity is one of the major factors for such behaviour of employees. Flexpatriates frequently have a keener understanding of subtle cultural distinctions [12]. Moreover, the relation with cognitive behaviour is strongly associated with the improvement of the global assignment management process. In these scenarios, employees are adapted to changing their actions and communication patterns to be considerate and efficient in a variety of cultural contexts [13].

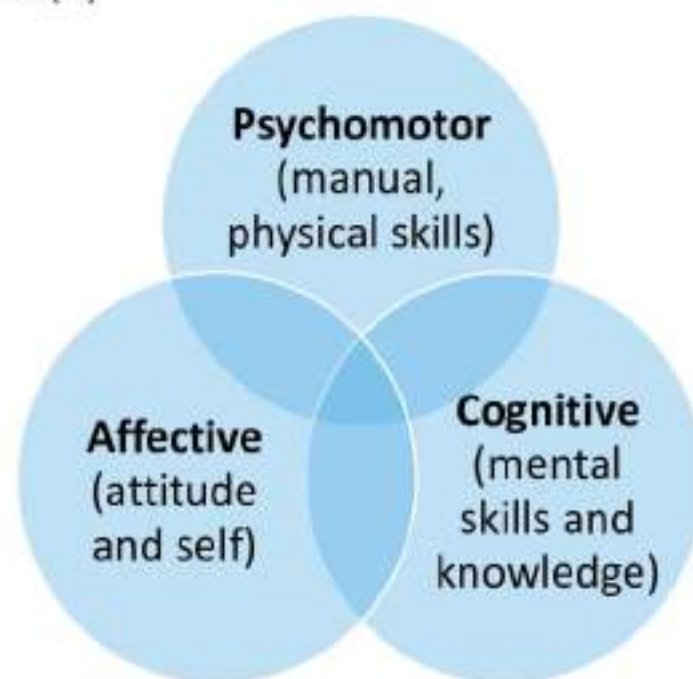


Fig 3: Features of flexpatriates behaviour
(Source: Influenced by 14)

Another cognitive ability that was found to be an important factor for the employee is related to linguistics. Moreover, a multilingualistic skill is found to be a profound skill that has a direct impact on the productivity of the international assignment's manager. Moreover, Language proficiency is a vital asset for working in polycontextual contexts [14]. Additionally, linguistic ability is found to be a skill that many flexpatriates may possess. Such skills were found to impact the team's collaboration with other team members on an international project. Moreover, the ability to speak in the local tongue of various situations is beneficial for IT firms across the globe [15]. Additionally, such skills aid in promoting better connections and understanding for

the flexpatriates as well. At the same time, the proficiency of the work depends on the understanding hence such cognitive, affective, and physio skills aid in the overall development of the project.

4. Methodology

An empirical analysis's methodology examines the variables that helped shape the analysis. As a result, a secondary mode of information gathering was selected. Additionally, all of the data was gathered from secondary sources like earlier publications, and research papers were analysed and closely observed [16]. Secondary data collection assists in gathering trustworthy data, allowing for the formulation of trustworthy results. At the same time, the concept of Flexpatriates is thus most of the people are not familiar with the concept. In the early years of the twenty-first century [17]. The term "Flexpatriates" became popular to characterize the rising number of employees who were going overseas but weren't migrating permanently [18]. Therefore, considering a primary method of analysis in such a scenario can impact the reliability of the final result. Moreover, it was noted that with the rise in usage of the phrase over time, these workers are now used to manage multinational tasks. Thus, for analysing such a modern and diverse topic in a short span of time secondary data was considered. Furthermore, a qualitative approach to analysis was used to examine the secondary data [19]. It is necessary to examine sociocultural aspects of cognitive learning for the Flexpatriate's behaviour. Additionally, comprehending the factual information in a coherent manner was the demand of the study [20]. Thus, for the analysis of Flexpatriate's behaviour in global assignment management for IT firms secondary qualitative procedures were employed in order to support the development of trustworthy connections that are rooted in a globalised corporate world [21].

5. Results/Findings

It was noted that the lifestyle factor that provokes Flexpatriate's behaviour is related to different elements. For instance, work-life balance is a major factor in such a lifestyle. From the analysis of different past articles, it was noted that, even though Flexpatriate employees are always moving, work-life balance is on their prime priority list [22]. Moreover, personal growth and mental health boat are in balance in such a lifestyle. Therefore, with such balance a decreased stress level was noticed [23]. They look for methods to mesh their passion for adventure and cultural discovery with their professional objectives. Thus, employers of IT firms are shifting their paradigm to such a workforce as the quality of work is vividly impacted by their stress-free attitude [24].

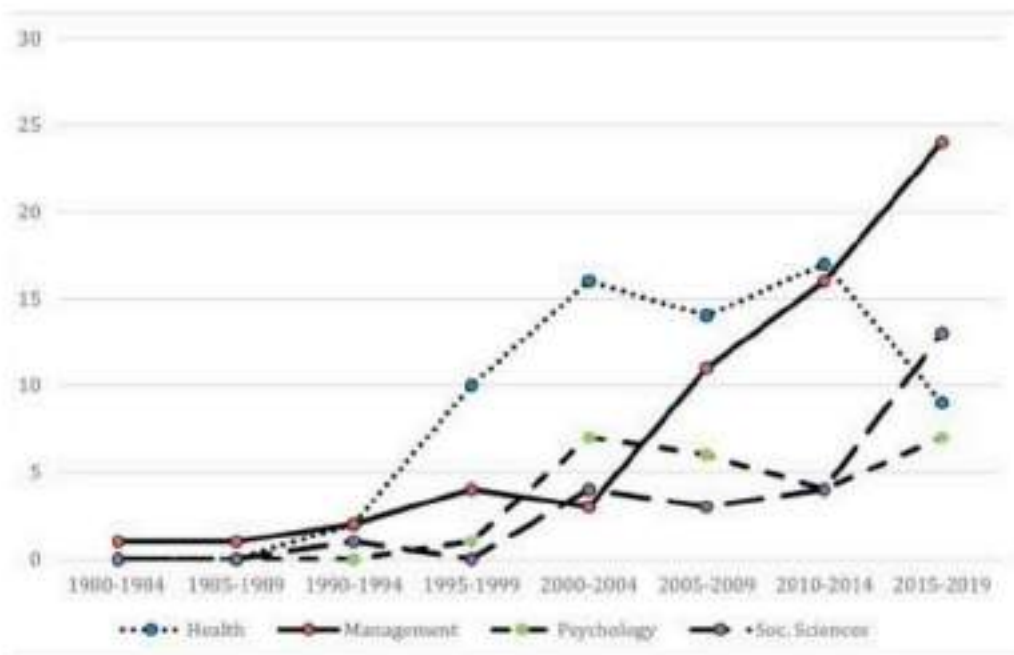


Fig 4: Factors for employee development
(Source: Influenced by 24)

From the graph Adobe it can be seen that firms are focusing on the factors that aid in the work-life balance of the employees. Moreover, it can be contemplated that factors such as management have seen spiking growth over time. Hence in such a scenario, a Flexpatriate employee can be beneficial for the firms [25]. It was observed that there is a constant growth in the Flexpatriate employee and globalization can be the reason for that. It was noted that for flexpatriates, establishing a globalized network is a major skill. The network can be of friends and professional contacts which is considered crucial for the integration of international assignments [26]. They cherish friendships with individuals from other cultures, which frequently results in a vibrant social life. In addition to the generalization and popularisation of the Internet, the number of flexpatriate employees is on the rise [27].

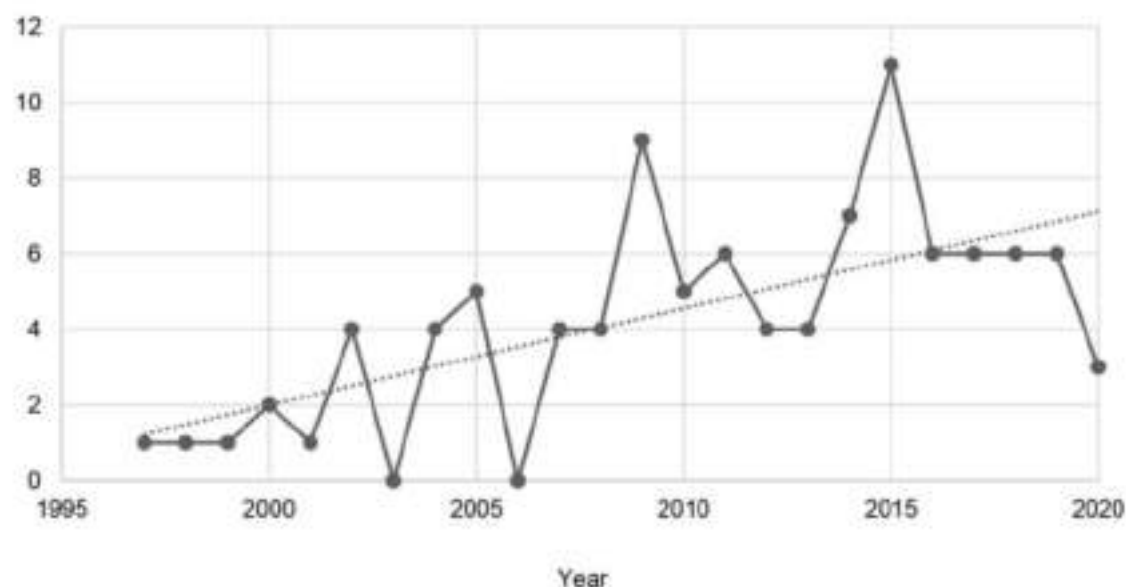


Fig 5: Growth of flexpatriate employees over the years
(Source: Influenced by)

The above figure is related to the growth of flexpatriate employees over the years. It can be seen that from the initiation phases, there are constant drops and spikes in the numbers of such employees [28]. It was observed that flexpatriates have a high level of adaptability and can easily become used to a new environment. Therefore, such factors can be a major cause of the popularity of flexpatriate behaviour in international project management [28]. Additionally, it was concluded that globalization have provoked such behaviours among the employees thus it can be stated that flexpatriate behaviour for international assignments is evolving as one of the trends for IT employee.

6. Discussion

The term "Flexpatriates" refers to people who are extremely adaptive to the environment and can be flexible when it is required. Moreover, such traits are seen when it comes to relocating and working in various foreign or cross-cultural environments. Thus, cultural sensitivity is found to be one of the major factors for international assignment of IT employees [29]. It was noted that flexpatriates put a lot of emphasis on cultural sensitivity. In addition, they are open to change and uncertainty in their job. Furthermore, in such a lifestyle employee are committed to living fulfilled lives despite frequently relocating or adjusting to new situations [30]. In order to contemplate the factors secondary data was considered and qualitative research was done. Thus, a tangible result is formulated for the study.

7. Conclusion

Thus, a detailed analysis related to Flexpatriate's behaviour for intonation assignment in IT firms is conducted in the study. It can be concluded that Flexpatriates have been found to be highly adaptable and capable

of quickly acclimating to different environments. Additionally, globalization has a major impact on the incorporation of Flexpatriate's behaviour for international assessments. Additionally, it was noted in such behaviour a quality work-life balance can be maintained. Thus, a better stress-free lifestyle and work quality improve drastically.

8. Future Research

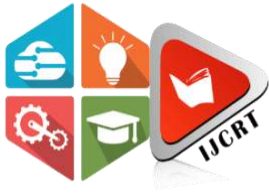
The study's discussion of Flexpatriate's behaviour of employees associated with international assignments of IT firms. The work might thus serve as the foundation for other, Flexpatriate's related research where a lack of data was noticed. Furthermore, the production of findings for such aspects was based on trustworthy data sources, and the outcomes are concrete. As a result, at the time of contemplation of Flexpatriate's behaviour and implementing the same real life, the research findings can be applied.

References

- [1] Al Dilby, H. K., & Farmanesh, P. (2023). Exploring the impact of virtual leadership on job satisfaction in the post-COVID-19 era: The mediating role of work-life balance and trust in leaders. *Frontiers in Psychology*, 14, 994539. Available at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2023.994539/full>
- [2] Alexander, A., De Smet, A., Langstaff, M., & Ravid, D. (2021). What employees are saying about the future of remote work. McKinsey & Company, 1-13. Available at: https://emilea.ceu.es/wp-content/uploads/what-employees-are-saying-about-the-future-of-remote-work_vf.pdf
- [3] Anwar, M. A., & Graham, M. (2021). Between a rock and a hard place: Freedom, flexibility, precarity and vulnerability in the gig economy in Africa. *Competition & Change*, 25(2), 237-258. Available at: <https://journals.sagepub.com/doi/full/10.1177/1024529420914473>
- [4] Arunprasad, P., Dey, C., Jebli, F., Manimuthu, A., & El Hathat, Z. (2022). Exploring the remote work challenges in the era of COVID-19 pandemic: review and application model. *Benchmarking: An International Journal*, 29(10), 3333-3355. Available at: Arunprasad, P., Dey, C., Jebli, F., Manimuthu, A., & El Hathat, Z. (2022). Exploring the remote work challenges in the era of COVID-19 pandemic: review and application model. *Benchmarking: An International Journal*, 29(10), 3333-3355.
- [5] Arunprasad, P., Dey, C., Jebli, F., Manimuthu, A., & El Hathat, Z. (2022). Exploring the remote work challenges in the era of COVID-19 pandemic: review and application model. *Benchmarking: An International Journal*, 29(10), 3333-3355. Available at: <https://www.emerald.com/insight/content/doi/10.1108/BIJ-07-2021-0421/full/chitra.dey@vit.ac.in>
- [6] Basilaia, G., Dgebuadze, M., Kantaria, M., & Chokhanelidze, G. (2020). Replacing the classic learning form at universities as an immediate response to the COVID-19 virus infection in Georgia. *International Journal for Research in Applied Science and Engineering Technology*, 8(3), 101-108. Available at: https://www.researchgate.net/profile/Marine-Dgebuadze-2/publication/339740814_Replacing_the_Classic_Learning_Form_at_Universities_as_an_Immediate_Response_to_the_COVID-19_Virus_Infection_in_Georgia/links/5e623d3b4585153fb3c500c8/Replacing-the-Classic-Learning-Form-at-Universities-as-an-Immediate-Response-to-the-COVID-19-Virus-Infection-in-Georgia.pdf
- [7] Caligiuri, P., De Cieri, H., Minbaeva, D., Verbeke, A., & Zimmermann, A. (2020). International HRM insights for navigating the COVID-19 pandemic: Implications for future research and practice. *Journal of international business studies*, 51, 697-713. Available at: <https://link.springer.com/article/10.1057/s41267-020-00335-9>
- [8] Choudhury, P., Foroughi, C., & Larson, B. (2021). Work-from-anywhere: The productivity effects of geographic flexibility. *Strategic Management Journal*, 42(4), 655-683. Available at: https://dash.harvard.edu/bitstream/handle/1/37371302/choudhury,foroughi,larson_work-from-anywhere.pdf?sequence=1
- [9] Chung, H., & Van der Lippe, T. (2020). Flexible working, work-life balance, and gender equality: Introduction. *Social indicators research*, 151(2), 365-381. Available at: <https://link.springer.com/article/10.1007/s11205-018-2025-x>

- [10] Gigauri, I. (2020). Effects of Covid-19 on Human Resource Management from the Perspective of Digitalization and Work-life-balance. *International Journal of Innovative Technologies in Economy*, (4 (31)). Available at: <https://rsglobal.pl/index.php/ijite/article/download/1438/1485>
- [11] Hjálmsdóttir, A., & Bjarnadóttir, V. S. (2021). "I have turned into a foreman here at home": Families and work-life balance in times of COVID-19 in a gender equality paradise. *Gender, Work & Organization*, 28(1), 266-283. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7537149/>
- [12] Irawanto, D. W., Novianti, K. R., & Roz, K. (2021). Work from home: Measuring satisfaction between work-life balance and work stress during the COVID-19 pandemic in Indonesia. *Economies*, 9(3), 96. Available at: <https://www.mdpi.com/2227-7099/9/3/96/pdf>
- [13] Jayasekara, P. (2021). Global Mobility beyond Traditional Assignments-A Review on Flexpatriates and International Business Travellers. *International Journal of Scientific Research and Management (IJSRM)*, 9(03), 570-576. Available at: <https://ijsrm.net/index.php/ijsrm/article/download/3122/2273>
- [14] Jooss, S., McDonnell, A., & Conroy, K. (2021). Flexible global working arrangements: An integrative review and future research agenda. *Human Resource Management Review*, 31(4), 100780. Available at: <https://www.sciencedirect.com/science/article/pii/S105348222030053X>
- [15] Kaduk, A., Genadek, K., Kelly, E. L., & Moen, P. (2019). Involuntary vs. voluntary flexible work: Insights for scholars and stakeholders. *Community, Work & Family*, 22(4), 412-442. Available at: https://stacks.cdc.gov/view/cdc/121199/cdc_121199_DS1.pdf
- [16] Khateeb, F. R. (2021). Work life balance-A review of theories, definitions and policies. *Cross-Cultural Management Journal*, 23(1), 27-55. Available at: https://seaopenresearch.eu/journals/articles/CMJ2021_11_3.pdf
- [17] Madero Gómez, S., Ortiz Mendoza, O. E., Ramírez, J., & Olivas-Luján, M. R. (2020). Stress and myths related to the COVID-19 pandemic's effects on remote work. *Management Research: Journal of the Iberoamerican Academy of Management*, 18(4), 401-420. Available at: https://research.cbs.dk/files/67928223/sergio_manuel_madero_g_mez_et_al_stress_and_myths_accept_edversion.pdf
- [18] McDonnell, A., Jooss, S., & Conroy, K. M. (2023). The unrealized value of global workers: the need for global talent management. *Smart Talent Management: Managing People as Knowledge Assets*, 165. Available at: McDonnell, A., Jooss, S., & Conroy, K. M. (2023). The unrealized value of global workers: the need for global talent management. *Smart Talent Management: Managing People as Knowledge Assets*, 165.
- [19] Muralidhar, B., Prasad, D. K., & Mangipudi, D. M. R. (2020). Association among remote working concerns and challenges on employee work-life balance: an empirical study using multiple regression analysis with reference to international agricultural research institute, Hyderabad. *International Journal of Advanced Research in Engineering and Technology*, 11(6). Available at: https://www.researchgate.net/profile/Kdv-Xxx/publication/342378057_Association_among_Remote_Working_Concerns_and_Challenges_on_Employee_Work-Life_Balance_An_Empirical_Study_using_Multiple_Regression_Analysis_with_Reference_to_International_Agricultural/links/5ef171dea6fdcc73be96c31b/Association-among-Remote-Working-Concerns-and-Challenges-on-Employee-Work-Life-Balance-An-Empirical-Study-using-Multiple-Regression-Analysis-with-Reference-to-International-Agricultural.pdf
- [20] Nadeak, B. (2020). The effectiveness of distance learning using social media during the pandemic period of covid-19: A case in universitas kristen Indonesia. *International Journal of Advanced Science and Technology*, 29(7), 1764-1772. Available at: <http://repository.uki.ac.id/1717/1/16270-Article%20Text-24181-1-10-20200518.pdf>
- [21] Pretti, T. J., Etmski, B., & Durston, A. (2020). Remote Work-Integrated Learning Experiences: Student Perceptions. *International Journal of Work-Integrated Learning*, 21(4), 401-414. Available at: <https://files.eric.ed.gov/fulltext/EJ1271299.pdf>
- [22] Przytuła, S., Strzelec, G., & Krysińska-Kościańska, K. (2020). Re-vision of future trends in human resource management (HRM) after COVID-19. *Journal of Intercultural Management*, 12(4), 70-

90. Available at:
https://wir.ue.wroc.pl/docstore/download/UEWRf9b0e5aeddc4c6582927908000f2092/Przytula_Strzelao_Krysinska-Koscianska_Re-vision_Of_Future_Trends.pdf
- [23] Purgal-Popiel, J. (2021). In search of the contribution of non-traditional expatriation to global talent management. *European Journal of International Management*, 16(4), 610-630. Available at: <https://www.inderscienceonline.com/doi/abs/10.1504/EJIM.2021.118575>
- [24] Purgal-Popiel, J. (2021). In search of the contribution of non-traditional expatriation to global talent management. *European Journal of International Management*, 16(4), 610-630. Available at: <https://www.inderscienceonline.com/doi/abs/10.1504/EJIM.2021.118575>
- [25] Robbins, S. P., Judge, T. A., & Vohra, N. (2019). *Organizational behaviour by pearson 18e*. Pearson Education India. Available at:
https://books.google.co.in/books?hl=en&lr=&id=nlyqDwAAQBAJ&oi=fnd&pg=PP1&dq=Flexpatriates+behaviour+in+firms&ots=a_LeYwAFlo&sig=87d12Va1UYRK3AssbB2WGgtuXC8
- [26] Selmer, J., Dickmann, M., Froese, F. J., Luring, J., Reiche, B. S., & Shaffer, M. (2021). The potential of virtual global mobility: implications for practice and future research. *Journal of Global Mobility: The Home of Expatriate Management Research*, 10(1), 1-13. Available at: https://dspace.lib.cranfield.ac.uk/bitstream/handle/1826/17464/The_potential_of_virtual_global_mobility-2021.pdf?sequence=1&isAllowed=y
- [27] Sengupta, S., Patel, P., Mohyuddin, S., Priksat, V., Rajesh, J. I., & Rana, V. (2023). Wind of change brought by COVID-19: Exploring the response and the new normal from the perspectives of Indian flexpatriates. *Thunderbird International Business Review*, 65(1), 103-116. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9347784/>
- [28] Setti, I., Sommovigo, V., & Argentero, P. (2020). Enhancing expatriates' assignments success: the relationships between cultural intelligence, cross-cultural adaptation and performance. *Current Psychology*, 1-21. Available at: Setti, I., Sommovigo, V., & Argentero, P. (2020). Enhancing expatriates' assignments success: the relationships between cultural intelligence, cross-cultural adaptation and performance. *Current Psychology*, 1-21.
- [29] Shirmohammadi, M., Chan Au, W., & Beigi, M. (2022). Antecedents and outcomes of work-life balance while working from home: A review of the research conducted during the COVID-19 pandemic. *Human Resource Development Review*, 21(4), 473-516. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9535461/>
- [30] Tahir, R. (2021). Flexpatriates: issues and challenges for short-term assignments in the United Arab Emirates. *International Journal of Management Practice*, 14(3), 283-305. Available at: https://www.researchgate.net/profile/Rizwan-Tahir-6/publication/350723819_Flexpatriates_issues_and_challenges_for_short-term_assignments_in_the_United_Arab_Emirates/links/606eba1da8fddc5f778d1037/Flexpatriates-issues-and-challenges-for-short-term-assignments-in-the-United-Arab-Emirates.pdf



Work Life Balance Of Flexpatriate In International Assignments

Authors

Shruti Khemshetty
Research Scholar
Dayananda Sagar University

Dr. Roohi Kursheed Khan S
Associate Professor and BBA Program Manager,
School of Commerce & Management Studies Dayananda Sagar University

Abstract

The aim of this paper is to explore the impact of work-life balance on flexpatriates behavior. The flexpatriates are to be considered as flexible assignees the paper aims to know what are the work life balance factors which make flexpatriates to be called as flexible short-term Assignees. The study is been conducted using 50 flexpatriates working in the IT sector in Bangalore district Karnataka. The IT sector in Bangalore is one of the largest sector in Karnataka and has globally been recognized and more number of flexpatriates are flying frequently on the assignments. It is an empirical study, analysis is conducted by using IBM SPSS 23 tool. The result of the study insisted to come out with work-life balance programs, HR policies, commitments, and strategies for the Assignees. The study concluded by stating work-life balance has a strong impact on flexpatriates behavior in international assignees.

Keywords:- Flexpatriates , Work-life balance, Family separation, Spousal support, Flexible Behavior

1.Introduction

Globalization has brought new impact in the world the system of working, a huge range of changes taking place regarding the international assignment's and employees being allotted to these assignment's earlier expatriates were been allotted to international assignments and study is also been conducted on these expats, the study has also come with the result the failure of these expatriates, family adjustment to host country, cultural adjustment, huge cost incurred on them made to think on the new form of assignees called as short term assignees. Meyerhofer;2004: came up with a new set of employees who are been called as flexpatriates who go on assignment for 1 week to 3months on an average leaving their families behind in the home country and these assignees are been completely left on themselves to complete the assignments and no such Hr policies are been framed for them as it's been done to expatriates. The literature has come up with how there is a rise in flexpatriates from the corporate perspective as boundary spanners, effective cost, knowledge exchange, offer flexibility, and maintaining

a healthy relationship in global market (Myskens et al., 2009; Collings et al., 2007; Minbaeva & Michailova 2004; McKenna & Richardson, 2007; Nakamura & Mizoguchi, 2013; Schaper, Amann, Jaussaud)

Flexpatriates obscure the frontier between non-work and work domains (Ilies et al., 2009) they function as cross boundaries interaction more no of assignments means more no of the learning experience of cultural contexts and skill meanwhile it is also a burden on psychological and physical aspects tension in work-family, family separation, work-life issues, health stress, travel stress, relationship with children, international working pattern are most common problem cited (Harvey et al., 2010; Suutari, 2003; DeFrank et al., 2000; Kappelhoff et al., 2006; Welch and Worm, 2006).

The aim of this paper is to study the factors of work-life balance which influence the behavior of the flexpatriates their international assignments. It begins with the study of literature exploring what are the factors which influence work-life balance which impacts behavior than the research method, study and result are discussed coming up with the finding the suggestion with the final conclusion of the study.

Helene Mayerhofer, Linley C. Hartmann, Gabriela Michelitsch-Riedl and Iris Kollinger:- as global trade has increased the usage of expatriates are been more but it is only in large-sized but small and medium-sized are using short term, flexible who can have better coordination in HCN those are been named as flexpatriates. Flexpatriates are been mostly used in a small organization to avoid cost constraints, difficulties arise due to expatriates' difficulties like family separation, dual careers. The flexpatriates are been used for wide purposes like to assist in projects, to provide expert knowledge, to offer support in technical problems or stock audits (controlling), and to attend meetings, congresses, and conferences as well as training courses. This paper also stated that less involvement of HRM with flexpatriates compared to expatriates.

Helene Mayerhofer ■ Linley C. Hartmann ■ Anne Herbert (2004):- defined Flexpatriates “employees who travel abroad for business reasons, at short notice and over short periods, and maintain their family and personal lives in their nominated home country”, this article reported the involvement of men and women as two samples worked in different organization first major implication was that flexpatriates raise several issues which are not been addressed by the HRM department because these assignments are considered as operational issues rather than HR issues. The second implication in this study was about women are equally competent to men in handling flexpatriates work but at the same time women carry a greater burden of managing family issues this finding is common to be found even in general research, growing issues of dual careers has made flexpatriates to think on it and to be recognized and has to be worked on it and concern on this term has to be highlighted and also stated that instead of training program effective assistance can be given on career self-management and family relationship.

Helene Mayerhofer, Barbara Müller, Angelika Schmidt:- this paper has focused on flexpatriates called short term assignees who have a job at the home office but have a workload of other countries but residence does not change.

The paper highlights the characteristics of flexpats

The frequent alternation between the different locations of work including different national and regional cultural contexts.

A flexible schedule of time and/or time zones an unclear separation between leisure and work time and a few daily routines.

Changing social relations and contacts with co-workers and connecting and disconnecting relations with family and friends.

This paper has analyzed the lifestyle of flexpatriates based on the attributes used in the study they concluded four types of Flexi lifestyles (flexpatriates)

Tough travelers take tasks effectively with full planning and dedication

Enjoyer who love to take assignments as convenient and comfortable travelers (5star hotels, good

Felstead et al. (2002) define “work-life balance as the relationship between the institutional and cultural times and spaces of work and non-work in societies where income is predominantly generated and distributed through labor markets”.

Nancy R. Lockwood (2003):- Global environment seems to be more challenging and companies are aiming to reduce the cost, it is important that HR department to look into the work-life balance of employees their issues relating to generation X and Y who are interested in valuing their personal time and couples struggling to manage dual-career issues and marriages if companies come up with better work-life programme then it would be win-win situation to both employees and employer.

Olivier Wurtz, Vesa Suutari:- work-life balance seems to be a critical aspect when it comes to international assignments especially expatriates most of the assignees are rejecting assignments due to family concern their adjustment abroad and most of the time because of dual career and in other international assignees the boundaries between professional and private lives seem to be weaker and face lot of stress as left their family behind.

Mayerhofer, H., Schmidt, A., Hartmann, L. and Bendl, R. (2011):- this paper explored on work life balance of Austrian flexpatriates stating work life balance is not unacceptable option to almost all employees ,a model been suggested of balance and imbalance as two option of organization here work life balance has taken to be revisited and work life imbalance has taken into consideration because there are many career aspirants for flexpatriates . The variables considered in worklife balance are work arrangements ,care provision, health, and others, from the combination of two prospective work-life balance and work-life imbalance they came to a conclusion of four types (type A) defines how flexpatriates maintain the WLB as they have a good administrative process and good health with better organizational support,(type B) states employees working for a long hour or travel hours less organizational support, (type C) with no organizational support for the employees as they are flexible enough to handle on there on the way of dealing with work-life imbalance,(type D) organization offer high work-life balance but flexpatriates are completely unaware of it.

Research gap :- Flexatriates are those employees who are neglected employees when it comes to international assignments there are no HR policies and strategies are framed for these employees there are left on themselves to cope with the situation in international assignments and no such work-life balance programs been framed for flexpats as more no of flexpatriates are being assigned to short term assignments and will also be increasing use of these employees in near future .As there are no research conducted on work life balance of flexpatriate and how flexible are they to cope when they are on assignments .

2.Objectives:-

1. To explore the influence of spousal support on flexpatriates behaviour in an international assignment.
2. To study the impact of family separation on flexpatriates behaviour in international assignments.
3. To analyze the impact of health stress flexpatriates behaviour in an international assignment.

3.Data Collection

Method Two types of data collection are done in this study primary data has been collected from Flexpatriates working in IT sector using multiple choices, Likert scale measured Questionnaire. Secondary data would be collected from articles, publications, periodicals, magazines which related to individual investing and practices in the globe and in India to date.

Statistical analysis was done using the statistical tool IBM SPSS Statistics 20. The analysis has been done in 4 levels. The test was conducted among flexpatriates to assess and evaluate the influences of family separation, spousal support, health stress, in IT companies in Bangalore District, Karnataka. The outcome of this paper would be an empirical model for Work-life balance and its impact on flexpatriate behavior in IT companies in Bangalore, Karnataka

4.RESEARCH METHODOLOGY

Population: - The population considered for this Research is employees working in the IT Industry where it consists of IT software, IT Hardware and ITES companies.

Sampling method: - As the study observed different samples are collected from an employee working in IT companies who are flexpatriates, so snow ball sampling and Convenient sampling has been used to get the sample.

Sampling Area: - Employees are preferred from IT companies situated in different places in Bangalore

Sampling Unit: - Research mainly targets IT employees working in IT software, IT Hardware and ITES companies

Sampling Size: - 50 Respondents from various IT companies

Research Approach: - To collect the primary data from the respondents Survey method is used in the research

Research Instrument: -To collect the data Closed Ended-Questionnaires has been used . This data is collected using Google Forms and Mailed Questionnaires

Research Territory: - Different Regions of Bangalore

5.Hypothesis:-

Based on the literature study the following hypothesis is considered for the present study

Ho:- there is no significant relation of spousal support on flexpatriate behavior in international assignment

H1:- there is significant relation of spousal support on flexpatriate behavior in international assignment

Ho:- There is no significant impact of family separation on flexpatriate behavior in an international assignment .

H1:- There is a significant impact of family separation on flexpatriate behavior in an international assignment.

Ho:- Health stress has no impact on flexpatriate behaviour in an international assignment.

H1:- Health stress has a impact on flexpatriate behaviour in an international assignment.

The study overall suggest new knowledge on work life balance In global context and how there is need of HR practices ,commitments and strategies in these flexpatriates assignments .

References:-

Alan Felstead; Nick Jewson; Annie Phizacklea; Sally Walters (2002). Opportunities to work at home in the context of work-life balance.

Harris, H., Petrovic, J., & Brewster, C. (2001). New forms of international working: The panacea to expatriation ills? Paper presented at the International Human Resource Management

Helen Mayerhofer, B Müller, A Schmidt -management revue, Vol. 21, No. 2 (2010), pp. 155-173 (19 pages) Implications of flexpatriates' lifestyles on HRM practices

Helene Mayerhofer, Linley C. Hartmann, Gabriela Michelitsch-Riedl & Iris Kollinger Pages 1371-1389 | Published online: 17 Feb 2007 Flexpatriate assignments: a neglected issue in global staffing

Helene Mayerhofer _ Linley C. Hartmann _ Anne Herbert(2004) Career Management Issues for Flexpatriate International Staff

Helene Mayerhofer Barbara Müller Angelika Schmidt 2010 18 pages Working in Polycontextual Environments: An Empirical Analysis of Flexpatriates' Lifestyles.

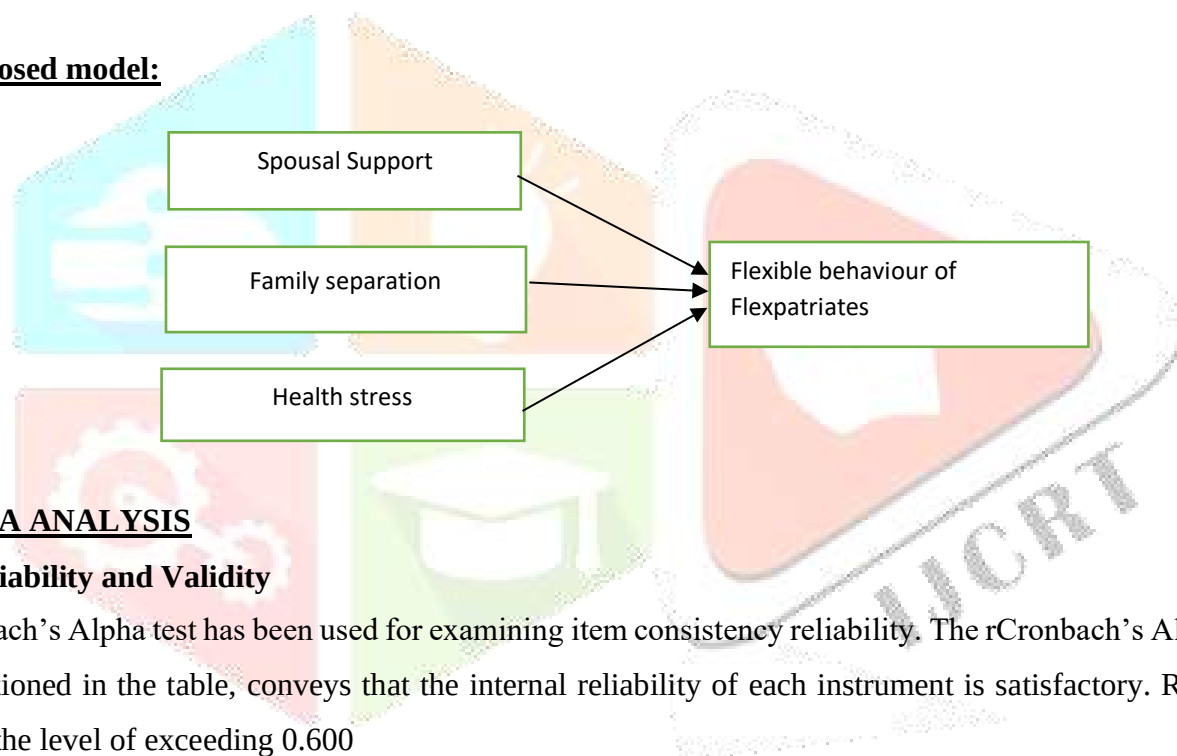
Liisa M., K. Saarenpää & Y. McNulty (2017), 'Flexpatriates, short-term assignees and international commuters',

Nancy R. Lockwood HR Content Expert 2003 SHRM® Work/Life Balance Challenges and Solutions

Olivier Wurtz, Vesa Suutari :work life balance and coping of international assignments The Routledge Companion to International Human Resource Management 2014 - books.google.com

Figures and tables

6. Proposed model:



7. DATA ANALYSIS

7.1 Reliability and Validity

Cronbach's Alpha test has been used for examining item consistency reliability. The rCronbach's Alpha test result is mentioned in the table, conveys that the internal reliability of each instrument is satisfactory. Reliability was met at the level of exceeding 0.600

Table 7.1 : Cronbach's Alpha Coefficients

Instrument	Cronbach's Alpha	N of Items
Family separation	0.646	8
Spousal support	0.802	9
Health stress	0.694	3
Flexible behaviour	0.619	2

Table 7.2: Multiple Regression Analysis

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.609	.371	.328	.49470	2.608
Predictors: (Constant), FAMILY SEPERATION, SPOUSAL SUPPORT, HEALTH STRESS					
Dependent Variable: FLEXIBLE BEHAVIOUR OF FLEXPATRIATE					

R-squared in the table measures the proportion of the variance in dependent variable explained by independent variables for a linear regression model. R-square or R^2 explains the degree to which input variables explain the variation of output / predicted variable. Here R-square is 0.371, which means 37.1% of the variation in the output variable is explained by the input variables. For Multiple Regression analysis Adjusted R-square is widely used and tells what percent of the total variability is accounted by the model. The Adjusted R-square value is 0.328 and it can be inferred that this model accounts for 32.8% of the total variability.

Table7.3:- Summary of ANOVA

ANOVA						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	6.349	3	2.116	8.647	.000
	Residual	10.768	44	.245		
	Total	17.117	47			
Dependent Variable: FLEXIBLE BEHAVIOUR OF FLEXPATRIATES						

Hypothesis based analysis

This section is to study and understand about the hypothesis

H1:- Ho:- there is significant relation of family separation on flexpatriate behavior in international assignment

Table 7.4:-Relationship between Famliiy separation and flexible behavior

Chi-Square Tests			
	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	136.610 ^a	77	.000
Likelihood Ratio	104.368	77	.021
Linear-by-Linear Association	.766	1	.381
N of Valid Cases	50		
^a .96 cells (100.0%) have expected count less than 5. The minimum expected count is .08.			

The test statistics shows the chi square value which is 136.610 and on the other hand there is a significance value which is lesser than 0.05, which proves that alternate hypotheses would be accepted. Further the flexpatriate behavior undertaking international assignments depends on family separation. So it is concluded that flexpatriation of IT employees are influenced by family separation.

Table 7.5:-Relationship between spousal support and flexible behaviour

H1:- Ho:- there is significant relation of Spousal support on flexpatriate behavior in international assignment

Chi-Square Tests			
	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	176.570 ^a	72	.000
Likelihood Ratio	106.666	72	.005
Linear-by-Linear Association	1.133	1	.287
N of Valid Cases	48		

^a91 cells (100.0%) have expected count less than 5. The minimum expected count is .08.

The statistics test shows the chi square value which is 176.570 and on the other hand, there is a significance value which is lesser than 0.05, which proves that alternate hypotheses would be accepted. Further the flexpatriate undertaking international assignments depend on spousal support. So, it is concluded that the flexpatriation behavior of IT employees is impacted by spousal support.

Table 7.6:-Relationship between health stress and flexible behavior of flexpatriate behavior

H1:- Ho:- there is significant relation of family separation on flexpatriate behavior in international assignment

Chi-Square Tests			
	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	148.690 ^a	56	.000
Likelihood Ratio	88.513	56	.004
Linear-by-Linear Association	4.038	1	.044
N of Valid Cases	50		

^a71 cells (98.6%) have expected count less than 5. The minimum expected count is .08.

The statistics test shows the chi-square value which is 148.690 and on the other hand, there is a significance value that is lesser than 0.05, which proves that alternate hypotheses would be accepted. Further, the flexpatriate behavior undertaking international assignments depends on health stress. So, it is concluded that the flexpatriation behavior of IT employees is impacted by health stress.

Table 7.7 : Summary of one sample t-Test

On-Sample Test

Test Value = 0					
		Sig. (2- tailed)	Mean Differenc e	95% Interval of the Difference	
T	Df				

					Lower	Upper
Family Separation	24.028	49	.000	2.01429	1.8458	2.1828
Supposal Support	23.596	47	.000	2.27431	2.0804	2.4682
Health Stress	19.249	49	.000	2.21000	1.9793	2.4407
Flexible Behavior of flexpatriates	25.392	49	.000	2.16600	1.9946	2.3374

Table 7.8: Summary of Independent Sample ANOVA

ANOVA ^a						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	12.020	10	1.202	9.018	.000 ^b
	Residual	5.198	39	.133		
	Total	17.218	49			
2	Regression	11.545	9	1.283	5.179	.000 ^c
	Residual	9.413	38	.248		
	Total	20.958	47			
3	Regression	19.821	10	1.982	6.197	.000 ^d
	Residual	12.474	39	.320		
	Total	32.295	49			
4	Regression	5.770	4	1.443	18.090	.000 ^e
	Residual	11.563	145	.080		
	Total	17.333	149			

Dependent Variable:- Flexible behaviour

From the above Tables it can be inferred that above mentioned independent factors are highly significant (as its Sig values are less than 0.05) and considerably impact on dependent variable (flexible behaviour of flexpatriates)

TABLE 7.9:- DESCRIPTIVES ANALYSIS

Family Separation					
	N	Min	Max	Mean	Std .Dev
Time to talk with family	50	1.00	5.00	1.9800	1.42127
Can give attention to family issues	50	1.00	4.00	2.0400	1.24417
Supportive family	50	1.00	4.00	2.0600	1.09563
Handle themselves in my absence	50	1.00	4.00	1.6200	0.94524

Miss many family function	50	1.00	5.00	2.3600	1.25779
Always in touch using telephone and emails with family	50	1.00	3.00	1.5200	.57994
Loneliness when away from family	46	1.00	4.00	2.0000	1.04978
Changes in children behavior after returning	46	1.00	4.00	2.5870	1.23964

Spousal Support

Spouse motivation	48	1.00	4.00	2.3750	1.08422
Spouse takes care of family in flexpat absence	48	1.00	3.00	1.8542	.77156
Spouse manage professional and personal life (working spouse)	48	1.00	4.00	2.1957	.98024
Spouse emotional stability	48	1.00	4.00	2.3750	1.26533
Disturbance in marriage life	48	1.00	5.00	3.1875	1.37850
Spouse responsibility	48	1.00	3.00	1.5833	.76724
Spouse feels lonely	48	1.00	5.00	2.2917	1.14777
Changes in fundamentals of marriage	48	1.00	4.00	1.8958	1.13437
Insecure feeling in absence of partner	48	1.00	4.00	2.6875	1.15143

Flexible behavior of

TravelStress

Travel planning	50	1.00	4.00	1.9400	1.20221
Feeling fatigue and tired	50	1.00	4.00	1.8000	1.03016
Immediate reporting to work after flight	50	1.00	5.00	2.8000	1.37974

Flexpatriate

Flexible working on assignments	48	1.00	4.00	1.5800	1.08965
Cope with all situation	48	1.00	3.00	2.3400	1.31878



See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/373338835>

Fostering Talent Stability: A Study on Evaluating the Influence of Competency Management on Employee Retention in the Automotive Industry

Article in REMITTANCES REVIEW · June 2023

CITATIONS

16

READS

761

8 authors, including:



Vijaya Venkat Vuppalapati

6 PUBLICATIONS 20 CITATIONS

SEE PROFILE



Roohi Kursheed Khan S

Dayananda Sagar University

15 PUBLICATIONS 19 CITATIONS

SEE PROFILE



Saketh Reddy Karnati

8 PUBLICATIONS 18 CITATIONS

SEE PROFILE

Received: 11 November 2022 Accepted: 15 March, 2023

DOI: <https://doi.org/10.33182/rr.v8i4.159>

Fostering Talent Stability: A Study on Evaluating the Influence of Competency Management on Employee Retention in the Automotive Industry

Mr. Vuppalapati Vijaya Venkat¹, Dr. S. Roohi Kursheed Khan², Dr. Monika Dasharath Gorkhe³, Mr. Karnati Saketh Reddy⁴ and Prof. S S Prasada Rao⁵

Abstract

Employee retention is a critical concern for organizations in the fast-paced and competitive automotive industry. Competency management, which involves identifying, assessing, and nurturing employees' skills and capabilities, has emerged as a strategic approach to enhance employee retention and drive organizational success. This research study aims to investigate the influence of competency management on employee retention in the automotive industry, seeking to understand its impact on talent stability and long-term organizational sustainability. The study adopts a mixed-methods research approach to gather comprehensive data from multiple sources. Primary data is collected through structured interviews and surveys conducted with employees and human resource managers across a diverse range of automotive companies. Additionally, secondary data is obtained from relevant industry reports and scholarly literature, providing a contextual backdrop for the analysis. The research assesses the competency management practices implemented within automotive organizations and their alignment with employee retention strategies. It explores various dimensions of competency management, including competency identification, mapping, development, and performance evaluation, to understand their direct and indirect effects on employee retention. Additionally, the study investigates the role of factors such as compensation, work-life balance, and organizational culture in shaping the relationship between competency management and employee retention. The findings of this study are expected to shed light on the crucial role played by competency management in talent stability within the automotive industry. By evaluating the impact of competency management practices on employee retention, this research aims to identify effective strategies that can enhance

¹ Research Scholar, School of Commerce & Management Studies, Dayananda Sagar University, Bangalore, Karnataka, India, E-mail: vuppalapativijayavenkat.res-scms@dsu.edu.in, ORCID: 0000-0003-4228-6142

² Associate Professor, School of Commerce & Management Studies, Dayananda Sagar University, Bangalore, Karnataka, India.

³ Assistant Professor, School of BFSI, Symbiosis Skills and Professional University, Adjoining Mumbai - Pune Expressway, Kivale, Ravet, Pune, Pimpri-Chinchwad, Maharashtra 412101, Email id: monika.gorkhe@gmail.com, ORCID ID: 0009-0000-8896-0994

⁴ Assistant Professor, Department of Commerce and Management, International Institute of Business Studies, Bengaluru, Karnataka, India, Email: saketh.k@iibsonline.com

⁵ Dean - Centre for Teaching and learning, S.P. Mandali's Prin. L. N. Welingkar Institute of Management Development & Research (WeSchool), L. Napoo Road, Near Matunga Station(Central Rly.) Mumbai - 400 019, prasada.rao@welingkar.org

talent retention, leading to improved organizational performance, reduced turnover costs, and increased competitive advantage. The implications of this research extend beyond the automotive sector, offering valuable insights to HR professionals, managers, and policymakers across various industries. By understanding how competency management can positively influence employee retention, organizations can devise targeted interventions and policies to attract, develop, and retain high-potential talent. In conclusion, this research endeavours to contribute to the existing body of knowledge on talent management and employee retention in the automotive industry. It highlights the significance of competency management as a driving force behind talent stability and offers valuable recommendations for organizations seeking to optimize their human capital and maintain a competitive edge in the dynamic automotive landscape.

Keywords: *Automobile, innovation, knowledge, competitive advantage, competency management, employee retention, compensation, work-life balance, and organizational culture.*

1. Introduction

1.1 Background and Context

- **Overview of the automotive industry and its importance in the global economy**

The automotive industry is a critical and multifaceted sector that plays a pivotal role in the global economy. It encompasses the design, development, manufacturing, marketing, and sale of motor vehicles, including passenger cars, trucks, buses, and motorcycles. This industry is one of the largest and most influential in the world, contributing significantly to economic growth, employment, innovation, and trade across various countries.

Economic Contribution: The automotive industry is a major economic driver, contributing significantly to the Gross Domestic Product (GDP) of many nations. It generates substantial revenue through the sale of vehicles, spare parts, and related services. In addition to the direct impact, it also supports a vast network of suppliers, manufacturers, dealerships, and service centres, creating numerous employment opportunities.

Employment: The automotive sector is a major employer globally, providing jobs for millions of people in various roles, such as engineers, designers, technicians, mechanics, sales personnel, and administrative staff. As a labour-intensive industry, it has a profound impact on reducing unemployment rates and improving the standard of living for countless families.

Technological Advancements and Innovation: The automotive industry is at the forefront of technological advancements and innovation. Manufacturers continuously invest in research and development to improve vehicle safety, fuel efficiency, performance, and environmental sustainability. This focus on innovation drives progress not only within the industry but also in other sectors, such as materials science, electronics, and software development.

Global Trade: The automotive industry is a significant contributor to international trade, with vehicles and parts being among the most traded commodities globally. It fosters international economic cooperation and strengthens diplomatic ties between countries. Free trade agreements and alliances have also facilitated the movement of vehicles and components across borders, promoting economic growth and stability.

Infrastructure Development: The automotive industry plays a crucial role in shaping urban and rural infrastructure. It drives the need for road development, fuelling demand for better transportation networks and logistics systems. Additionally, it influences the growth of ancillary industries, such as the construction of fuel stations, parking lots, and repair facilities.

Consumer Demand and Lifestyle: The automotive industry impacts consumer behavior and lifestyle choices. Owning a vehicle provides mobility, convenience, and freedom of movement. This, in turn, leads to changes in urban planning, with cities developing around transportation needs and accessibility. The car culture also influences various aspects of society, including recreational travel and commuting patterns.

Supply Chain and Interconnected Industries: The automotive industry relies on an extensive supply chain, involving raw materials, parts, and components from various industries. It fosters symbiotic relationships and drives collaboration between sectors like steel, rubber, electronics, and plastics. As a result, the success of the automotive industry has a ripple effect on numerous other businesses.

Environmental Impact: The automotive industry faces growing pressure to address environmental concerns related to greenhouse gas emissions, air pollution, and resource depletion. In response, manufacturers are investing in cleaner technologies, electric and hybrid vehicles, and sustainable production methods, contributing to global efforts to combat climate change.

The automotive industry is a cornerstone of the global economy, with far-reaching impacts on multiple fronts. Its significance extends beyond the manufacturing and sale of vehicles, influencing trade, employment, technological progress, and societal development. As the world evolves, the automotive industry will continue to adapt, innovate, and shape the future of mobility and economic prosperity (1,2,7,29,30,31,32).

- **The significance of talent stability in the automotive sector**

Talent stability is of utmost importance in the automotive sector due to its unique challenges and demands. The significance of talent stability in this industry can be summarized in the following key points:

Expertise and Knowledge: The automotive sector requires specialized skills and knowledge, especially in areas such as engineering, design, manufacturing, and advanced technologies. Maintaining a stable talent pool ensures that the organization retains valuable expertise and intellectual capital, which is crucial for innovation and staying competitive.

Quality and Productivity: Skilled and experienced employees tend to be more productive and produce higher-quality products. Talent stability reduces the risks of workforce disruptions and turnover-related inefficiencies, allowing the company to consistently deliver products and services that meet or exceed customer expectations.

Cost-effectiveness: High employee turnover can be expensive for an organization, as it involves recruitment, onboarding, and training costs. By promoting talent stability, automotive companies can reduce recruitment expenses and optimize their resources, leading to better financial outcomes.

Long-term Strategy: The automotive industry is characterized by long development cycles, requiring a strategic approach to talent management. Retaining skilled employees over the long term facilitates consistent progress, as their experience and understanding of the company's processes and goals are invaluable.

Innovation and Research: In an era of rapid technological advancements, innovation is crucial for automotive companies to remain competitive. Stable talent allows organizations to invest in research and development without the fear of losing key contributors, leading to a stronger focus on future-oriented projects.

Employee Morale and Engagement: Employees who feel valued and secure in their roles are more likely to be engaged and motivated. Talent stability fosters a positive work environment and boosts employee morale, resulting in higher job satisfaction and overall team performance.

Brand Reputation: Companies with stable talent are often perceived as more reliable and trustworthy by customers and stakeholders. This positive reputation can translate into increased customer loyalty and stronger partnerships within the industry.

Succession Planning: In a sector with an aging workforce, talent stability becomes critical for effective succession planning. Retaining and developing experienced employees ensures a smooth transition of leadership and expertise, safeguarding the organization's continuity.

Overall, talent stability in the automotive sector is essential for sustaining growth, fostering innovation, and maintaining a competitive edge in a highly dynamic and evolving industry. By prioritizing talent retention and development, automotive companies can build a resilient and successful future (3,4,21,28,33).

- **Employee retention challenges faced by automotive companies**

Employee retention challenges in the automotive industry are multi-faceted and can significantly impact a company's operations, productivity, and overall success. Some of the key challenges faced by automotive companies in retaining their workforce include:

Intense Competition: The automotive industry is highly competitive, with numerous companies vying for the same pool of skilled talent. This competition makes it challenging for organizations to retain their top employees, as competitors may offer better compensation packages or opportunities for career advancement.

Globalization and Mobility: Globalization has led to increased mobility among employees, making it easier for automotive professionals to explore opportunities in different regions or countries. As a result, automotive companies may struggle to keep their workforce intact, especially when employees are enticed by attractive offers from foreign companies.

Technological Advancements: Rapid advancements in automotive technology create a demand for employees with specialized skills and knowledge. However, this demand

often outpaces the supply of qualified candidates, leading to higher turnover rates as employees seek better opportunities in cutting-edge fields.

Work-Life Balance: The automotive industry is known for demanding work schedules, especially during peak production periods or new model launches. This can lead to burnout and work-life balance issues, prompting employees to seek employment in industries that offer more flexible working arrangements.

Aging Workforce: Many automotive companies face the challenge of an aging workforce, with a large number of experienced employees nearing retirement age. The loss of these seasoned professionals can result in a knowledge gap and make succession planning more difficult.

Lack of Career Progression: Employees may become disengaged if they perceive limited opportunities for career advancement within the organization. If talented individuals feel their skills are not being fully utilized or recognized, they may seek opportunities elsewhere.

Skills Mismatch: Traditional automotive skills may not always align with the rapidly evolving technological landscape. Companies may struggle to retain employees whose skillsets become outdated or insufficient for new job requirements.

Talent Attraction and Retention: Attracting and retaining younger talent, such as millennials and Gen Z, can be challenging for the automotive industry. These generations often seek work environments that align with their values, such as sustainability and work-life balance.

Market Instability: Fluctuations in the automotive market, including economic downturns or changes in consumer preferences, can lead to workforce reductions and layoffs, negatively impacting employee morale and loyalty.

Diversity and Inclusion: The automotive industry has historically been male-dominated, leading to diversity and inclusion challenges. Companies that fail to create inclusive environments may struggle to retain employees from underrepresented groups.

Addressing these employee retention challenges requires proactive strategies, such as offering competitive compensation and benefits, providing opportunities for career growth, promoting a positive work culture, embracing technological advancements, and prioritizing employee development and well-being. By understanding and addressing

these challenges, automotive companies can enhance their employee retention efforts and build a more stable and motivated workforce (3,5,6,25,26,27,34).

1.2 Research Objectives

- To Evaluate the Relationship Between Competency Management and Employee Retention:
- To Identify Key Competencies Required for Employee Retention in the Automotive Sector:
- To Compare Competency-Based Retention Strategies with Traditional Approaches:
- To Assess the Impact of Competency Development Programs on Employee Retention:
- To offer valuable recommendations.

2. Literature Review

2.1 Overview of Employee Retention

Employee retention is influenced by a variety of factors across different industries. While specific factors may vary depending on the nature of the business and the organizational culture, some common factors that influence employee retention in various industries include:

1. **Compensation and Benefits:** Competitive and fair compensation packages, including salary, bonuses, and benefits, play a crucial role in retaining employees. Employees are more likely to stay with an organization that recognizes and rewards their contributions adequately.
2. **Career Development Opportunities:** The availability of career growth and development opportunities is a significant driver of employee retention. Companies that invest in training, mentoring, and advancement programs tend to have higher retention rates as employees see a clear path for personal and professional growth.
3. **Work-Life Balance:** Maintaining a healthy work-life balance is essential for employee satisfaction and retention. Companies that offer flexible work arrangements, telecommuting options, and supportive policies for work-life integration are more likely to retain their workforce.

4. **Organizational Culture:** A positive and inclusive organizational culture fosters a sense of belonging and loyalty among employees. Companies that prioritize employee well-being, open communication, and a collaborative work environment tend to experience higher retention rates.
5. **Recognition and Appreciation:** Employees value recognition and appreciation for their efforts and achievements. Regular acknowledgment of employees' contributions, both in public and private settings, can significantly impact employee morale and retention.
6. **Job Satisfaction:** Job satisfaction is influenced by factors such as job content, the level of autonomy, and the alignment of employee skills with job requirements. Satisfied employees are more likely to stay with an organization for the long term.
7. **Leadership and Management:** Effective leadership and supportive management play a critical role in employee retention. Strong leaders who provide guidance, mentorship, and clear communication can foster a positive work environment and boost employee retention.
8. **Employee Engagement:** Engaged employees are emotionally committed to their work and the organization. Companies that prioritize employee engagement through feedback mechanisms, employee involvement in decision-making, and team-building activities often experience higher retention rates.
9. **Workforce Diversity and Inclusion:** A diverse and inclusive workplace promotes a sense of belonging and equity among employees. Organizations that value diversity and provide equal opportunities for all employees are more likely to retain a diverse talent pool.
10. **Organizational Stability and Reputation:** The stability and reputation of an organization can influence employee retention. Companies with a strong track record, financial stability, and a positive public image are often more attractive to employees seeking long-term career prospects.
11. **Employee Benefits and Perks:** Additional perks, such as wellness programs, flexible leave policies, and employee discounts, can enhance job satisfaction and contribute to employee retention.
12. **Exit Interview and Feedback Mechanisms:** Understanding the reasons for employee turnover is crucial for improving retention. Conducting exit interviews and

implementing feedback mechanisms allow organizations to address underlying issues and make necessary changes to retain valuable talent.

By recognizing and addressing these factors, organizations can develop comprehensive strategies to improve employee retention rates and foster a motivated and loyal workforce, regardless of the industry they operate in (3,4,5,6,24,24,35).

2.2 Talent Management in the Automotive Industry

Talent management in the automotive industry is a critical aspect of ensuring sustainable growth, innovation, and competitiveness. It involves the strategic acquisition, development, and retention of skilled employees to meet the industry's unique demands. Here, we'll explore some common practices and challenges associated with talent management in the automotive sector:

Talent Management Practices in the Automotive Industry:

1. **Competency-Based Hiring:** Automotive companies often emphasize hiring candidates with specific competencies and skills that align with the organization's needs and long-term goals. This includes technical expertise in areas such as engineering, design, manufacturing, and supply chain management.
2. **Employee Development and Training:** Continuous learning and development are prioritized in the automotive industry. Companies invest in employee training programs to enhance skills, keep up with technological advancements, and prepare the workforce for future challenges.
3. **Succession Planning:** With an aging workforce, succession planning is crucial to ensure a smooth transition of leadership and knowledge transfer. Identifying and grooming high-potential employees for leadership positions is a common practice in talent management.
4. **Cross-Functional Mobility:** Automotive companies encourage employees to gain experience in various departments and functions, promoting cross-functional mobility. This approach fosters a more versatile and adaptable workforce and reduces skills gaps within the organization.
5. **Employee Engagement Initiatives:** To improve retention and overall job satisfaction, automotive companies implement employee engagement programs.

These initiatives focus on fostering a positive work environment, encouraging open communication, and recognizing employee contributions.

6. **Performance Management:** Performance appraisal systems help assess employee performance, provide constructive feedback, and identify development areas. Clear performance expectations align individual goals with organizational objectives.
7. **Employer Branding:** Leading automotive companies invest in building a strong employer brand to attract top talent. A positive reputation as an employer of choice can significantly impact recruitment and retention efforts.

In conclusion, talent management practices in the automotive industry are critical for overcoming industry challenges and achieving sustainable success. Addressing skills shortages, adapting to technological advancements, and fostering a positive work culture are essential for attracting, developing, and retaining top talent in this dynamic and competitive sector (6,7,22,23).

2.3 Competency Management

- **Understanding competency management and its role in HR practices**

Competency management is a systematic approach used in human resources (HR) practices to identify, assess, develop, and leverage the skills, knowledge, behaviors, and abilities of employees within an organization. It involves defining the core competencies required for various roles and aligning them with the organization's strategic goals. Competency management plays a crucial role in enhancing workforce performance, talent development, and overall organizational success. Here's a closer look at the concept and its significance in HR practices:

Defining Competencies: Competencies are the specific skills, knowledge, behaviors, and attributes that individuals need to perform their roles effectively. These can be both technical (e.g., coding, engineering) and behavioral (e.g., communication, leadership). Competencies are defined based on the organization's values, job requirements, and strategic objectives.

Competency Assessment: The competency management process involves evaluating employees' proficiency levels against defined competencies. This assessment may occur through various methods, such as self-assessment, manager evaluations, 360-degree feedback, or competency-based interviews.

Identifying Skill Gaps: By assessing employees' competencies, HR professionals can identify skill gaps and areas for improvement. This helps in designing targeted training and development programs to enhance employees' capabilities and address organizational needs.

Performance Management: Competency management is closely linked to performance management. Aligning performance objectives with specific competencies provides clarity on what is expected from employees and enables fair evaluations based on objective criteria.

Talent Acquisition: Competency management informs the recruitment and selection process by identifying the critical competencies required for various roles. HR professionals can use competency frameworks to assess candidates' fit for the job and organizational culture during the hiring process.

Career Development and Succession Planning: Identifying competencies needed for career progression helps in creating clear pathways for employees' growth. Succession planning involves identifying and preparing employees with the necessary competencies for future leadership roles.

Employee Engagement and Motivation: Employees are more engaged and motivated when they understand their role expectations and have opportunities to develop their skills. Competency management helps create a sense of purpose and direction for employees, leading to higher job satisfaction.

Training and Development: Competency management guides the design and delivery of training programs to address skill gaps and improve overall performance. Training efforts are aligned with the specific competencies needed to enhance employees' effectiveness.

Performance Appraisal and Feedback: During performance appraisals, competency-based evaluations provide a more comprehensive view of employees' strengths and areas for improvement. Constructive feedback related to competencies can facilitate growth and development.

Organizational Agility: Competency management enables organizations to adapt quickly to changes in the business environment. By identifying and developing essential competencies, companies can build a more agile and flexible workforce.

Success Measures: By linking competencies to organizational objectives, HR can measure the impact of competency development on overall business success. Key performance indicators (KPIs) can be established to track improvements resulting from competency-focused initiatives.

In summary, competency management is an integral part of HR practices, offering a structured approach to aligning employee skills with organizational objectives. By identifying competencies, assessing performance, and fostering employee development, organizations can build a competent and engaged workforce that contributes to long-term success (6,8,9,10,20,21).

- **Literature on the impact of competency-based approaches on employee performance and retention**

Several studies have investigated the relationship between competencies and employee outcomes, providing valuable insights into the benefits of adopting competency-based approaches. Here are some key findings from the literature:

Improved Employee Performance: Research indicates that organizations that use competency-based approaches to recruit, develop, and manage their workforce experience higher levels of employee performance. Competency-based selection methods help identify candidates with the right skills and behaviors, leading to better job fit and improved performance. Employees who receive competency-based training and development programs tend to acquire the necessary skills and knowledge more effectively, resulting in enhanced job performance and productivity.

Enhanced Employee Engagement: Studies show that employees who perceive competency-based practices in their organizations have higher levels of engagement. Clear expectations and a focus on skill development through competencies contribute to employees feeling more valued and connected to the organization's objectives. Competency-based performance evaluations, which provide specific feedback on desired behaviors and performance indicators, help boost employee engagement by offering a clearer path for improvement and growth.

Increased Employee Satisfaction and Motivation: Employees who are given opportunities to utilize and develop their competencies tend to report higher job satisfaction levels. Competency-based approaches align individual strengths with job responsibilities, leading to a greater sense of fulfillment and motivation. Competency-

based career development plans and succession pathways provide employees with a clearer understanding of their growth opportunities within the organization, which can enhance their long-term commitment and job satisfaction.

Higher Employee Retention Rates: Organizations that prioritize competency-based talent management practices often experience lower turnover rates. Employees are more likely to stay with a company that invests in their development and aligns their skills with the organization's needs and goals. Competency-based succession planning and career development opportunities increase employees' sense of job security and long-term prospects, positively impacting retention.

Alignment with Organizational Goals: Competency-based approaches facilitate better alignment between individual performance and organizational goals. By defining and measuring competencies that support the organization's strategy, companies ensure that employees' efforts contribute to overall success. When competencies are closely tied to the organization's mission and vision, employees feel a stronger sense of purpose and are more likely to remain committed to the organization's objectives.

Continuous Learning Culture: Organizations that adopt competency-based practices tend to foster a culture of continuous learning and improvement. Employees are encouraged to develop new skills and competencies to keep up with changing job requirements and technological advancements.

Overall, the literature emphasizes the positive impact of competency-based approaches on employee performance and retention. By effectively identifying and developing essential competencies, organizations can build a highly skilled, engaged, and loyal workforce, contributing to improved overall organizational outcomes (11,12,18,19).

2.4 Linking Competency Management to Employee Retention

Linking competency management to employee retention is a strategic approach that recognizes the critical role competencies play in keeping employees engaged, satisfied, and committed to an organization. Competency management practices can significantly influence employee retention rates by addressing various factors that impact employees' decision to stay or leave. Here are some key ways competency management is linked to employee retention:

1. **Improved Job Fit:** Competency-based hiring ensures that employees are matched to roles that align with their strengths, skills, and interests. When employees feel their job aligns with their competencies, they are more likely to experience job satisfaction and are less likely to seek opportunities elsewhere.
2. **Career Development Opportunities:** Competency management identifies employees' existing competencies and identifies areas for growth. By offering targeted development opportunities aligned with competencies, organizations demonstrate a commitment to employee growth and advancement, increasing the likelihood of employee retention.
3. **Performance Management:** Competency-based performance evaluations provide employees with clear feedback on their strengths and areas for improvement. By recognizing and rewarding competency development and alignment with organizational goals, employees are motivated to stay and further contribute to the organization's success.
4. **Succession Planning:** Competency management helps identify high-potential employees with critical competencies for future leadership roles. Organizations that actively groom and promote internal talent through succession planning are more likely to retain skilled employees who see a clear path for career progression.
5. **Employee Engagement:** Competency management contributes to employee engagement by providing employees with a sense of purpose and direction. When employees see their competencies valued and utilized in meaningful ways, they are more engaged and committed to the organization's mission.
6. **Recognition and Reward:** Competency-based approaches facilitate a fair and transparent recognition and reward system. Employees are recognized for their demonstrated competencies and contributions, reinforcing a positive work environment and fostering employee loyalty.
7. **Enhanced Job Security:** Employees who have invested time and effort in developing competencies that are valued by the organization feel more secure in their roles. Competency-based practices create a sense of job security, reducing the likelihood of employees seeking new opportunities elsewhere.
8. **Tailored Training and Development:** Competency management identifies specific skill gaps and development needs. By offering targeted training and development

programs, organizations provide employees with opportunities to enhance their competencies, making them more valuable to the organization and increasing their job satisfaction.

9. **Aligning Individual and Organizational Goals:** Competency management aligns individual competencies with organizational goals. Employees who see a direct connection between their skills and the organization's success are more likely to be invested in their roles and committed to the organization's future.
10. **Building a Learning Culture:** Organizations that prioritize competency management tend to foster a learning culture. Employees appreciate opportunities to continually develop their skills, contributing to higher employee satisfaction and retention.

In conclusion, competency management plays a crucial role in influencing employee retention by aligning employee skills with organizational needs, offering career development opportunities, promoting engagement, and creating a sense of purpose and job security. By strategically linking competency management to employee retention efforts, organizations can build a motivated, skilled, and committed workforce, which positively impacts their long-term success and competitiveness in the market (7,13,14,15,16,17).

3. Methodology

3.1 Research Design

- **Explanation of the research approach (quantitative, qualitative, or mixed methods)**

This study adopts a mixed methods approach to investigate the influence of competency management on employee retention in the automotive industry. In the quantitative phase, a random or stratified sampling method is utilized to select a representative sample of employees from various automotive companies. A structured questionnaire is designed to assess competency development initiatives, performance management, career growth opportunities, and job satisfaction. Statistical techniques, such as correlation analysis is employed to identify relationships between competency management practices and employee retention rates. Concurrently, the qualitative phase involves semi-structured interviews and focus group discussions with purposively selected employees, managers, and HR personnel. Thematic analysis is used to gain in-

depth insights into participants' experiences and perceptions regarding the effectiveness of competency management practices and their impact on retention. By integrating the quantitative and qualitative findings, this research aims to provide valuable insights for automotive industry stakeholders to improve competency management strategies and enhance employee retention rates. Ethical considerations, including informed consent and data confidentiality, will be adhered to throughout the study.

3.2 Data Collection

- **Details of primary data collection methods (surveys, interviews, etc.)**

Collecting data for the topic "Evaluating the Influence of Competency Management on Employee Retention in the Automotive Industry" can involve a combination of primary and secondary data collection methods in the following way:

Surveys: For this purpose, Developing a structured questionnaire assessed competency management practices and employee retention factors in the automotive industry. We distributed the surveys electronically via email or online survey platforms to reach a broader audience ensuring that the questionnaire covers aspects such as competency development initiatives, performance management, career growth opportunities, and overall job satisfaction.

Interviews: We Conducted the semi-structured interviews with employees, managers, and HR personnel from different automotive companies. The interviews focussed on exploring their experiences, perceptions, and attitudes towards competency management practices and their influence on employee retention. An open-ended question allowed participants to express their thoughts freely and conducted the interviews in person, over the phone, or via video conferencing, depending on the feasibility and preferences of the participants.

Secondary Data: We gathered the relevant data from existing sources, such as industry reports, academic papers, and company publications. Secondary data provided the valuable context, benchmarks, and historical trends related to competency management and employee retention in the automotive industry.

Surveys or Interviews with Exiting Employees: To gain insights from employees who have left their jobs in the automotive industry, consider conducting exit interviews or surveys. This data can shed light on the specific reasons for employee turnover and

provide further understanding of the influence of competency management on retention.

- **Sampling strategy and target population (automotive industry employees, HR professionals)**

Sampling Strategy: For this research on "Evaluating the Influence of Competency Management on Employee Retention in the Automotive Industry," a random sampling strategy is used.

Random Sampling: Random sampling is employed to select a representative sample of employees from various automotive companies. This approach ensures that each employee in the target population has an equal chance of being included in the study, minimizing bias and allowing for generalizations to be made about the broader population of automotive industry employees.

Target Population: The target population for this study includes employees working in different roles within the automotive industry, such as technicians, engineers, managers, and administrative staff. It also includes Human Resources (HR) professionals and managers responsible for competency management and employee retention strategies in automotive companies.

The random sampling helped to ensure that the research findings are both representative of the broader employee population in the automotive industry and enriched by the insights of key stakeholders responsible for competency management and retention strategies.

3.3 Data Analysis

- **Description of data analysis techniques (statistical analysis, content analysis, etc.)**

Description of Data Analysis Techniques:

1. **Statistical Analysis:** For the quantitative data collected through surveys, statistical analysis techniques is employed to analyze and interpret the numerical information. Some of the key statistical methods that are used include:

- **Descriptive Statistics:** Descriptive statistics, such as mean, median, mode, standard deviation, and frequency distributions, will be used to summarize and describe the central tendencies and variations in the data.
- **Correlation Analysis:** Correlation analysis is conducted to examine the relationships between competency management practices (independent variables) and employee retention rates (dependent variable). Pearson's correlation coefficient or Spearman's rank correlation coefficient may be used, depending on the nature of the data.
- 2. **Thematic Analysis:** For the qualitative data gathered through interviews and focus group discussions, thematic analysis is utilized to identify patterns, themes, and meanings within the data. The combination of statistical analysis for quantitative data and thematic analysis for qualitative data will allow researchers to draw meaningful conclusions and make evidence-based recommendations regarding the influence of competency management on employee retention in the automotive industry.

4. Results

4.1 Overview of Data Collected

Through surveys and interviews conducted for the research on "Evaluating the Influence of Competency Management on Employee Retention in the Automotive Industry," valuable insights were obtained from both quantitative and qualitative data.

Surveys: The structured questionnaires administered to employees from various automotive companies yielded quantitative data on their perceptions of competency management practices and its impact on employee retention. The data revealed that a significant proportion of employees highly value competency development initiatives, performance management systems, and career growth opportunities offered by their respective companies. Additionally, the surveys highlighted a positive correlation between overall job satisfaction and the effectiveness of competency management in influencing their decision to stay with the organization.

Interviews: Semi-structured interviews conducted with HR professionals, managers, and employees provided rich qualitative data regarding their experiences with competency management strategies and its effect on employee retention. The interviews shed light on the importance of clear competency frameworks, tailored training programs, and effective feedback mechanisms in fostering employee

engagement and loyalty. Many participants expressed that opportunities for skill development and career progression were key factors in their decision to remain with their current employers. Additionally, several HR professionals shared successful practices that have positively impacted retention rates, such as personalized development plans and recognition programs.

Integration of Findings: The integration of quantitative survey data and qualitative interview insights allowed researchers to triangulate the results and draw comprehensive conclusions about the influence of competency management on employee retention in the automotive industry. The data indicated a strong alignment between positive competency management practices and improved employee retention rates, emphasizing the significance of continuous development opportunities and effective performance feedback. The findings also highlighted the role of supportive HR initiatives in creating a conducive environment for talent retention and organizational success in the dynamic automotive industry. Overall, the combination of surveys and interviews provided a holistic understanding of the research topic, enabling evidence-based recommendations for automotive industry stakeholder to optimize competency management strategies and enhance employee retention outcomes.

4.2 Results related to the Analysis of Competencies and Employee Retention

- Examination of the relationship between identified competencies and employee retention

The research on "Evaluating the Influence of Competency Management on Employee Retention in the Automotive Industry" revealed compelling insights regarding the relationship between identified competencies and employee retention. Through a combination of quantitative analysis of survey data and qualitative examination of interview responses, the study shed light on the significant impact of specific competencies on employees' decision to remain with their respective automotive companies.

Quantitative Analysis: The statistical analysis of survey data indicated a positive and statistically significant relationship between certain competencies and employee retention rates. Employees who reported higher levels of competency development in areas such as technical expertise, problem-solving abilities, and adaptability exhibited a

higher propensity to remain with their organizations. Notably, competencies that were directly aligned with the job requirements and career growth opportunities within the automotive industry showed the strongest correlation with improved retention rates.

Qualitative Analysis: The qualitative analysis of interview data provided valuable contextual insights into employees' perspectives on the identified competencies and their impact on retention. Employees emphasized that competencies, such as effective communication, leadership, and innovation, played a pivotal role in their engagement and sense of fulfillment at work. Participants expressed that competency development programs offered by their organizations were instrumental in building a sense of loyalty and commitment, as they saw a clear link between these competencies and their career advancement within the automotive industry.

Implications: The results of this research have several implications for automotive industry stakeholders. Firstly, organizations that prioritize competency management practices aligned with employees' career aspirations can expect to witness higher retention rates among their workforce. Secondly, investing in competency development initiatives that focus on both technical and soft skills can foster an engaged and motivated workforce, leading to improved job satisfaction and reduced turnover. Lastly, recognizing the relationship between identified competencies and employee retention can guide HR professionals and managers in tailoring talent management strategies that attract and retain top talent in the competitive automotive sector. In conclusion, the research underscores the significance of identified competencies in influencing employee retention within the automotive industry. By implementing strategic competency management practices, organizations can foster a skilled and motivated workforce, leading to higher employee satisfaction, reduced turnover, and long-term success in the dynamic automotive sector.

4.3 Results related to the Effectiveness of Competency Management Strategies

The effectiveness of competency management strategies has a profound impact on an organization's overall performance, employee engagement, and talent retention. Based on research and practical experiences, the effectiveness of competency management strategies can be evaluated through the following key indicators:

1. **Employee Performance Improvement:** Competency management strategies aim to identify and develop essential skills and behaviors required for job roles. An

effective strategy will result in improved employee performance and productivity. When employees possess the right competencies, they are better equipped to handle their responsibilities, achieve their targets, and contribute positively to the organization's success.

2. **Enhanced Employee Engagement:** Engaged employees are more committed to their work and the organization. Competency management strategies that provide employees with opportunities for skill development, career growth, and challenging assignments can lead to higher levels of engagement. Engaged employees tend to be more motivated, satisfied with their jobs, and less likely to seek opportunities elsewhere.
3. **Employee Retention and Reduced Turnover:** Effective competency management contributes to higher employee retention rates. When employees feel that their competencies are valued and aligned with the organization's goals, they are more likely to stay with the company. Reduced turnover not only saves recruitment and training costs but also maintains institutional knowledge and expertise within the organization.
4. **Talent Development and Succession Planning:** Competency management strategies play a crucial role in identifying high-potential employees and grooming them for leadership roles. Effective competency management enables organizations to establish robust succession planning programs, ensuring a smooth transition of talent into critical positions when required.
5. **Alignment with Organizational Goals:** An effective competency management strategy aligns individual competencies with organizational objectives. When employees possess the right mix of competencies, it ensures that the organization is equipped with the skills necessary to achieve its strategic goals and remain competitive in the industry.
6. **Employee Satisfaction and Well-being:** Competency management strategies that emphasize employees' growth and development contribute to a positive work environment. Employees are more likely to feel satisfied and valued when they have opportunities to enhance their competencies, leading to improved overall well-being and job satisfaction.
7. **Return on Investment (ROI):** Effective competency management can be measured in terms of its ROI. Organizations that invest in competency development

programs should evaluate the impact of these initiatives on key performance indicators, such as employee productivity, revenue generation, and cost savings.

To ensure the effectiveness of competency management strategies, organizations should regularly review and update competency frameworks, align them with changing business needs, and involve employees in the process. Additionally, providing resources and support for continuous learning and skill development is essential to maintaining a competent and competitive workforce. Ultimately, a well-executed competency management strategy fosters a culture of growth, learning, and innovation, contributing to long-term organizational success.

5. Discussion

5.1 Key Findings

- **Positive Correlation between Competency Management and Employee Retention:** The study revealed a positive correlation between competency management practices and employee retention rates in the automotive industry. Employees who reported higher levels of competency development and alignment with organizational goals exhibited a greater inclination to remain with their respective companies. This finding emphasizes the importance of nurturing employee competencies to foster a sense of loyalty and commitment within the organization.
- **Impact of Competency Development Initiatives on Retention:** Competency development initiatives, including training programs, workshops, and personalized development plans, played a pivotal role in influencing employee retention. Employees who had access to such initiatives expressed higher levels of job satisfaction and engagement, which contributed to their decision to stay with the organization. This highlights the significance of providing continuous learning opportunities and career growth pathways as effective retention strategies.
- **Importance of Soft Skills and Career Advancement:** Soft skills, such as effective communication, leadership, and adaptability, emerged as crucial factors influencing employee retention. Employees who felt that their competency development encompassed both technical skills and soft skills showed a greater sense of fulfillment and were more likely to stay with their employers. Additionally, the presence of clear and transparent career advancement opportunities based on demonstrated competencies positively impacted retention rates.

- **Effectiveness of Competency-Based Retention Strategies:** Competency-based retention strategies were found to be more effective than traditional approaches. Organizations that aligned their retention efforts with competency management practices observed higher employee retention rates. By focusing on individual skill development and career aspirations, competency-based retention strategies fostered a work environment that encouraged employee growth and commitment.
- **Employee Perception of Competency Management Impact:** Employees' perceptions of the influence of competency management on their retention aligned with the findings from the quantitative data. Participants reported that competency management practices positively affected their job satisfaction, career prospects, and overall commitment to the organization. This suggests that employees are aware of the impact of competency development initiatives on their decision to remain with their employers.

In conclusion, the research findings highlight the significance of competency management in enhancing employee retention rates within the automotive industry. Competency development initiatives, career growth opportunities, and an emphasis on both technical and soft skills play critical roles in fostering employee loyalty and satisfaction. By adopting effective competency-based retention strategies, organizations can build a skilled and committed workforce, leading to improved organizational performance and long-term success in the dynamic automotive sector.

5.2 Recommendations

- **Implement a Competency-Based Hiring Approach:** Integrate competency frameworks into the recruitment process to ensure that new employees possess the necessary skills and attributes for long-term success within the automotive industry.
- **Foster a Culture of Skill Development:** Encourage continuous learning and skill enhancement through training programs, workshops, and mentoring to improve employee competencies and job satisfaction.
- **Conduct Regular Competency Assessments:** Regularly evaluate employees' competencies to identify skill gaps and provide targeted development opportunities, aligning their growth with organizational needs.
- **Customize Retention Strategies:** Tailor retention strategies based on individual competencies, preferences, and career aspirations to enhance engagement and loyalty.

- **Promote Career Progression:** Establish clear pathways for career advancement within the company, recognizing and rewarding employees who demonstrate exceptional competencies and commitment.
- **Build Effective Competency Frameworks:** Develop comprehensive and adaptable competency models that align with the dynamic nature of the automotive industry to better evaluate and manage employee skills.
- **Monitor Employee Satisfaction and Engagement:** Implement regular surveys and feedback mechanisms to gauge employee satisfaction and engagement levels, using the insights to refine competency management practices.
- **Emphasize Leadership Development:** Invest in developing leadership competencies within the organization to foster effective management and improve employee retention at all levels.
- **Foster Collaborative Work Environment:** Encourage teamwork and cross-functional collaboration, leveraging diverse competencies to drive innovation and create a sense of belonging.
- **Measure the Impact:** Continuously monitor and measure the influence of competency management on employee retention, using data-driven insights to fine-tune strategies and ensure sustainable results.

5.3 Limitations of the Study

1. **Generalizability:** The study focused on a specific segment of the automotive industry and may not fully represent the entire industry's diversity. As a result, the findings might not be entirely applicable to other sectors or industries with different organizational structures and workforce dynamics.
2. **Self-Report Bias:** The reliance on self-reported data from surveys and interviews might introduce bias. Participants may have provided socially desirable responses or may not accurately recall their experiences, leading to potential inaccuracies in the data.
3. **Cross-sectional Nature:** The research adopted a cross-sectional design, capturing data at a specific point in time. This limited the ability to establish causal relationships between competency management and employee retention. Longitudinal studies would be more appropriate to examine changes over time and ascertain the long-term impact of competency management practices on retention.

4. **Sample Size and Representation:** Although efforts were made to select a representative sample, the sample size might not have been large enough to capture the full diversity of the automotive industry's workforce. Some subgroups or specific categories of employees might have been underrepresented in the data.
5. **Response Rate:** The response rate for surveys could be a limitation. Non-response bias may occur if those who chose not to participate in the study differ systematically from those who did respond, potentially impacting the generalizability of the findings.
6. **Subjectivity in Qualitative Analysis:** Thematic analysis of qualitative data involves some level of subjectivity during coding and theme development. Different researchers might interpret the data differently, leading to potential variations in the results.
7. **Single-Industry Focus:** The research exclusively focused on the automotive industry, which may limit the transferability of the findings to other sectors or industries with distinct organizational cultures and talent management practices.
8. **Time Constraints:** The study might have faced time constraints, limiting the scope of data collection and depth of analysis.

6. Conclusion

The research on "Evaluating the Influence of Competency Management on Employee Retention in the Automotive Industry" provides valuable insights into the critical relationship between competency management and employee retention. The study demonstrates that competency management practices significantly influence employees' decision to stay with their respective organizations. Through a mixed methods approach, the research revealed that competency development initiatives, career growth opportunities, and the emphasis on both technical and soft skills play pivotal roles in fostering employee loyalty and satisfaction. The findings underscore the effectiveness of competency-based retention strategies over traditional approaches. Organizations that align their retention efforts with competency management practices observe higher employee retention rates and enhanced performance. Employees who receive continuous competency development opportunities are more engaged, motivated, and committed to the organization, leading to reduced turnover and cost savings. Furthermore, the research highlights the importance of providing a work environment

that nurtures both technical expertise and soft skills. Competencies such as effective communication, leadership, and adaptability emerged as crucial factors influencing employee retention. Employees who perceive a clear link between their competency development and career advancement within the organization are more likely to remain dedicated to their employers. In conclusion, the research strongly advocates for competency management as a key driver of employee retention in the automotive industry. By adopting effective competency-based retention strategies, organizations can create a culture of growth, learning, and innovation that nurtures a skilled and committed workforce. As the automotive industry evolves, embracing competency management practices aligned with employee career aspirations will be pivotal for sustained success and competitive advantage. The research findings offer actionable insights and recommendations to automotive industry stakeholders, guiding them in optimizing competency management strategies and ultimately fostering a positive impact on employee retention, organizational performance, and long-term growth.

References

- Abok, A. M. (2015). Factors Affecting Integrated Talent Management in State Corporations in Kenya; A Case of Kenya Power and Lighting Company; *Strategic Journal of Business and Change Management* 2 (1) 1-16.
- Abraham R. (2011). Essentials of Talent and Competency Management. Certified Talent and Competency Professional Programme. ARTIDO International-ITD
- Ahmad, N., Tariq, M. S., Hussain, A. (2015). Human Resource Practices and Employee Retention, Evidences from Banking Sector of Pakistan; *Journal of Business and Management Research*. 6 186-188.
- AMI (2016). Training Talent; best Practices in Workplace Learning and Management Development in Africa; Nairobi.
- Andrews, A. (2011). Why Competency-based Talent Management? Lexonis Limited
- Anita, S.; Sanjeev, R. (2017). Talent Management for Developing Leadership: An Empirical Investigation; *Independent Journal of Management & Production*, 8, (3) 1130-1146.
- Armstrong, M. (2009). *Armstrong's Handbook of Human Resources Management*. Kogan Page, UK.
- Armstrong, M. (2012). *A Handbook of Human Resource Management Practice*, (12th Ed.), London, Kogan Page Publishers.
- Ary, D., Jacobs, C. & Razavich, A. (2010, 2002). *Introduction to Research in Education*, Belmont, CA; Wadsworth/Thomson Learning.
- Bagga, G. (2013). How to keep the talent you have got, *Human Resource Management International Digest*, 21 (1) 3-4.
- Barney, J. (1991). Organizations Resources and Sustainable Competitive Advantage. *Journal of Management* 17(1), 99-120.

- Dessler G. (2011). Human Resource Management; 12th Edition. Pearson Education Inc
- Du Plessis, L. (2010). The Relationship between Perceived Talent Management Practices, Perceived Organisational Support (POS), Perceived Supervisor Support (PSS) and Intention to Quit amongst Generation Y Employees in the Recruitment Sector. (Thesis), University of Pretoria, Pretoria, South Africa.
- Ernst & Young (2010). Managing Today's Global Workforce: Evaluating Talent Management to Improve Business; Ernst and Young, London.
- Eshiteti, N. S., Okaka, O., Maragi, N. S., Odera, O., Akerele, E. K. (2013). Effects of Succession Planning Programs on Staff Retention; Mediterranean Journal of Social Sciences. 4(6) 157-162
- Fitz-enz, J., Davison, B. (2002). How to Measure Human Resources Management. (3rd Ed) McGraw –Hill, New York.
- Fraenkel R. & Wallen, N. E. & Hyun, (2012). How to Design and Evaluate Research in Education: McGraw-Hill Publishing Company, New York.
- Kassim, A. (2015). Uptake of Mobile Number Portability in Kenya; (Unpublished MBA Thesis) University of Nairobi.
- Kataike, C. (2013). The Relationship between Talent Management and Employee Retention in the Banking Industry, Unpublished, University of Nairobi.
- Basha, S. M., & Ramaratnam, M. S. (2017). Construction of an Optimal Portfolio Using Sharpe's Single Index Model: A Study on Nifty Midcap 150 Scrips. Indian Journal of Research in Capital Markets, 4(4), 25-41.
- Agrawal, D. K. (2022). An Empirical Study On Socioeconomic Factors Affecting Producer's Participation In Commodity Markets In India. Journal of Positive School Psychology, 2896-2906.
- DrSanthosh Kumar, V., & Basha, S. M. (2022). A study of Emotional Intelligence and Quality of Life among Doctors in PandemicCovid 19. International Journal of Early Childhood, 14(02), 2080-2090.
- Shaik, M. B., Kethan, M., Jaggaiah, T., & Khizerulla, M. (2022). Financial Literacy and Investment Behaviour of IT Professional in India. East Asian Journal of Multidisciplinary Research, 1(5), 777-788.
- Krishnamoorthy, D. N., & Mahabub Basha, S. (2022). An empirical study on construction portfolio with reference to BSE. Int J Finance Manage Econ, 5(1), 110-114.
- Mohammed, B. Z., Kumar, P. M., Thilaga, S., & Basha, M. (2022). An Empirical Study On Customer Experience And Customer Engagement Towards Electric Bikes With Reference To Bangalore City. Journal of Positive School Psychology, 4591-4597.
- Basha, S. M., & Kethan, M. (2022). Covid-19 pandemic and the digital revolution in academia and higher education: an empirical study. Eduvest-Journal of Universal Studies, 2(8), 1-648.
- Shaik, M. B., Kethan, M., & Jaggaiah, T. (2022). Financial Literacy and Investment Behaviour of IT Professional With Reference To Bangalore City. Ilomata International Journal of Management, 3(3), 353-362.

- Kethan, M., & Basha, M. (2022). Relationship of Ethical Sales Behaviour with Customer Loyalty, Trust and Commitment: A Study with Special Reference to Retail Store in Mysore City. *East Asian Journal of Multidisciplinary Research*, 1(7), 1365-1376.
- Kumarai, G. S., Bajaj, P. K., Rana, S. S., Basha, M., & Karumuri, V. (2022). An empirical study on customer satisfaction towards organized Retail outlets in Bengaluru city, Karnataka. *Academy of Marketing Studies Journal*, 26(5).
- Basha, S. M., Kethan, M., & Aisha, M. A. (2021). A Study on Digital Marketing Tools amongst the Marketing Professionals in Bangalore City. *JAC: A Journal of Composition Theory*, 14(9), 17-23.
- Lokesh, G. R., Harish, K. S., & Geethanjali, G. (2023). A Study on Benefits, Challenges and Factors Impressing Customer Relationship Management (CRM) WRT Private Commercial Banks at Bengaluru. *Journal of Corporate Finance Management and Banking System (JCFMBS)* ISSN: 2799-1059, 3(03), 1-13
- Sneha, R., & Hajira, B. (2022). Rural Marketing Strategies in India: Recent Trends. *East Asian Journal of Multidisciplinary Research*, 1(8), 1527-1536..
- Ravi, A., Kumar, T. P., & Anjum, M. A. (2022). Derivatives And Price Risk Management: A Case Of Indian Commodity Cotton Futures And Spot Prices In India. *Journal of Positive School Psychology*, 9391-9397.
- Kethan, M., & Basha, M. (2023). Impact of Indian Cinema on Youths Lifestyle and Behavior Patterns. *East Asian Journal of Multidisciplinary Research*, 2(1), 27-42.
- Isac Gunday, D. M. K. (2023). A study on consumer perception towards fast food retail outlets with reference to bengaluru karnataka. *Journal of Pharmaceutical Negative Results*, 418-424.
- Reddy, K., SN, M. L., Thilaga, S., & Basha, M. M. (2023). Construction Of An Optimal Portfolio Using The Single Index Model: An Empirical Study Of Pre And Post Covid 19. *Journal of Pharmaceutical Negative Results*, 406-417.
- Shaik, M. (2023). Impact of artificial intelligence on marketing. *East Asian Journal of Multidisciplinary Research*, 2(3), 993–1004. <https://doi.org/10.55927/eajmr.v2i3.3112>
- M. B. S., M. Kethan, V. Karumuri, S. K. Guha, A. Gehlot and D. Gangodkar, "Revolutions of Blockchain Technology in the Field of Cryptocurrencies," *2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART)*, Moradabad, India, 2022, pp. 761-764, doi: 10.1109/SMART55829.2022.10047225.
- S. H. Krishna, N. Vijayanand, A. Suneetha, S. Mahabub Basha, S. C. Sekhar and A. Saranya, "Artificial Intelligence Application for Effective Customer Relationship Management," *2022 5th International Conference on Contemporary Computing and Informatics (IC3I)*, Uttar Pradesh, India, 2022, pp. 2019-2023, doi: 10.1109/IC3I56241.2022.10073038.
- Lokesh, G. R., & Kotehal, P. U. A Study on the Effect of Electronic Payment Systems on Small Business in Urban Bengaluru.
- Kethan, M. (2022). A STUDY ON THE FACTORS AFFECTING EMPLOYEE RETENTION IN INFORMATION TECHNOLOGY SECTOR. *Journal of Contemporary Issues in Business and Government*, 28(4), 980-996.

- Y. A. B. Ahmad, S. S. Kumari, M. S, S. K. Guha, A. Gehlot and B. Pant, "Blockchain Implementation in Financial Sector and Cyber Security System," *2023 International Conference on Artificial Intelligence and Smart Communication (AISC)*, Greater Noida, India, 2023, pp. 586-590, doi: 10.1109/AISC56616.2023.10085045.
- Basha S., M., Reddy, K., Mubeen, S., Raju, K. H. H., & V., J. (2023). Does the Performance of Banking Sector Promote Economic Growth? A Time Series Analysis. *International Journal of Professional Business Review*, 8(6), e02128. <https://doi.org/10.26668/businessreview/2023.v8i6.2128>
- Reddy, K. S., & Ranganathan, S. Factors Influencing Customer Satisfaction in Bangalore Shopping Malls: Before & During COVID–19 Pandemic. *RVIM Journal of Management Research*, 26.
- Gope, S., Elia, G., & Passiante, G. (2018). The effect of HRM practices on knowledge management capacity: a comparative study in Indian IT industry. *Journal of Knowledge Management*, 22(3), 649-677.
- Schwaiger, M. (2004). Components and parameters of corporate reputation—An empirical study. *Schmalenbach business review*, 56, 46-71.



"Transforming Education: Exploring Leadership Dynamics And Teachers' Performance In 21st Century Schools"

Kavitha K^{1*}, Roohi Kursheed Khan S², Sana Saima³, Sahana B S⁴

¹School of Commerce & Management Studies, Dayananda Sagar University, Bengaluru, India

<https://orcid.org/0009-0007-5627-1079>, E-mail: kavithak.res-scms@dsu.edu.in

²School of Commerce & Management Studies, Dayananda Sagar University, Bengaluru, India

<https://orcid.org/0000-0002-0731-4868>, E-mail: drroohi-socm@dsu.edu.in

³CMS, JAIN (deemed-to-be) University, Bengaluru, India, <https://orcid.org/00000-0002-2571-675>,

E-mail: sanasaima.khan90@gmail.com

⁴CMS, JAIN (deemed-to-be) University, Bengaluru, India, <https://orcid.org/0000-0002-4831-7731>, E-mail: drsahanabs@gmail.com

Citation Kavitha Ket al. (2024), ""Transforming Education: Exploring Leadership Dynamics And Teachers' Performance In 21st Century Schools", Educational Administration: Theory and Practice, 30(4), 9671-9683

Doi: 10.53555/kuey.v30i4.4826

ARTICLE INFO

ABSTRACT

The study explores the critical role educators play in attaining the Sustainable Development Goals (SDGs) through education. Education is a powerful force for social change because it gives students the self-assurance they need to take an active role in the advancement of their country. This study provides insight into examining several facets of transformational leadership and how it affects the teacher-student dynamics. The study is descriptive in nature of the research design and investigates the relationship between transformational leadership and teacher performance in schools across Bangalore, India. Simple random sampling was employed to select 123 teachers from various schools, representing diverse socioeconomic backgrounds and geographic locations within the city. The results show a significant positive correlation between teacher performance and transformational leadership. In addition, the study reveals differences in gender and experience based on the teachers' perception towards the principals' leadership style. The findings contribute to understanding leadership dynamics emphasizing the need for effective leadership practices to support teachers' performance and achieve sustainable development goals. Thus, the study suggests best practices that create the ideal learning environment in schools and improve learning outcomes for students in the twenty-first century contributing towards educational leadership.

Keywords: 21st-century education, Educational leadership, Teacher performance, Transformational leadership, Sustainable Development Goals (SDGs).

Introduction

The ability of education is to fundamentally alter a country's destiny, with a focus on the SDGs and the crucial role that teachers play in accomplishing these goals and highlights the crucial role of education in the development of a nation, particularly in the context of a developing economy as follows:

Extending Perspective and Vision: Education is characterized as a tool that helps people see and perceive the world more broadly. This suggests that education does more than merely impart knowledge; it also moulds people's viewpoints and gives them the ability to view the world from a wider angle. This enlarged vision may inspire a drive to accomplish more and support the growth of the country.

Education is viewed as a tool for empowering young people: Young people are given the knowledge and abilities needed to actively contribute to the development of their country through high-quality education. Using the potential of the young population requires this empowerment.

Fighting Ignorance: The goal of education is to combat ignorance with a weapon. Ignorance can impede advancement in a larger social setting. It is believed that education can eliminate ignorance and advance an informed and enlightened society.

Alignment with SDG4: The 2030 Agenda for Sustainable Development's Sustainable Development Goal 4 (SDG4) is mentioned in the statement. By 2030, SDG 4 seeks to guarantee inclusive, equitable, high-quality education and to encourage opportunities for lifelong learning for all. This demonstrates a dedication to offering inclusive, high-quality education that is not only easily accessible but also leaves no one behind.

Implementation and Monitoring of Teachers: The significance of teachers is underscored, implying that they are essential to accomplishing the goals delineated in SDG 4. Teachers are important stakeholders in the implementation and monitoring of educational initiatives, which must be done effectively. Frequently, investing in teacher preparation, support, and continuous professional development is necessary to ensure the quality of education.

It is only via development that takes place in formative education, or through schools, that equitable and inclusive education can be achieved. The school's principal and instructors are crucial to the growth and development of each individual. Any school's educational objective can only be achieved with the participation of two change agents in the system, namely the principal and the instructors. Similar to the writings of, the position of the educational leader—who chooses, nurtures, and empowers the human resources and builds positive relationships with all students, faculty, staff, and the surrounding communities—has a significant impact on the success of the schools. An intriguing strategic element that might affect an organization's characteristics and behaviours is leadership. Transformational leadership is a prominent paradigm of leadership that is widely recognized as an effective methodology. Transformational leadership, as proposed by (Bass & Riggio, 2005), is a leadership style that inspires and encourages leaders to work with energy, enthusiasm, and attention from their staff. With its four dimensions, the theory provides a useful framework for comprehending how the teachers in the current study perceived the leadership of their principals.

Perspectives on Leadership and Transformational Leadership

The adjective "transformational" refers to the ability "to change the appearance or character of something or somebody completely," in the Oxford Advanced Learner's Dictionary (edition 5), this is followed by the noun "leadership," which is derived from the verb "lead" and means "to influence the actions or opinions of somebody." The ability of a leader to alter or transform their followers is thus what is meant to be understood by the term "transformational leadership."

Furthermore, (Burns, 2012) developed the theory of transformational leadership.

According to (Oc et al., 2023), this leadership theory implies that certain leaders, through their character attributes and their interaction with their followers, go above and beyond the trade of goods and productivity and aid in the growth and empowerment of people to the fullest extent possible.

As a result, (Leithwood, K., & Jantzi, n.d.). began publishing a great deal of research on transformational leadership among school principals in the late 1990s. According to (Insan et al., 2013) study, school principals who exhibit transformational leadership behaviours build positive relationships between teachers and students, boost teachers' confidence, and increase their sense of efficacy.

The four dimensions of transformational leadership, according to (Bass, B. M., & Avolio, 1983) are as follows:

Idealized Influence (Charisma): Leaders serve as role models for their followers, igniting their respect and trust.

Inspirational Motivation: Effective leaders inspire others to strive toward common objectives by articulating a compelling vision.

Intellectual Stimulation: Leaders push followers to think critically and solve problems by fostering creativity and innovation.

Individualized Consideration: Leaders offer tailored guidance and assistance, acknowledging the distinct requirements and proficiencies of every subordinate.

Factors Affecting Teachers' Performance

Building on the findings of the study, (Jovanovic & Ciric, 2016)] and (Arifin et al., 2014) explore the complex variables affecting teachers' effectiveness. The key factors influencing the educational landscape are identified as work targets, workload, gender, and the work experience of teachers. Principals become key players mediating these factors through their transformational leadership. A positive work environment is fostered by principals' effective communication and support, which lessen the negative effects of high work targets and workload. The study also recognizes that gender and work experience may have an impact on teachers' performance, but it emphasizes how a principal's leadership style can either mitigate or exacerbate these

effects. This sophisticated comprehension adds to the conversation about maximizing the effectiveness of educators and, consequently, improving the general performance of the educational system.

Principals and teachers must work together, communicate effectively, and be transparent. In order to foster a supportive leadership culture that recognizes the contributions of all educators, principals should aggressively solicit feedback from teachers and include them in decision-making procedures. This strategy can improve student outcomes, raise teacher satisfaction, and improve the general school climate. Because it creates a welcoming and inclusive learning environment, stimulates creativity, and advances a common vision for academic success, transformational leadership is highly compatible with academic goals. Apart from the principal, the teachers also play an important role of element in improvising the school's quality and vision as they directly interact with the students by showing their professional duties and performance. In the words of (Mahmudah et al., 2020) teacher performance refers to the ability of teachers to carry out their duties at school, discipline and teacher behaviour during their daily activities at school. The teacher needs to work agreeably and cooperatively with the principal in order to train & facilitate students. Principals need to have a working relationship with parents so as to help the students benefit both academically and socially. In Indian schools as per RMSA (Rastriya Madhyamik Shiksha Abhiyan) norms, teacher recruitment is based on PTR (Pupil Teacher Ratio) and the subject-specific requirements of the State. Each school is mandated to have a minimum of five subject teachers specifically for the core subjects: English, Language, Mathematics, Science and Social Science. However due to shortage of teachers they take extra classes and most teachers felt that they spend large amounts of time on non-teaching activities and strenuous administrative tasks. According to the works by (Allen et al., 2021) in England, teachers work more than 59 hours per week, hence teachers' workload and their health care need to be addressed by the education policy makers. The workload of teachers must be distributed evenly as the working conditions of teachers have an impact on students' learning outcomes. The objective of this research paper is to perform a thorough investigation of how educators see the transformational leadership demonstrated by their school administrators and the ensuing effects on learning. The main goals are to give light on how instructors view their principals' leadership styles, how work targets are set, and what a day in the life of these teachers looks like. It is imperative to comprehend the viewpoints of individuals engaged in decision-making procedures in order to cultivate a constructive educational atmosphere, expedite advancement, and augment the erudition of 21st-century scholars. The goal of the research is to shed light on the advantages and difficulties of transformational leadership in education, providing insightful information that can inform best practices for creating and putting into practice successful teaching methods. This study aims to further the ongoing conversation about improving teacher performance and educational leadership in the ever-changing context of 21st-century learning by exploring teachers' perceptions. The research's core findings are signalled by the title, "Teachers' Performance and Transformational Leadership: A Perception Study," which captures the nuanced relationship between educators' perceptions and leadership styles in the quest of educational excellence.

Understanding the complex relationships that exist between innovative practices, teacher dedication, and transformational leadership in educational settings is the focus of current research studies. The study is especially interested in finding out how transformative leadership and teacher results are mediated by trust in school principals. The current research projects centre on investigating novel strategies for fostering students' inquiry in classroom environments and interested in finding out how classroom practices that are in keeping with professional standards and that promote students' identities in line with their questions can support students' engagement and inquiry through the use of learning designs, such as doubly authentic learning designs. The current areas of interest in study are how transformational leadership affects teachers' effectiveness in classroom environments. The area of interest is the ways in which school administrators' leadership philosophies affect several facets of teacher efficacy and work satisfaction. This entails looking into the connections between innovative practices, organizational engagement, and teacher commitment in transformational leadership. Furthermore the study is investigating the ways in which leadership styles interact with demographic variables like gender and years of experience to influence teachers' views and performance outcomes.

Problem statement

With instructors acting as catalysts for accomplishing both educational aims and more general societal goals, the area of education is a cornerstone for society advancement. It is crucial to comprehend the dynamics of leadership in educational institutions, particularly in Bangalore, India, where the educational landscape is dynamic and diversified. It becomes clear that transformational leadership has a critical role in determining how well instructors perform and, in turn, how well kids get education. The complex relationship between transformative leadership and teachers' performance in Bangalore's local educational setting is still little understood, despite its acknowledged importance.

Literature Review

The amount of research on the relationship between teachers' performance and the ideas of transformational leadership has been steadily increasing in recent years. Human resource development, psychology, management, professional communities, and most recently, the education sector are becoming more and more interested in these discussions (Insan et al., 2013) (Malik et al., 2012), and (Kadyschuk, 1997).

Transformational leadership

Transformational leadership, as defined by Bernard Bass, is the process of changing the goals and assets of both leaders and followers. There are four main behaviors that transformational leaders usually exhibit. These actions encourage team objectives, clearly communicate the vision, set high standards for performance, and stimulate the mind. The leader's behavior that helps teachers cooperate and work together toward shared objectives is known as "fostering group goals and support." A leader who exhibits articulating vision will be able to find new avenues for their school to pursue as well as develop, articulate, and motivate others with a future-focused vision. The conduct that shows a leader's expectations for excellence, quality, and high performance from their subordinates is known as holding high performance expectations. The leader's action of challenging the teachers to reconsider some of their work-related presumptions and methods of execution constitutes intellectual stimulation. Organizational success is attributed to transformational leadership, which is typified by leaders who inspire, motivate, and steer their teams toward common objectives. (Algohani & Mydin, 2022)

Teachers' Performance

In order to fulfil their responsibilities and perform to the best of their abilities in order to meet institutional objectives, teachers engage in a number of process activities that make up their teacher performance. The effort put forth by teachers to realize their abilities—which include attitudes, knowledge, and skills—in the areas of organizing, carrying out, assessing, and efficiently following up on learning outcomes in order to maximize learning outcomes—is what is used to evaluate their performance. As stated in the works of (Anik Herminingsih & Widianti Supardi, 2017), a teacher's performance is defined as their ability to demonstrate their abilities through activities they complete at school and acts they perform in or during learning activities. It also includes their behavior at work that demonstrates the necessary competence, which includes their pedagogical, personality, social, and professional competence. A teacher's performance is influenced by a variety of internal factors, such as their personality, experience, gender, and even their family background.

The elements outside of their control that affect their performance, such as their pay, work environment, peers, infrastructure, management support, and leadership, can serve as external motivators for teachers. The external factor—leadership or supervisory support—that enhances their performance is the main focus of this study.

Teachers' performance varies according to how they view the support that school leadership offers, their own role and responsibilities, how their workload is divided, and the goals that their principal has set for them.

Six NCERT indicators of teacher performance—Designing Learning Experiences, Knowledge and Understanding of Subject Matter, Strategies for Facilitating Learning, Interpersonal Relationship, Professional Development, and School Development—were identified in the study.

Studies related to teachers' performance under transformational leadership

Apart from the aforementioned ground-breaking investigations, the most recent study conducted by (Kılınç et al., 2024) offers significant understanding into the impact of the transformational leadership model's moderated mediation model on innovative techniques employed by teachers. Using data from 611 Turkish teachers, the study uses a cross-sectional survey approach and sophisticated statistical methods such as multilevel structural equation modelling with Bayesian estimation. Through the mediator role of teacher dedication, the data demonstrate the strong indirect benefits of transformational leadership on creative techniques used by teachers. The study also reveals the critical moderating effect of principal trust, showing that teachers' level of trust in their principals determines how transformational leadership affects their commitment to teaching and creative practices.

The research by (Rahmian et al., 2024) adds to the important studies already cited by illuminating the effectiveness of doubly authentic learning designs in fostering students' inquiry. Examining Humanistic Knowledge Building Communities (HKBCs) in detail, the study explores the relationship between students' identities, interests, and learning areas. The research offers fresh insights into how students' inquiry interests might be fostered and sustained within knowledge-building communities by creating the ENDURE framework based on several case studies. This study emphasizes how crucial it is to provide learning activities that help students make the connections between their academic goals and their personal interests in order to improve their learning outcomes and experiences.

The first study that (Algohani & Mydin, 2022) reviewed focuses on the transformational leadership of the principal and how it affects teacher motivation. The study's conclusions imply that the transformational leadership approach is both successful and capable of bringing about constructive adjustments in the learning environment. Purposive sampling is used in (Madjid & Samsudin, 2021) study to gather information from 117 teachers. The study uses organizational commitment as a mediating factor to examine how transformational leadership affects teacher performance using a deductive quantitative approach. The transformative influence of leadership is indicated by the positive correlation that has been found between superior performance and committed teachers. The review by (Mahaputra & Farhan Saputra, 2021) includes a number of articles that develop theories to investigate the complex function of transformational leadership in school headmasters. The study pinpoints the three crucial elements that have a major impact on a headmaster's leadership:

motivation, loyalty, and teacher performance. Additional research is advised, with a focus on factors like environment, work culture, workload, and salary. (Novitasari et al., 2020) add to the body of literature by investigating how female teachers' performance is impacted by job satisfaction, transformational leadership, and religiosity. The study, which involved private school teachers Tangerang, shows that organizational citizenship behaviour and influencing elements like job satisfaction and religiosity act as a mediating factor for the indirect impact of transformational leadership on teacher performance. (Purwanto et al., 2020) conducted a qualitative study to examine six leadership model literatures and determine whether transformational leadership is anti-democratic or elitist. Contrary to the idea of elitism, the study reveals that democratic leadership styles have a positive impact on teacher performance. It also highlights how important transformational leadership is to improving teacher effectiveness. By creating a questionnaire to evaluate the elements of transformational leadership and their effect on teachers' performance, (Alzoraiki et al., 2018) add to the body of literature. 374 teachers from ten different school districts participated in the study, which shows a significant improvement in both organizational development and teacher performance. (Andriani et al., 2018) examine the connection between teachers' performance, work motivation, and transformational leadership. The study demonstrates a favourable and significant impact of transformational leadership and work motivation on teachers' performance through correlation and multiple regression analysis techniques, suggesting a potentially universal relationship across diverse contexts. (Arifin et al., 2014) looked into the effects of transformational leadership and organizational culture on teacher engagement and performance using a cross-sectional survey. The study, which was carried out in an Islamic environment, emphasizes how crucial teachers' perceptions of culture and leadership are in determining employee engagement. New engagement development strategies and structures are based on the findings. In this study by (DeAndrade-Oliveira, 2022), the authors investigate the relationship between transformational leadership, teacher commitment, and innovative practices, with trust in the principal acting as a moderator. Utilizing a cross-sectional survey design and data from 611 teachers in Turkey, the researchers employed multilevel structural equation modeling with Bayesian estimation. Their findings suggest that teacher commitment mediates the effects of transformational leadership on innovative practices, and trust in the principal significantly moderates this relationship. This research contributes valuable insights to the global literature on the importance of trust in principals for effective leadership and its impact on teachers' commitment and innovative practices. In a 2024 study by (Kılınc et al., 2022), the authors investigated the impact of transformational leadership on teachers' job satisfaction and its subsequent influence on their performance. The research was conducted with a sample of 611 teachers from 56 schools in Turkey, employing a mixed-methods approach. The findings revealed that transformational leadership positively affected teachers' job satisfaction, which in turn, enhanced their performance. This study underscores the significance of transformational leadership in fostering a positive work environment and improving teachers' performance in education. In another 2023 publication by (Kilag et al., 2023) study effectively demonstrates the significance of transformational leadership in fostering educational innovation within primary and secondary schools. The findings emphasize the importance of empowering stakeholders, creating supportive environments, and providing valuable insights for educational leaders and policymakers. In summary, the aforementioned studies collectively enhance our comprehension of the critical significance of transformational leadership within educational environments. Echoing the larger reports found in educational leadership literature, like those given by (Sanchez & Watson, 2021) and the OECD, which emphasize the role of leadership in goal-setting, assessment, and positively influencing teacher and student performance, they highlight the positive impact on teacher performance, organizational commitment, and engagement. Apart from the aforementioned groundbreaking investigations, the most recent study conducted by (Kılınc et al., 2024) offers significant understanding into the impact of the transformational leadership model's moderated mediation model on innovative techniques employed by teachers. Using data from 611 Turkish teachers, the study uses a cross-sectional survey approach and sophisticated statistical methods such as multilevel structural equation modelling with Bayesian estimation. Through the mediator role of teacher dedication, the data demonstrate the strong indirect benefits of transformational leadership on creative techniques used by teachers. The study also reveals the critical moderating effect of principal trust, showing that teachers' level of trust in their principals determines how transformational leadership affects their commitment to teaching and creative practices. The research by (Rahmian et al., 2024) adds to the important studies already cited by illuminating the effectiveness of doubly authentic learning designs in fostering students' inquiry. Examining Humanistic Knowledge Building Communities (HKBCs) in detail, the study explores the relationship between students' identities, interests, and learning areas. The research offers fresh insights into how students' inquiry interests might be fostered and sustained within knowledge-building communities by creating the ENDURE framework based on several case studies. This study emphasizes how crucial it is to provide learning activities that help students make the connections between their academic goals and their personal interests in order to improve their learning outcomes and experiences. (Algothani & Mydin, 2022) reviewed the literature with an emphasis on transformational leadership's positive effects on the learning environment and how it affects teacher motivation. Organizational commitment was used as a mediator by (Madjid & Samsudin, 2021) to investigate the relationship between transformational leadership and teacher performance, highlighting the favourable association between the two. (DeAndrade-Oliveira, 2022) looked into the connection between innovative

practices, teacher dedication, and transformational leadership. The author found that this relationship is moderated by the principal's trust, which provides important information about good leadership techniques. The focus on both theory and empirical research is a defining feature of transformational leadership. For academics and serious leadership students, it provides an extensive overview and resource that provides insights into the wide range of transformational leadership in diverse contexts. (Bass & Riggio, 2005). Effective leadership styles, particularly transformational leadership, significantly impact organizational success (Algohani & Mydin, 2022). The research emphasizes the critical role of transformational leadership during reform, highlighting the leader's role in inspiring and assisting teachers, while acknowledging the difficulties in accomplishing these goals. (Alzoraiki et al., 2018). Transformational leadership on the performance and work engagement of teachers in schools shows strong and positive correlations, highlighting the critical roles that both variables play in improving teacher effectiveness. (Arifin et al., 2014). The transformational leadership model in South Sulawesi Province affects worker performance and job satisfaction. (Insan et al., 2013) Therefore, even though a number of international studies (Adhi et al., 2013) (Eliophotou-menon & Ioannou, 2016) (Hauserman & Stick, 2013) (Shila & Sevilla, 2015) discuss the impact of leadership on educators, these studies also looked into the relationship between leadership and educators' commitment to the organization as well as the influence of socio-cultural factors on leadership. To date, no research has looked at the relationship between leadership styles and teacher performance and satisfaction in India. In order to close this gap, this study includes data from the completely absent region of India as well as researched data on the effects of transactional and transformational leadership on Indian school teachers.

H1: There is no relationship between transformational leadership and teachers' performance.

H2: There is no difference in teachers' performance scores based on certain demographics.

H3: Transformational leadership does not significantly enhance educational outcomes or foster a conducive learning environment in Bangalore schools.

Methodology

Type: Descriptive Research

Method: Simple Random Sampling

Instruments: Structured Questionnaire Principal Leadership questionnaire (PLQ) 1996 and Teacher Performance scale as per NCERT indices.

Sample size: 123 Questionnaires returned with complete data.

Tools used: Descriptive statistics, Pearson's correlation, ANOVA, and z test.

Selection Criteria for Schools:

The study's participating schools were chosen according to predetermined standards in order to guarantee representativeness and diversity within the Bangalore area. These standards include features like:

Geographic Distribution: To represent Bangalore's varied educational environment, schools were selected from a range of neighbourhoods. **School Type:** To take into consideration variations in student demographics, resources, and governance, both public and private schools were included. **Educational Level:** The purpose of this study was to investigate the effects of transformational leadership at various educational levels in primary and middle schools. **Socioeconomic Status:** In an attempt to represent Bangalore's socio-cultural variety, schools catering to a range of socioeconomic backgrounds were included. **Identification of Potential Participants:** Working with school officials, a list of qualified instructors from each chosen school was identified. **Random Selection:** Teachers were chosen at random to take part in the study from the list using a randomization technique. This reduced bias in the sample by guaranteeing that each qualified teachers had an equal chance of being chosen. **Invitation and Involvement:** A few teachers were contacted and extended an invitation to take part in the research. They received comprehensive information regarding the goals of the study, the methods used, and their part in it. **Data Collection:** After gaining permission, the participating teachers were given standardized questionnaires to complete in order to gather pertinent information about how they felt about transformational leadership and how well they performed. **Final Sample:** The final sample for analysis consisted of 123 instructors from the chosen Bangalore schools who submitted filled-out questionnaires with thorough data.

Instruments

In the year (Leithwood et al., 1996), developed the to assess the principals' leadership capacities in the perceptions of their fellow students and teachers. In this study, the PLQ (Principal Leadership Questionnaire) was used and the number of items in the questionnaire is 24 items. The items were measured along the standard measurement scale (Five-point scale of Likert) ranging from "5" = strongly agree to "1" = strongly disagree. The maximum score possible is 120 and the minimum is 24. The total cumulative scores of the responses of all items yield scores on principals' leadership. All the items of the questionnaire consist of

positive worded items. Higher the mean scores for items means the teachers perceive their leadership high and low mean scores indicate low perception of that item. The scale had a Cronbach alpha for all items as 0.79. Teachers' Performance is measured using the PINDICS which means Performance Indicators for Elementary School Teachers and Evolving performance standards for teachers' accountability. This indices is framed every year by NCERT that will be developed through appropriate provision of training and support measuring teachers' performance standards. This framework is used for performance indicators for Elementary School Teachers (PINDICS) that is based on norms and standards as enunciated in various studies and statutory orders of the government. The number of items in the questionnaire is 40 items. The items were measured along the standard measurement scale (Five-point scale of Likert) ranging from "5" = strongly agree to "1" = strongly disagree. The maximum score possible is 200 and the minimum is 40. The total cumulative scores of the responses of all items yield scores on teachers' performance. All the items of the questionnaire consist of positive worded items. Higher the mean scores for items means the teachers perceive high performance and low mean scores indicate low perception of that item. The scale had a Cronbach alpha for all items as 0.72. The content validity for both the scales was performed.

Research Questions

The research questions were formulated to determine how teachers' performance are impacted by the transformational leadership style of school principals.

1. Is there any significant relationship between Transformational leadership and Teachers Performance?
2. Will the teacher's differ on their scores on teachers' performance based on certain demographics?
3. What role does transformational leadership play in enhancing educational outcomes and fostering a conducive learning environment in Bangalore schools?

Data Analysis

The descriptive statistics was used to understand the teachers' demographic classification.

Table 1: Demographic Classification

Category	Number of respondents	Percentage
Gender		
Male	30	24.39
Female	93	75.60
Age distribution		
23-26	23	18.71
26-29	33	26.82
29-32	27	21.95
Above 32	40	32.52
Educational Qualification		
TGT	40	32.52
PGT	67	54.47
Diploma	11	8.943
Ph.D./Others	5	4.07
Marital Status		
Married	93	75.60
Unmarried	20	16.26
Prefer not to say	10	8.13
Subjects Taught		
Mathematics	40	32.52
Science	27	21.95
Social science	33	26.82
Language	23	18.71
Experience		
1-3 Years	45	36.58
3-5 Years	14	11.38
5-7 Years	9	7.32
Above 7 Years	55	44.72

***Source: Primary Data**

Interpretation: The demographic classification shows that majority of the respondents with 75.06% were female (Figure 2) 54.47% of the teachers had completed PGT (post graduate training) teachers followed by 32.52% of employees belong to the age group above 32 years. 75.60% belong to married category followed by 32.52% employees were teaching mathematics subject. 44.72% of teachers had more than 7 years of experience.

Research Question 1

H1: There is no relationship between transformational leadership and teachers' performance.

The Pearson correlation coefficient between transformational leadership and teachers' performance was calculated. The result indicates a significant positive correlation ($r = 0.539$, $p < 0.01$), contradicting H1. Thus, the null hypothesis is rejected.

To have an idea on whether there is any significant relationship between transformational leadership and teachers' performance the Pearson's correlation coefficient was calculated.

Table 2: Showing the correlation between Transformational leadership and Teachers' Performance

Variables	Correlation Coefficient	Sig. (2- tailed)
Transformational leadership Teachers' Performance	0.539*	.000

Source: Primary data

***Correlation is significant at the 0.01 level (2-tailed).**

Interpretation: The correlation coefficient between the two variables is 0.539; this is significant at 0.01 level. The null hypothesis that there is no relationship between transformational leadership and teachers' performance is rejected. The direction of the relationship is indicated by the sign and the strength of the relationship is represented by the absolute size of the co-efficient i.e. how close it is +1 or -1. Here the co-efficient is +0.539 this indicates that there is a high positive relationship between the two variables.

Research Question 2

Teachers differ on their scores on teachers' performance based on certain demographics

Table 3: Showing the results of experience & teachers' performance

Variables		Sum Squares	df	Mean Square	F	Sig.
Designing Learning Experiences	Between years of experience	37.833	10	9.458	1.915	0.506
	Within years of experience	1366.391	113	11.482		
	Total	1404.224	123			
Knowledge and Understanding of Subject Matter	Between years of experience	187.254	10	37.450	2.291	0.001*
	Within years of experience	2327.024	113	19.720		
	Total	2514.278	123			
Strategies for Facilitating Learning	Between years of experience	41.965	10	4.196	2.915	.002*
	Within years of experience	1599.361	113	14.15		
	Total	1641.326	123			
Interpersonal Relationship	Between years of experience	53.382	10	15.794	3.891	.015*
	Within years of experience	1497.944	113	4.458		
	Total	1551.326	123			
Professional Development	Between years of experience	11356.192	10	3166.480	4.238	
	Within years of experience	40092.692	113	92.561		
	Total	51448.883	123			
School Development	Between years of experience	25.729	10	8.576	2.903	0.954
	Within	2741.981	113	17.354		

	years of experience					
	Total	2767.71	123			

***Source: Primary data**

****Denotes the significance at 5%***

Interpretation: The ANOVA table shows that there is a significant difference among the years of experience between the groups and the teachers' performance. The F ratio (1.915) is not significant ($p = 0.506$) at the 0.05 levels of Designing Learning Experiences, the null hypothesis is accepted. The F ratio (2.291) is significant ($p = 0.001$) at the 0.05 levels of Knowledge and Understanding of Subject Matter, so the null hypothesis is not accepted followed by the F ratio (2.915) is significant ($p = 0.002$) at the 0.05 levels of Strategies for Facilitating learning is significant and hence the null hypothesis is rejected. The F ratio (3.891) is significant ($p = 0.015$) at the 0.05 levels of Interpersonal Relationship, so the null hypothesis is not accepted. The F ratio (4.238) is significant ($p = 0.001$) at the 0.05 levels of Professional Development, so the null hypothesis is not accepted. The F ratio (2.903) is not significant ($p = 0.954$) at the 0.05 levels of School Development, the null hypothesis is accepted. Based on the results of the Knowledge and Understanding of Subject Matter, there is a significant difference and so the post- Hoc test is conducted.

Table 4: Knowledge and Understanding of Subject Matter

SMEAN (Level of education)	N	Subset for alpha= 0.05
		1
Postgraduate with teacher education	67	17.6
Graduate with teacher education	40	17.3
Diploma/others	11	12.5
Ph. D/Others	5	7.3
Sig.		0.141

***Source: Primary data**

Interpretation: The highest score of 17.6 was obtained by the teachers who are graduates with teacher education and the least scores was 15.3 obtained by the teachers holding Ph.D degree. The mean score difference is 10.3. This shows that there is vast difference in the teachers' performance based on their educational qualification.

H2: There is no difference in teachers' performance scores based on certain demographics.

ANOVA tests were conducted to compare teachers' performance scores across different demographic factors. The analysis revealed significant differences in teachers' performance scores based on years of experience and gender. Post-hoc tests may be conducted to identify specific differences between groups.

Table 5: Differences on teachers' performance & Gender Using z-test

Designing Learning Experiences						
Variables	n	Mean	SD	Mean Diff	z	p
Male	30	14.2676	2.89313	0.8972	-1.802	0.73
Female	93	15.1648	3.43920			
Knowledge and Understanding of Subject Matter						
Variables	n	Mean	SD	Mean Diff	z	p
Male	30	16.7465	3.76343	1.1656	-1.740	0.84
Female	93	17.9121	4.56228			
Strategies for Facilitating Learning						
Variables	N	Mean	SD	Mean Diff	z	p
Male	30	14.8169	3.80717	1.282	-2.082	0.039*
Female	93	16.0989	3.99181			
Interpersonal Relationship						
Variables	N	Mean	SD	Mean Diff	z	p
Male	30	16.9114	2.32236	-.56663	-2.454	.044*
Female	93	17.4780	1.93458			
Professional Development						
Variables	N	Mean	SD	Mean Diff	z	p
Male	30	14.4666	2.99313	0.9972	-1.811	0.86
Female	93	15.1749	3.56920			
School Development						
Variables	N	Mean	SD	Mean Diff	z	p
Male	30	16.9114	2.32236	1.1781	-1.755	.089
Female	93	17.4780	1.93458			

***Source: Primary data**

***Denotes the significance at 5%**

Interpretation: The table 5 reveals that the mean, standard deviation and the mean difference scores on all of the dimensions of teachers' performance. Based on the z test, the result shows that there exists a significant difference between the Strategies for Facilitating Learning and the Interpersonal Relationship dimensions of teachers' performance and the gender of the teachers. As the p values of these two dimensions are below 0.05 the null hypothesis is rejected and we can infer that the male and female teachers have a variation where female teachers' try to create more of a learning environment for the students and build interpersonal relationships with the students more compared to their male counterparts.

Research Question 3

H3: In Bangalore schools, transformational leadership has no appreciable impact on improving academic performance or creating a positive learning atmosphere. The results of the analysis demonstrated that transformational leadership significantly improves the performance of teachers. This goes against H3, indicating that transformative leadership can improve learning outcomes and create a positive learning atmosphere. Overall Interpretation: According to the analysis, transformational leadership has a favourable impact on teachers' work, which in turn improves learning outcomes and creates a supportive learning environment. This shows that, in the context of 21st-century education, good leadership is essential to encouraging academic brilliance. The study underscores the significance of the principal-teacher interaction in educational results and the necessity for ongoing research and initiatives to improve school leadership practices. A culture of excellence that optimizes the potential of educators and eventually benefits society at large can be fostered by stakeholders through the investment in leadership development programs and the creation of supportive, collaborative educational settings.

Discussions

The study's findings, are in consistent with the earlier studies that highlight the important link between teachers' performance and administrators' transformative leadership. It has been repeatedly shown that transformational leadership, which inspires and motivates followers toward shared objectives, improves organizational outcomes, such as teacher effectiveness and student accomplishment ((Bass and Riggio 2005, Algothani and Mydin 2022)). In light of the most recent research and body of literature, principals can employ a number of ways to raise the calibre of instruction in their schools. For instance, study lessons and off-the-job training have been found to be successful strategies for teachers' professional development (Hyler & Gardner, 2017) Furthermore, as was also discussed in the discussion, classroom action research prove Principals can encourage a culture of continuous improvement and assist instructors in improving their teaching methods by offering chances for professional development and collaborative learning (Hyler & Gardner, 2017) Furthermore, as discussed the classroom action research provides teachers with an organized way to evaluate their methods, pinpoint the difficulties that their students are facing, and put evidence-based interventions in place to help those (Kılınç et al., 2022), Teachers can actively participate in reflective practice through principal-facilitated action research projects, which can result in iterative changes in teaching and learning outcomes (DeAndrade-Oliveira, 2022). Furthermore, a more dynamic and productive school culture can be created by utilizing the varied experiences and strengths of teachers. In order to facilitate teacher cooperation, mentorship, and peer learning—which allows educators to exchange best practices and work on sustainable goal 4 for quality education principals can play a critical role in setting these up (Hargreaves & Fink, 2004). Principals can foster a healthy work environment that supports teacher motivation and well-being by encouraging a sense of camaraderie and shared purpose among staff members (Sanchez & Watson, 2021) The gender disparities in teachers' assessments of their own performance are also discussed, highlighting the necessity of gender-sensitive leadership strategies. Gender differences in leadership preferences and communication styles have been shown in earlier research (Badia et al., 2013). Female leaders typically display a greater propensity for transformational and relational leadership activities. By identifying and utilizing the capabilities of both male and female teachers, principals can maximize their combined influence on student results by taking use of these findings. Further studies should examine more closely how teachers in various demographic groups perceive the leadership styles of principals. Focus groups and interviews are examples of qualitative methods that can offer extensive insights into the preferences and experiences of teachers with regard to leadership practices (Nadav et al., 2023). In addition, longitudinal research may investigate the long-term effects of suggested interventions on student outcomes and school pedagogies, providing insightful information to practitioners and educational policymakers alike.

Implications and Recommendations

The following recommendations can be made in light of the findings in order to help enhance the teachers' efficiency. Invest in Ongoing Professional Development: Principals should place a high priority on providing teachers with chances for on-the-job training, study lessons, and collaborative learning communities. Teachers' topic knowledge, pedagogical abilities, and instructional tactics can all be improved by giving them access to pertinent workshops, seminars, and online courses. Encourage Reflective Practice: To identify areas for improvement and apply evidence-based interventions, teachers should be encouraged to participate in reflective practice and classroom action research. In order to better address the needs of diverse learners, principals might assist teachers in carrying out action research projects, examining student data, and

improving their teaching strategies. Encourage a Collaborative School Culture: By encouraging cooperation, mentorship, and peer learning opportunities, you can help staff members develop a culture of collaboration and shared accountability. To encourage teachers to share ideas and best practices, principals can organize collaborative planning sessions, lesson studies, and professional learning communities. Acknowledge and Make Use of Teachers' Strengths: Recognize the teachers' varied backgrounds, specialties, and abilities within the school community. By giving teachers leadership responsibilities, organizing peer mentorship programs, and creating chances for teacher-led projects and creativity, principals may take advantage of the special skills and passions that each teacher possesses. Adopt Gender-Sensitive Leadership Practices: Acknowledge and resolve gender disparities in educators' experiences and perspectives in the classroom. It is recommended that principals implement leadership techniques that are inclusive, gender-sensitive, and foster equity, fairness, and respect for all employees. A more accepting and encouraging school climate can be created by offering leadership development opportunities that are customized to the requirements and preferences of both male and female teachers. Monitor and Assess Interventions: Put in place a methodical procedure to keep an eye on and assess the success of suggested initiatives and interventions. To evaluate the long-term effects of professional development programs and leadership practices, principals should gather information on teacher effectiveness, student results, and indications of the school atmosphere. Frequent systems for assessment and feedback can guarantee accountability and support efforts towards continual development.

Conclusion

The study used a quantitative methodology to look at the connection between teachers' performance in primary and middle schools in Bangalore and the transformational leadership displayed by school principals. By using tool like z-test, ANOVA, and correlation, the study sought to shed light on the relationships that exist between teacher performance and leadership style. Transformational leadership and teacher performance have a moderate association coefficient value of 0.569, according of the Pearson correlation test. This implies that principal leadership quality can have a good or negative impact on teacher performance, pointing to a complex relationship that needs more research. Furthermore, gender disparities in teaching styles are highlighted by the z-test results, which show that female teachers, in comparison to their male counterparts, typically provide a more positive learning atmosphere. This emphasizes how gender may influence educational practices and how gender-sensitive leadership strategies are necessary to accommodate a range of teaching philosophies and pedagogical preferences. The study's result emphasizes how crucial strong principle leadership is in influencing teacher performance and, in turn, student outcomes. Fostering a pleasant learning environment and promoting academic success can be achieved by teachers who are empowered and inspired to thrive professionally by a strong and transformative leadership style. On the other hand, poor leadership can stifle educators' passion and make it more difficult for them to provide high-quality instruction, which will eventually affect how well students learn and behave.

Disclosure Statement

Ethical Approval: This study did not receive formal ethics approval. On the other hand, every participant was made aware of the goal of the study, and precautions were taken to protect their privacy and confidentiality.

Informed Consent: All respondents were made aware of the nature and goal of the study before they agreed to participate. Every participant gave their verbal agreement, signifying that they were voluntarily participating in the study.

Conflicts of Interest: With relation to the publishing of this research, the authors have disclosed no conflicts of interest.

Funding: There was no outside funding or assistance given to this study.

Data Collection: Teachers in elementary and middle schools in Northern Bangalore provided on-the-spot data. The participants were given a structured questionnaire, and precautions were made to ensure their privacy and confidentiality.

Sample Selection: A lottery was used to choose the study's participating schools, and the final sample consisted of 123 instructors from each of the two schools. Unfilled response sheets were not included in the analysis.

Respect for Ethical Standards: Despite the lack of formal ethics approval, the research was carried out in a way that guaranteed participant confidentiality and well-being.

AI Support: During the research procedure, the authors made use of an AI language model.

Acknowledgements

The authors would like to thank the institutions for all of their important help and support during the research process. Their advice and criticism were really helpful in getting this study finished. The researchers also appreciate the collaboration and openness of the teachers who took part in this research to contribute their knowledge and experiences. This study would not have been done without their assistance and also recognize the help that others gave with data collecting, processing, and other research-related tasks. Their assistance was crucial to making sure this endeavour was successful. Finally, the researchers would want to express their gratitude to everyone for their insightful conversations, inspiration, and assistance during this project.

References

1. Adhi, S., Hardienata, S., & Sunaryo, W. (2013). The effect of organizational culture, transformational leadership and work motivation toward teacher performance. *Indian Journal of Positive Psychology*, 4(4), 537–539. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.677.56&rep=rep1&type=pdf>
2. Algohani, M., & Mydin, A.-A. (2022). The influence of Transformational Leadership Style on Teachers' Organizational Commitment: A Systematic Literature Review. *Multicultural Education*, 8(1), 94–104.
3. Allen, R., Benhenda, A., Jerrim, J., & Sims, S. (2021). New evidence on teachers' working hours in England. An empirical analysis of four datasets. *Research Papers in Education*, 36(6), 657–681. <https://doi.org/10.1080/02671522.2020.1736616>
4. Alzoraiki, M., Ab. Rahman, O. bin, & Mutalib, M. A. (2018). The Effect of the Dimensions of Transformational Leadership on the Teachers' Performance in the Yemeni Public Schools. *European Scientific Journal*, ESJ, 14(25), 322. <https://doi.org/10.19044/esj.2018.v14n25p322>
5. Andriani, S., Kesumawati, N., & Kristiawan, M. (2018). The influence of the transformational leadership and work motivation on teachers performance. *International Journal of Scientific and Technology Research*, 7(7), 19–29.
6. Anik Herminingsih, & Widienti Supardi. (2017). The Effects of Work Ethics, Transformational and Transactional Leadership on Work Performance of Teachers. *Management Studies*, 5(3). <https://doi.org/10.17265/2328-2185/2017.03.009>
7. Arifin, F., Troena, E. A., Djumahir, & Rahayu, M. (2014). Organizational Culture, Transformational Leadership, Work Engagement and Teacher's Performance : Test of a Model. *International Journal of Education and Research*, 2(1), 1–14. www.ijern.com
8. Badia, A., Meneses, J., & Sigalés, C. (2013). Teachers' perceptions of factors affecting the educational use of ICT in technology-rich classrooms. *Electronic Journal of Research in Educational Psychology*, 11(3), 787–808. <https://doi.org/10.14204/ejrep.31.13053>
9. Bass, B. M., & Avolio, B. J. (1983). Developing Transformational Leadership. 1–4.
10. Bass, B. M., & Riggio, R. E. (2005). Transformational leadership: Second edition. *Transformational Leadership: Second Edition*, 1–282. <https://doi.org/10.4324/9781410617095>
11. Burns, J. M. (2012). *Leadership*.
12. DeAndrade-Oliveira, O. (2022). The Impact of Transformational Leadership on Team Performance.
13. Eliophotou-menon, M., & Ioannou, A. (2016). The Link Between Transformational Leadership and Teachers' Job Satisfaction, Commitment, Motivation To Learn, and Trust in the Leader. *Academy of Educational Leadership Journal*, 20(3), 12–23.
14. Hargreaves, A., & Fink, D. (2004). The Seven Principles of Sustainable Leadership. *Educational Leadership*, 61(7), 8–13.
15. Hauserman, C. P., & Stick, S. L. (2013). The leadership teachers want from principals: Transformational. *Canadian Journal of Education*, 36(3), 184–203.
16. Hyler, M. E., & Gardner, M. (2017). Linda Darling-Effective Teacher Professional Development. June, 1–2. https://learningpolicyinstitute.org/sites/default/files/product-files/Effective_Teacher_Professional_Development_REPORT.pdf
17. Insan, a N., Astuti, E. S., Raharjo, K., & Hamid, D. (2013). The Effect of Transformational Leadership Model on Employees' Job Satisfaction and Performance at Perusahaan Listrik Negara (PLN Persero) 1 in South Sulawesi, Indonesia. 3(5), 135–142.
18. Jovanovic, D., & Ciric, M. (2016). Benefits of Transformational Leadership in the Context of Education. 496–503. <https://doi.org/10.15405/epsbs.2016.09.64>
19. Kadyschuk, R. (1997). Teacher Commitment: A study of the organizational commitment, professional commitment, and Union Commitment of teachers in public schools in Saskatchewan. 60502044, 220–222.
20. Kilag, O. K., Malbas, M., Nengasca, M., Longakit, L., Celin, L., Pasigui, R., & Valenzona, M. (2023). Transformational Leadership and Educational Innovation. *European Journal of Higher Education and Academic Advancement*, 1(2). https://www.researchgate.net/publication/371609552_Transformational_Leadership_and_Educational_Innovation
21. Kılınç, A. Ç., Polatcan, M., Savaş, G., & Er, E. (2022). How transformational leadership influences teachers' commitment and innovative practices: Understanding the moderating role of trust in principal. *Educational Management Administration and Leadership*. <https://doi.org/10.1177/17411432221082803>
22. Kılınç, A. Ç., Polatcan, M., Savaş, G., & Er, E. (2024). How transformational leadership influences teachers' commitment and innovative practices: Understanding the moderating role of trust in principal. *Educational Management Administration and Leadership*, 52(2), 455–474. <https://doi.org/10.1177/17411432221082803>
23. Leithwood, K., & Jantzi, D. (n.d.). Transformational leadership. *The Essentials of School Leadership*.
24. Leithwood, K., Menzies, T., Jantzi, D., & Leithwood, J. (1996). School restructuring, transformational leadership and the amelioration of teacher burnout. *Anxiety, Stress and Coping*, 9(3), 199–215.

- <https://doi.org/10.1080/10615809608249402>
25. Madjid, A., & Samsudin, M. (2021). Impact of Achievement Motivation and Transformational Leadership on Teacher Performance Mediated by Organizational Commitment. *Educational Sciences: Theory and Practice*, 21(3), 107–109.
 26. Mahaputra, M. R., & Farhan Saputra. (2021). Literature Review the Effect of Headmaster Leadership on Teacher Performance, Loyalty and Motivation. *Journal of Accounting and Finance Management*, 2(2), 103–113. <https://doi.org/10.38035/jafm.v2i2.77>
 27. Mahmudah, C., Bafadal, I., & Sobri, A. Y. (2020). Relationship between Transformational Leadership and Teacher Performance: A Correlation Analysis. <https://doi.org/10.2991/assehr.k.201214.206>
 28. Malik, M. E., Danish, R. Q., & Munir, Y. (2012). The role of transformational leadership and leader's emotional quotient in organizational learning. *World Applied Sciences Journal*, 16(6), 814–818.
 29. Nadav, N., Benoliel, P., & Schechter, C. (2023). Principals' systems thinking and school effectiveness: The mediating role of collective teacher efficacy. *Educational Management Administration and Leadership*. <https://doi.org/10.1177/17411432231152355>
 30. Novitasari, D., Asbari, M., Wijayanti, L. M., Hyun, C. C., & Farhan, M. (2020). The Role of Religiosity, Leadership Style, Job Satisfaction and Organizational Citizenship Behavior Mediation on Woman Teachers' Performance. *Solid State Technology*, 63(6), 2953–2967. <http://solidstatetechnology.us/index.php/JSST/article/view/3380>
 31. Oc, B., Chintakananda, K., Bashshur, M. R., & Day, D. V. (2023). The study of followers in leadership research: A systematic and critical review. *Leadership Quarterly*, 34(1). <https://doi.org/10.1016/j.leaqua.2022.101674>
 32. Purwanto, A., Kusumaningsih, S. W., & ... (2020). Did Transformational Leadership Elitist and Antidemocratic? A Literature Review. ... *Journal of Social, Policy* <https://www.ijospl.org/index.php/ijospl/article/view/1>
 33. Rahmian, L., Hod, Y., Yuan, G., & Zhang, J. (2024). Supporting students' inquiry through doubly authentic learning designs: four configurations of interests, domain, and identity. *European Journal of Psychology of Education*. <https://doi.org/10.1007/s10212-024-00818-5>
 34. Sanchez, J., & Watson, J. M. (2021). Effective Instructional Leadership Practices in High Performing Elementary Schools. *Journal of School Administration Research and Development*, 6(2), 60–70. <https://doi.org/10.32674/JSARD.V6I2.3975>
 35. Shila, J. M., & Sevilla, A. V. (2015). The influence of teachers' job satisfaction on their organizational commitment: An Indian context. *International Journal of Education and Management Studies*, 5(1), 53–57.

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/377064161>

DONOR'S BEHAVIOUR TOWARDS "DONATION BASED CROWDFUNDING": AN EMPIRICAL STUDY USING EXTENDED THEORY OF PLANNED BEHAVIOUR

Article in *Journal of Commerce and Accounting Research* · January 2024

CITATIONS

0

READS

255

1 author:



[Chandrakala Govindappa](#)

Dayananda Sagar Institutions

5 PUBLICATIONS 4 CITATIONS

SEE PROFILE

DONOR'S BEHAVIOUR TOWARDS “DONATION BASED CROWDFUNDING”: AN EMPIRICAL STUDY USING EXTENDED THEORY OF PLANNED BEHAVIOUR

Meghana C.*, K. Anil Babar**, Chandrakala G.***

Abstract *Philanthropy includes practices and deeds that are signs of a voluntarily committed effort to improve the lives of others. The idea of philanthropy can solve all of the major problems in the economy. Recently, online philanthropy (donation-based crowdfunding) has gained its own importance. The present study is primarily focused on the backers or donors point of view. The objective of the study focused on understanding the behaviour pattern and intentions of potential and actual donors towards the donation based model by with the Extended Theory of Planned Behaviour. Data was gathered from 207 responses via a carefully constructed questionnaire include Theory of Planned Behaviour factors. Data responses that fulfilled the requirements were carefully selected for analysis. The data were analysed using SPSS and SmartPLS 4.0. Statistical tools such as descriptive statistics, confirmatory factor analysis and path analysis are used. The factors such as attitude, perceived behaviour control, subjective norms, self-identity and cognitive based trust have significantly positive influences on donation intention.*

Keywords: *Philanthropy, Donation based Crowdfunding Model, Donors Behavior, Theory of Planned Behavior, India*

JEL Classification: D64, D91, G40.

INTRODUCTION

Philanthropy is a concept that can solve all of our difficulties (Fuentenebro, 2020). “philanthropy” is the term connected which is evolved from predominant, philosophical and trends in culture in contemporary set up (Sulek, 2010). According to Walt Whitman, stated “Behold I do not give lectures or a little charity, When I give, I give myself.” Giving is a voluntary act that provides support to those in need. It can take both tangible and intangible forms. We feel good when we share what we have with each other (Silverman, 2009).

Philanthropy includes practises and deeds that are signs of a voluntarily committed effort to improve the lives of others (Kaushal, 2018). Cultural and religious beliefs about the obligations of the affluent towards those who are less prosperous or experiencing hardship are the foundation of philanthropy (Silverman, 2009). Family enterprises

charitable work contributes significant financial resources to the world’s social services, healthcare, humanities and arts (Feliu & Botero, 2016). One of the consistently studied topics in economics, commerce and management is philanthropy (Upadhaya & Chadha, 2019).

Philanthropy can create goodness to the different sectors in the society. It can play a vital role and creates a wonderful things for the world (Whitchurch & Comer, 2016). Many talented people often young men and women have opted for this career for development and believing that it will benefits the recipients of philanthropic act (Saiia et al., 2003). However, it differs based on culture, socio-economic and levels of development across the country (Sen et al., 2020).

Philanthropy associated with experiential learning is a cutting-edge pedagogy in higher education policy (Upadhaya & Chadha, 2019). Colleges and universities have started to actively fund and to response to societal causes. The

* Research Scholar, Dayananda Sagar University, Bengaluru, Karnataka, India. Email: megghanac1092@gmail.com; ORCID: 0000-0002-7881-0404

** Former Assistant Professor, Dayananda Sagar University, Bengaluru, Karnataka, India. Email: anilk916k@gmail.com; ORCID: 0000 -0002-6758-398X

*** Associate Professor, Dayananda Sagar University, Shavige Malleshwara Hills, 1st Stage, Kumarswamy Layout, Bengaluru - 560 078, Karnataka, India. Email: chandrakala-socm@dsu.edu.in; ORCID: 0000 -0002-0406-7371

teaching method is regarded as a type of service-learning. It is described as a method of teaching that gives pupils the chance to research social issues and non-profit organisations before deciding whether to donate money (McDougle et al., 2017; Sands, 2019).

Individual financial contributions deserve special attention because they are frequently the primary private source of funding for charities (Alhidari et al., 2018). This originates from the intrinsic and extrinsic motivations of individuals, foundations, charitable trusts and businesses. Cash donations dominate all other types of giving, and small contributions are indeed a substantial source of revenue for charitable causes. Donors contribute the minimum amount which is necessary to get into a philanthropically activities (Feliu & Botero, 2016).

Crowdfunding is a rapidly growing financing alternative based on the technology enabled sector process (Salido-Andrés et al., 2019). It disrupted the method of handling finance for larger crowd business (Beaulieu et al., 2015). The crowdfunding phenomenon is pushed through founder's unfulfilled want for capital.

It is important to know the major key players in crowdfunding concepts (Kusumarani & Zo, 2019) they are: The "founders" (creators or borrower) are those who advertise their business idea on a crowdfunding website in order to raise money. People who are looking for money have a mixed aspirations and come from a varied backgrounds (Skirnevskiy et al., 2017). The backers (contributor/donors) responsibility extends beyond monetary support. Those who support a project might do so by contributing funds or by promoting it on social media and through their own networks (Butticè & Noonan, 2020) and the platforms (technology providers) website providers play a key and central part in the crowdfunding phenomena since technology at its core makes crowdfunding possible (Brem et al., 2019). They offer the technological foundation that enables innovators to reach out to numerous possible backers for their project (Wang et al., 2018).

Indians believes traditionally with the feelings that humble kindness since childhood of being empathy towards giving the charity from our personal pockets states believing in the faith that doing something good for others will get good blessings (Nilekani, 2008). Intrinsically interesting factor influences individuals donors to contribute towards are private warm glow and public prestige is a one of the factor influences the behaviour individual's and create a competitions among others donors in the charitable amounts (Harbaugh, 1998).

During the COVID-19 pandemic, high net worth individuals, well-known individuals and the philanthropic community as a whole reacted quickly by organising local and international

initiatives to raise money and bring attention to a serious global health crisis (Fuentenebro, 2020) .

From literature it is listed most significant factors which are have an impact towards donation or charitable behaviour are gender, age, cash or kind, marital status, family size, work life balance, warm glow, altruism, pledging, (Sen et al., 2020) Weather, Mood (Kuttanda et al., 2019) trust (Alhidari et al., 2018). Requirements, cost/benefit, status, philanthropy, costs and benefits, reputation, efficacy, psychological benefits and values (Bekkers & Wiepking, 2011).

Recently touch of finance and technology, as made online philanthropy (Liu et al., 2017). In order to process and work efficiently, understanding the issues surrounding in phenomenon is much needed and there is large existing research gap to fill in different point of views (Kusuma & Anafisati, 2020).

Corporate charity specific to institutional – firm related to the top and middle managers is tested towards charitable behaviour; there is a gap on individual behaviour. In order to process and work efficiently, understanding the issues surrounding in phenomenon is much needed and there is large existing research gap to fill in different point of views (Kusuma & Anafisati, 2020).

Understanding the factors which influences the donors to contribute towards the online philanthropy will makes donation based crowdfunding more successful (Ya, Zheng, Li, Tong-Liang He & Yi-Ran Song, 2017) and which impact many creators life's and it's will definitely lead their lives successful and achieving sustainable growth (Changati & Kansal, 2019).

The present study is majorly focused on the backers or donors point of view. To study is aimed at understand the behaviour pattern and intentions of potential and actually donors towards donation based model.

In my opinion, resources need to be in constant flow, whether they be financial, in-kind, or volunteer activities. Understanding the nature of philanthropy plays a significant role to think, inspire and motivate the prospective donors to involve in more philanthropy activities.

REVIEW OF LITERATURE AND DEVELOPMENT OF A HYPOTHESIS

Research based on Donation Crowdfunding

Donation crowdfunding has developed as novel and flourished globally in recent years as an innovative and remarkable fundraising model. It is an alternate source of

funding for a range of private and public goals as a unique approach to problem-solving strategy and a well-established social practice (Xu, 2018). This idea was influenced by crowdsourcing.

Crowdfunding is a method for individuals or groups to raise funds for their projects by relative contribution of minimal amounts from a lot of people through internet without relying on traditional finance intermediary. A financial technology platform is intended to raise money through micro finance, donations and community service.

Donation-based crowdfunding addresses an eliminating wide range of issues, including resolving medical emergencies, saving abandoned animals, solving neighbourhood issues and reallocating educational resources. The goal of crowdfunding campaigns is to enlist the support of large numbers of people for initiatives that supporters have posted both on their own pages and on websites that facilitate mass fundraising. Rewards are usually not offered but rather social benefits like acknowledgments (Rijanto, 2018).

Philanthropy turns become a strategy for improving societal status, image management and other extrinsic value sources. Donation is a perspective that has the potential to be more powerful and valuable than others. Donations for sales can have a more self-serving attribution, and as a result, they have less intrinsic value to stakeholders. Also, it can reduce the possible extrinsic value when others perceive it as less desired social care (Cason & Zubrickas, 2019).

Theoretical Background

A Concept of behaviourism or behavioural psychology is a study, which as explains the influences of environment on individuals behaviour pattern. The observable behaviour modification is the most fundamental definition of the concept (Watson, 2011). A person's motivation to exert effort to do the intended action can be articulated by the conscious plan, self-instructions, required decisions is represented by their behavioural intentions.

In the mid of 20th century, the concept has got more importance. Theories which are engaged in the determinant of action are Theory of Reasoned Action, Reasoned Action Approach, among the many theories (Ajzen 1985, 1998 & 1991) the most widely used theory is Theory of Planned Behaviour which predict the action of human behaviour.

The prediction of intention factors which are studied under TPB are as follows: Subjective norms, attitude and PBC, which help in anticipation of different behaviours, populations and circumstances (Conner, 2020)

Theory of Planned Behaviour

Ajzen introduced the TPB in 1985 which is extension of Theory of Reasoned Action. It is one of wide applicable behavioural model, which has been used for analysis the understanding and predictive behavioural intention of the individuals from the past decade (Krueger & Carsrud, 1993; Parker & Stradling, 1995; Parker & Manstead, 1995; Terry et al., 1999). It widely applicable in the domain of social psychology which demonstrates its applicability in the understanding the online charitable behavioural intention using recent emerging mode of finance for personal and social causes know as donation based crowdfunding model.

The Ajzen-Fishbein models of behavioural intentions have been text highlights in both fundamental and applied research for a very long time by social psychologists and marketing researchers. In investigations of career-related behaviours, these cognitive models frequently perform well in predicting behaviour and intentions, was more successful.

Self – Identity Theory

Incorporating the identity theory with TPB as the theoretical framework, we have discovered probable components that may influence donation intentions. Extrinsic and intrinsic motives combine to influence most people's behaviour. In addition to these, earlier studies have shown the significance of contextual support in shaping people's behaviour. Therefore, in order to better understand people's motivations, we have also included Self Identity aspects in our model. We've reviewed a significant amount of literature on identity theory research to provide some clarity on building the conceptual framework. Social identity and Self-theory are two viewpoints on social foundation of self-concept and the nature of acceptable behaviour. Self-identity is primarily a micro sociological term that seeks to explain people's behaviour in relation to their roles.

Trust Theories

In several crowdfunding contexts, trust has become a significant factor in determining funding intention (Sargeant & Lee, 2002). Moreover, previous studies have been revealed insights over the trust in crowdfunding. From the previous literature we found that there has been comparatively minimal research carried based on donation-based crowdfunding. The intellectual/cognitive component of trust is prominent but in the context of crowdfunding, less focus has been devoted on the cognitive components of trust.

Research Framework and Hypothesis Development

The framed research model is incorporated from TPB, by adding two external constructs self-interest from Self Determination Theory and cognitive based trust from Trust theories which reflect behaviour of donor's towards online philanthropy (donation model).

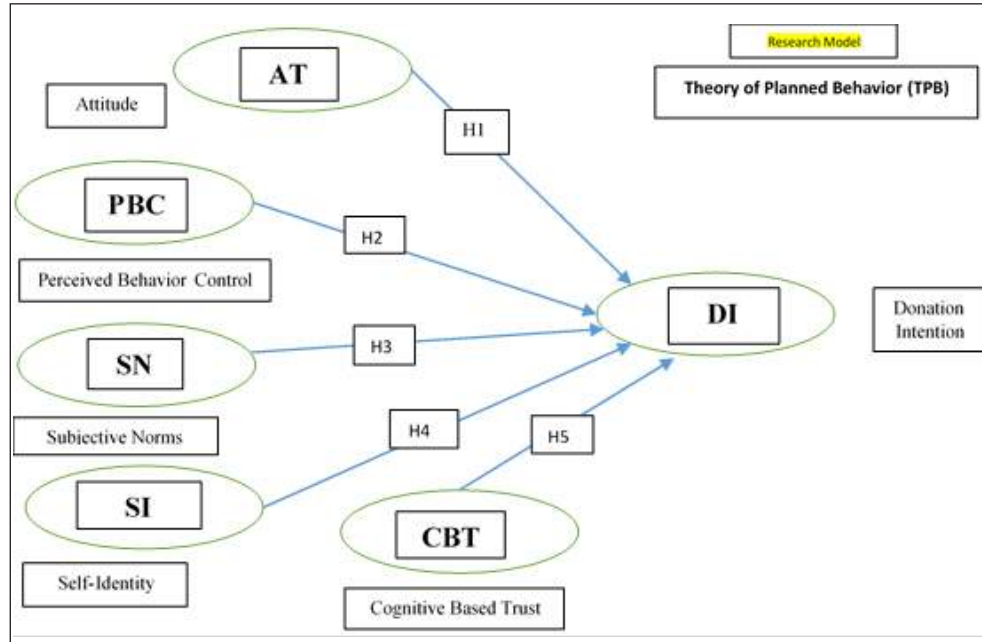
Measures

The operational definitions of constructs made necessary changes accordingly to the objectives of the study in which measurements were developed using the literature review. The survey is intended in understanding the behavioural intentions and perceptions of donors towards online philanthropy. It may have a positive or negative aspects towards donation based crowdfunding.

Operational Definitions

Sr. No.	Factor		Definitions
1	Attitude	(AT)	The persons (he/she) who have a wiliness to donate towards online philanthropy using donation based crowdfunding model.
2	Perceived Behavior Control	(PBC)	The persons (he/she) who have knowledge with confidence towards knowing the resources and like to donate towards online philanthropy using donation based crowdfunding model.
3	Subjective Norms	(SN)	The persons (he/she) who have been influenced from others (personal or social media group) and encouraged in donating towards online philanthropy using donation based crowdfunding model.
4	Self-Identity	(SI)	The persons (he/she) who have self-interest and role of social identity/social guide to donate towards online philanthropy using donation based crowdfunding model.
5	Cognitive Based Trust	(CBT)	The persons (he/she) who have good reasons and empathy towards others and are self-motivated to donate towards online philanthropy using donation based crowdfunding model.
6	Donation Intention	(DI)	The persons (he/she) who have an intention to donate towards online philanthropy using donation based crowdfunding model without any expectation.

Research Design



Theory of Planned Behaviour (TPB)

The TPB proposed by Ajzen (1991) is applied as a base theory for this study. The intent is the best predictor of such individual's behaviour in the different, from conceptual and empirical point of view (Krueger & Carsrud, 1993). According to the theory, there are three different types of deliberations

that can have an impact on a person's behaviour: "normative beliefs" (beliefs of others normative expectations and motivation to conform to these expectations), "behavioural beliefs" (beliefs about expected outcomes of the behaviour and assessment of these outcomes), and "control beliefs" (beliefs about existence of factors that obstruct or facilitate the performance of behaviour and perceived power of

these factors). Normative beliefs have a subjective norm or perceived social pressure as their corresponding aggregate, behavioural beliefs have a favourable or negative attitude towards the behaviour as their aggregate, and control beliefs have perceived control behaviour as their aggregate. TPB states that incorporating “attitude toward usage behaviour.”

H1: Attitude of having a significant donation intention to participate in donation-based crowdfunding.

H2: Perceived behaviour control have a significant donation intention to participate in donation-based crowdfunding.

H3: Subjective norms have a significant donation intention to participate in donation-based crowdfunding.

Self-Identity Theory

Self-identity is described as a cognitive construct of the self that provides a response to the inquiry “Who am I?” It emphasises on unique qualities that make each person unique. People are inclined to engage in activity when they involved in high-level of role identification because they constantly build expectations based on role-related behaviour and then engage in proper behaviour to meet these expectations. Something individuals might use to validate themselves using self-concept. According to earlier studies, self-identity provides for a substantial amount of difference in behavioural intentions. People who identify as caring about charity issues will have more intentions to donate as donation crowdfunding is a form of charitable giving.

H4: Self – Identity have a significant donation intention to participate in donation-based crowdfunding.

Trust Theory

Cognition based trust is based on rational reasoning and careful consideration. It emphasises the “positive reasons”

why others can be trusted and urges rational decision-making based on reliable knowledge about the motives or potential of others. Prior studies have shown that prospective donors frequently base their choice to support a cause on their assessment of the legitimacy of a crowdfunding initiative. If potential donors perceive that the platform is trustworthy and the charitable request of the fundraiser is rational and this will promote their cognition-based trust and their willingness to give.

H5: Cognition-based trust has influences to participate in donation-based crowdfunding.

METHODS

Instruments

The survey items which is consider for the measurement were designed using adopted scales from earlier studies with the adoptable changes to ensure the content validity. All the items related to questions are taken care, to match the objectives of this research. To examine the face validity of the questionnaire, whether items are clearly understandable by the respondents. Prior to circulation the items were evaluated by subject experts in this domain and to add better readability the pilot study was conducted with 25 undergraduate students. To support the study in the beginning of a questionnaire a brief description was included regarding online philanthropy (DCF). The first part of the questionnaires consists of demographic information and the second section were relating to donors contributing behaviour scored using a 5-point Likert scale.

To evaluate the donors behaviour we used adopted scales from the listed below authors which have been used TPB with different dimensions. Necessary changes are made relating to DCF in view to satisfices the research objectives.

Sr. No	Construct	Number of Items	Adopted Scale Reference
1	Attitude (AT)	5	(Kim & Hall, 2019) (Rotem Shneor & Munim, 2019) (Baber, 2020a),
2	Perceived Behavior Control (PBC)	5	(Kim & Hall, 2019) (R Shneor & Munim, 2019)(Baber, 2020a)
3	Subjective Norms (SN)	4	(Kim & Hall, 2019) (R Shneor & Munim, 2019) (Baber, 2020a)
4	Cognitive based Trust (CBT)	4	(Zhang et al., 2021)
5	Self – Identity (SI)	3	(T. Wang et al., 2019)
6	Donation Intention (DI)	4	(T. Wang et al., 2019) (R Shneor & Munim, 2019)

Data Collection Method

As the study concentrates on the donation based crowdfunding as well as from donors perspective, the sample units selected for this study are actual donors and potential donors, who have a empathy towards others causes and need

, who likes to helps and willing to contribute the donations financial for activities towards online philanthropy using donation based crowdfunding model. Online survey method was used to collect data from different states of southern India that represents the different population from India. The study used a non – probability based convenience and

purposive sampling methods because it is challenging to estimate the definite population size of the donors who likes to donate towards donation based model. The questionnaire was sent by mail and posted on social media sites like Facebook, Instagram and WhatsApp for both personal and professional groups. Respondents who likes to participate or who had made online charitable contributions in donation crowdfunding campaigns were chosen to complete the survey. The data was collected from January 2023 to March 2023 using a well-structured with closed ended questionnaire. Each respondent was at least 18 years old and had good reading, writing, and understanding abilities. The survey's respondents were given the assurance that their identity would remain anonymous and that no personal information or details were needed. A reminder mail and message were sent to the participants every 14 days until March 2023. In order to boost the response rate. Almost 250 submissions were received from the respondents, out of which only 207 responses that fulfilled the requirements were chosen carefully for study and it satisfies the acceptance rate and ratio suggested by (Anil Kumar & Natarajan, 2020). A total of 54 people were disqualified after the check because of inaccurate or missing information. The sample size as well satisfies the thumb rule in reference to structural equation modelling (Kline, 2011). The sample size would be 10 times more than the maximum number of measurement items for a specified construct in the instrument (Hair, Hult, Ringle & Sarstedt, 2016).

Results

Before testing proposed model, normality test was employed and using the Shapiro-wilk test, showed a significant result among the variables selected.

Sampling Adequacy

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.946
Bartlett's Test of Sphericity	Approx. Chi-Square	5139.805
	Df	300
	Sig.	0.000

The value of Kaiser–Meyer–Olkin is 0.946 which is acceptable and counted as positive sampling adequacy. Bartlett's test of sphericity is .300 degrees of freedom and it significant at 0.000. According to Barrett et al., (2005) and Bartlett, (1954), it shows that data is appropriate and valid for factor analysis.

Table 1: Demographic Profile

Demographics	Category	Frequency	Percentage (%)
Gender	Male	102	49.3
	Female	104	50.2
	Other	1	0.5
Age	18-22	59	28.5
	23-30	45	21.7
	31-40	68	32.9
	41-50	29	14
	Above50	6	2.9
Education	High School	6	2.9
	Diploma	3	1.4
	Graduates	64	30.9
	Post Graduates	79	38.2
	PhD	49	23.7
	Other	6	2.9
Occupation	Employee	100	48.3
	Entrepreneur	5	2.4
	Professional	25	12.1
	Stay at home	4	1.9
	Student	70	33.8
	Other	3	1.4

Table 1 shows the demographic characteristics of respondents. A total of 102 (49.3%) of respondents were male and 104 (50.2%) were female. Age of most of respondents were 31–40 (68- 32.9%), 18–22 (59- 28.5%) and 23–30 (45- 21.7%). Regarding educational qualification most of the respondents were post graduates (79- 38.2%), graduates (64- 30.9%) and PhD holders (49- 23.7%). With concern to occupation majority of them are employee (100- 48.3%) and students are (70-33.8%).

Data collected were analysed using three steps. First, we tested for the outliers, normality of the data and missing values. Second in evaluating internal and external validity of the measurement scales. Finally examined the reliability, validity, correlations, confirmatory factor analysis and model fit using path analysis. Table 3 depicts the measures of constructs.

Partial Least Squares (PLS) were selected to test the research model, as this technique has number of benefits. The first is that structural equation modelling, a second-generation technique, can examine indicator loading (and weights) on constructs (thus quantifying construct validity), and it can predict casual interactions with constructs in multistage

models (Sarstedt, Ringle & Hair, 2017). Second, PLS is a reliable covariance-based modelling approach for theory testing which is suitable for this research. Furthermore, PLS offers a better approximation for the results estimates (Hair, Hollingsworth, Randolph & Chong, 2017).

Table 2: Correlation Among Study Variables

Constructs	ATT	CBT	DI	PBC	SI	SN
ATT	1					
CBT	0.651	1				
DI	0.642	0.606	1			
PBC	0.559	0.559	0.497	1		
SI	0.646	0.58	0.653	0.584	1	
SN	0.454	0.529	0.339	0.362	0.351	1

Note: **correlation is significant at the 0.01 level (2 – tailed), N= 207.

Hence, PLS was selected to investigate research model of the present study. The data analysis was performed in two stages (a measurement model and a structural model). Firstly, the measurement mode was establishment to validity and reliability test to know the data fits for the study. Consequently, the study hypotheses were investigated using the structural model.

Measurement Model

To check the instrument reliability (internal consistency and stability) and validity, a six-factor measurement model was developed under confirmatory factor analysis method. To load the items on pre-specified factors; each item was restricted while the factors themselves were permitted to correlate freely.

Table 3: Confirmatory Factor Analysis Results

Construct	Items	Factor loadings	Average variance extracted (AVE)	Composite reliability - CR (rho_a)	Composite reliability - CR (rho_c)	Cronbach's alpha (α)
Attitude	ATT1	0.835	0.727	0.909	0.93	0.906
	ATT2	0.857				
	ATT3	0.874				
	ATT4	0.899				
	ATT5	0.795				
Perceived Behaviour Control	PBC1	0.837	0.567	0.844	0.863	0.799
	PBC2	0.793				
	PBC3	0.803				
	PBC4	0.817				
	PBC5	0.698				
Subjective Norms	SN1	0.694	0.656	0.853	0.883	0.824
	SN2	0.834				
	SN3	0.836				
	SN4	0.872				
Cognitive based Trust	CBT1	0.864	0.762	0.899	0.927	0.896
	CBT2	0.91				
	CBT3	0.864				
	CBT4	0.852				
Self-Identity	SI1	0.792	0.726	0.821	0.888	0.81
	SI2	0.901				
	SI3	0.859				
Donation Intention	DI1	0.911	0.821	0.93	0.948	0.927
	DI2	0.903				
	DI3	0.897				
	DI4	0.913				

Table presents the value of composite reliability and Cronbach's alpha of each construct ranges from 0.81 to 0.927, which is greater than the suggested threshold of 0.7 (Hair, Hollingsworth, Randolph, & Chong, 2017), thus demonstrating the reliability satisfactory level. The discriminant validity and convergent validity were tested to ensure the construct validity. Average variance extracted (AVE) and indicator loadings were examined to test the convergent validity. All the resulted values of AVE were above the desired threshold of minimum 0.5 (Fornell & Larcker, 1981). To ensure the convergent validity, all the standard loadings were inspected, which led to exceeding the recommended value of 0.6 and significance at 0.001 (Fornell & Larcker, 1981).

Table 4: Discriminant Validity & HTMT Criterion Test

	ATT	CBT	DI	PBC	SI	SN
ATT						
CBT	0.727					
DI	0.697	0.661				
PBC	0.672	0.675	0.562			
SI	0.754	0.682	0.747	0.723		
SN	0.532	0.626	0.377	0.501	0.433	

To determine the discriminant validity, square roots of AVEs should be higher than the inter-construct correlations shown in the off-diagonal entries (Hair, Hollingsworth, Randolph, & Chong, 2017), referring to the acceptance of discriminant validity.

Structural Model

Table 5: Path Analysis

Hypothesized Path	Original Sample (O)	Sample Mean (M)	Standard deviation (STDEV)	T Statistics	P Values	Sig	Results
ATT -> DI	0.237	0.221	0.172	1.382	0.067	Yes	Accepted
CBT -> DI	0.252	0.245	0.153	1.647	0.000	Yes	Accepted
PBC -> DI	0.458	0.455	0.062	7.414	0.021	Yes	Accepted
SI -> DI	0.539	0.541	0.044	12.652	0.014	Yes	Accepted
SN -> DI	0.134	0.131	0.042	3.181	0.045	Yes	Accepted

Note: p-value < 0.000 – significant at 1% level; p-value < 0.05 – significant at 5% level.

The Smart PLS path coefficients are shown. For all of the pathways, the t-statistics value is found to be higher than 1.96. Attitude, cognitive based trust, perceived behaviour control, self-identity and subjective norms has a positively significant effect on the donation intention. The explanatory power (R Square) of donation intention is 0.604. According to (Hair, Ringle, & Sarstedt, 2013) is considered as a better explanatory power.

DISCUSSION

Overall results indicate that our prediction model captures the drivers of financial behaviour in the context of donation crowdfunding and supports the conceptual application of the TPB in this context and the significance of the intended components in predicting crowdfunding behaviour with respect to actual and potential donors. By doing so, it provides new perspectives on the purpose cognitive antecedents serve in crowdfunding donation behaviour.

Our data findings shows that all TPB antecedents worked as the theory predicted, with attitude, perceived behaviour

control and subjective norms having a significant beneficial impact on donation intention by (Rotem Shneor & Munim, 2019; Baber, 2020b; Pérez & Egea, 2019; Kim & Hall, 2019; Chen et al., 2019; Arora & Kaur, 2018). However, it was supported even in our analysis also.

Establishing a relationship between trustors—those who create trust and act in a particular way given the circumstance and trustees is the first step in developing trust. The study results show that user's intentions to donate towards donation based crowdfunding are highly influenced by cognition-based trust. This result is consistent with earlier research showing the significant influence link between trust and charitable intention (Khan & Abbas, 2019; Zhang et al., 2021; Chen et al., 2019).

Self-identity hypotheses are statistically supported in our study. According to the findings of the studies done (Rodriguez-Ricardo et al., 2018), self-identity is proven to considerably influence donation intentions (Wang et al., 2019). These results suggest that users' intentions to donate may increase if they believe that engaging in charitable conduct fits with their sense of self-image (Chen et al., 2019).

Practical Implications

The demographic and personality information offers key facts about the population that takes part in crowdfunding initiatives. The majority of individuals are drawn to this creative method of fund-raising. People spend the majority of their time on social networking sites as well as using mobile devices in general, which makes it simple for them to invest using such technological means. Due to their extensive technological experience, individuals are also familiar with the idea and purpose of crowdfunding. Donations, in whatever form, provide joy, peace and a sense of belonging to the world that only those seeking the spiritual, divine, and energetic can appreciate. Platforms for crowdfunding work as intermediaries for those looking for assistance, and those who offer it will experience the wonderful pleasure of supporting worthy causes.

Managerial Implications

The findings of this study is useful to crowdfunding platforms in understanding the impact of contributors and public interest in taking part in donation-based campaigns, which will ultimately determine the success of those initiatives. They may better categorise funders and fundraisers with the aid of this study, and they can select the ideal target market for each campaign. For people or organisations that are unable to provide anything in exchange for the contribution received, donation-based crowdfunding can be helpful. Therefore, understanding the behaviour of donors is crucial. Positive attitudes can influence people's intentions to take part in these efforts.

Limitations

The study has shortcomings that should be taken into consideration in subsequent research. The study was carried out in a few southern Indian states. India has a population that is quite diversified. Given that India has the second-largest population; results from a bigger sample would be more representative. Future research should assess actual behaviour because intention may not always translate into behaviour.

CONCLUSION

The study focused on understanding the donor's behaviour usage and intention to participating in donation based crowdfunding campaigns by using TPB. Some external variables such as self-identity and cognitive trust were integrated with the models. After developing and testing the

proposed model, the research revealed that all the factors namely attitude, perceived behaviour control, subjective norms, identity theory factor – self-identity and trust theory factor – cognitive based trust have a significantly positive influences on donation intention.

REFERENCES

- Alhidari, I. S., Veludo-De-Oliveira, T. M., Yousafzai, S. Y., & Yani-De-Soriano, M. (2018). Modeling the effect of multidimensional trust on individual monetary donations to charitable organizations. *Nonprofit and Voluntary Sector Quarterly*, 47(3), 623–644. doi:https://doi.org/10.1177/0899764017753559
- Anil Kumar, K., & Natarajan, S. (2020). An extension of the expectation confirmation model (ECM) to study continuance behavior in using e-Health services. *Innovative Marketing*, 16(2), 15-28. doi:https://doi.org/10.21511/im.16(2).2020.02
- Arora, S., & Kaur, S. (2018). Perceived risk dimensions & its impact on intention to use e-banking services: A Conceptual study. *Journal of Commerce and Accounting Research*, 7(2), 18–27. Retrieved from <http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=129245162&lang=es&site=ehost-live>
- Baber, H. (2020a). Intentions to participate in political crowdfunding- from the perspective of civic voluntarism model and theory of planned behavior. *Technology in Society*, 63. doi:https://doi.org/10.1016/j.techsoc.2020.101435
- Baber, H. (2020b). Technology in society intentions to participate in political crowdfunding - From the perspective of civic voluntarism model and theory of planned behavior. *Technology in Society*, 63(October), 101435. doi:https://doi.org/10.1016/j.techsoc.2020.101435
- Beaulieu, T. Y., Sarker, S., & Sarker, S. (2015). A conceptual framework for understanding crowdfunding. *Communications of the Association for Information Systems*, 37(1), 1-31. doi:https://doi.org/10.17705/1cais.03701
- Bekkers, R., & Wiepking, P. (2011). A literature review of empirical studies of philanthropy: Eight mechanisms that drive charitable giving. In *Nonprofit and Voluntary Sector Quarterly*, 40(5). doi:https://doi.org/10.1177/0899764010380927
- Brem, A., Bilgram, V., & Marchuk, A. (2019). How crowdfunding platforms change the nature of user innovation – From problem solving to entrepreneurship. *Technological Forecasting and Social Change*, 144, 348–360. doi:https://doi.org/10.1016/j.techfore.2017.11.020

- Butticè, V., & Noonan, D. (2020). Active backers, product commercialisation and product quality after a crowdfunding campaign: A comparison between first-time and repeated entrepreneurs. *International Small Business Journal: Researching Entrepreneurship*, 38(2), 111-134. doi:<https://doi.org/10.1177/0266242619883984>
- Cason, T. N., & Zubrickas, R. (2019). Donation-based crowdfunding with refund bonuses. *European Economic Review*, 119, 452-471. doi:<https://doi.org/10.1016/j.eurocorev.2019.08.003>
- Changati, V., & Kansal, P. (2019). Factors influencing technology acceptance in the banking sector: A binary recursive partitioning approach. *Journal of Commerce & Accounting Research*, 8(1), 15. Retrieved from <http://web.b.ebscohost.com/aib.idm.oclc.org/ehost/detail/detail?vid=0&sid=b9e81226-c579-44af-8aa2-af992fbb2910%40sessionmgr103&bdata=JnNpdGU9ZWhvc3QtbgI2ZQ%3D%3D#AN=134381207&db=plh>
- Chen, Y., Dai, R., Yao, J., & Li, Y. (2019). Donate time or money? The determinants of donation intention in online crowdfunding. *Sustainability (Switzerland)*, 11(16), 1-21. doi:<https://doi.org/10.3390/su11164269>
- Conner, M. (2020). Theory of planned behavior Theory overview. *Handbook of Sport Psychology*, 1(4), 1-18.
- Feliu, N., & Botero, I. C. (2016). Philanthropy in family enterprises: A review of literature. *Family Business Review*, 29(1), 121-141. doi:<https://doi.org/10.1177/0894486515610962>
- Fuentenebro, P. (2020). Will philanthropy save us all? Rethinking urban philanthropy in a time of crisis. *Geoforum*, 117(July), 304-307. doi:<https://doi.org/10.1016/j.geoforum.2020.07.005>
- Harbaugh, W. T. (1998). What do donations buy? A model of philanthropy based on prestige and warm glow. *Journal of Public Economics*, 67(2), 269-284. doi:[https://doi.org/10.1016/S0047-2727\(97\)00062-5](https://doi.org/10.1016/S0047-2727(97)00062-5)
- Kaushal, P. (2018). Convergence of corporate governance and CSR: A view from the boardroom of Indian commercial banks. *Journal of Commerce and Accounting Research*, 7(3), 26-34. Retrieved from <http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=129240919&site=ehost-live>
- Khan, S., & Abbas, M. T. (2019). *Factors influencing the adoption of crowdfunding in Bangladesh: A study on start-up entrepreneurs*. 85.
- Kim, M. J., & Hall, C. M. (2019). Can co-creation and crowdfunding types predict funder behavior? An extended model of goal-directed behavior. *Sustainability (Switzerland)*, 11(24). doi:<https://doi.org/10.3390/su11247061>
- Krueger, J. N. F., & Carsrud, A. L. (1993). Entrepreneurship & regional development : An international entrepreneurial intentions: Applying the theory of planned behaviour. *Entrepreneurship & Regional Development: An International Journal*, 5(June 2012), 37-41.
- Kusuma, H., & Anafisati, V. (2020). Donor'S intention on the crowdfundingamong university students: An extension of the theory of planned behaviour. *Humanities & Social Sciences Reviews*, 8(4), 710-719. doi:<https://doi.org/10.18510/hssr.2020.8470>
- Kusumarani, R., & Zo, H. (2019). Why people participate in online political crowdfunding: A civic voluntarism perspective. *Telematics and Informatics*, 41(November 2018), 168-181. doi:<https://doi.org/10.1016/j.tele.2019.04.011>
- Kuttanda, V., T, D. D., & Philip, J. N. (2019). Weather, Mood and helping behavior: A comparative study between two Indian cities (Chennai and Mysore). *Journal of Psychosocial Research*, 13(2), 453-467. doi:<https://doi.org/10.32381/jpr.2018.13.02.20>
- Liu, L., Suh, A., & Wagner, C. (2017). Donation behavior in online micro charities: An investigation of charitable crowdfunding projects. *Proceedings of the Annual Hawaii International Conference on System Sciences, 2017-Janua*, 843-852. <https://doi.org/10.24251/hicss.2017.100>
- McDougle, L., McDonald, D., Li, H., McIntyre Miller, W., & Xu, C. (2017). Can philanthropy be taught? *Nonprofit and Voluntary Sector Quarterly*, 46(2), 330-351. doi:<https://doi.org/10.1177/0899764016662355>
- Nilekani, R. (2008). Philanthropy, old and new. *The Hindu*.
- Parker, D., & Manstead, A. S. R. (1995). Evaluating and extending the theory of planned behaviour. *European Review of Social Psychology*, 6(1), 69-95. doi:<https://doi.org/10.1080/14792779443000012>
- Parker, D., & Stradling, S. G. (1995). Extending the theory of planned behaviour: The role of personal norm. *British Journal of Social Psychology*, 34(2), 127-137.
- Pérez, L. P. Y., & Egea, P. (2019). About intentions to donate for sustainable rural development: An exploratory study. *Sustainability (Switzerland)*, 11(3), 1-14. doi:<https://doi.org/10.3390/su11030765>
- Rijanto, A. (2018). Donation-based crowdfunding as corporate social responsibility activities and financing. *Journal of General Management*, 43(2), 79-88. doi:<https://doi.org/10.1177/0306307017748125>
- Rodriguez-Ricardo, Y., Sicilia, M., & López, M. (2018). What drives crowdfunding participation? The influence of personal and social traits. *Spanish Journal of Marketing - ESIC*, 22(2), 163-182. doi:<https://doi.org/10.1108/SJME-03-2018-004>

- Saia, D. H., Carroll, A. B., & Buchholtz, A. K. (2003). Philanthropy as strategy. *Business & Society*, 42(2), 169-201. doi:https://doi.org/10.1177/0007650303042002002
- Salido-Andrés, N., Rey-García, M., Alvarez-González, L. I., & Vázquez-Casielles, R. (2019). Determinants of success of donation-based crowdfunding through digital platforms: The influence of offline factors. *CIRIEC-Espana Revista de Economía Publica, Social y Cooperativa*, 95, 119-141. doi:https://doi.org/10.7203/CIRIEC-E.95.13001
- Sands, S. (2019). Applying a rational systems approach to the analysis of education philanthropies' grantmaking practices. *New York State Political Science Association Annual Conference*, 1-23.
- Sargeant, A., & Lee, S. (2002). Individual and contextual antecedents of donor trust in the voluntary sector. *Journal of Marketing Management*, 18(7-8), 779-802. doi:https://doi.org/10.1362/0267257022780679
- Sen, A., Chatterjee, R. Sen, Nayak, N. C., & Mahakud, J. (2020). Determinants of Individual Giving Behavior in Urban India. *Voluntas*, 31(2), 271-285. doi:https://doi.org/10.1007/s11266-017-9913-6
- Shneor, R., & Munim, Z. H. (2019). Reward crowdfunding contribution as planned behaviour: An extended framework. *Journal of Business Research*, 103, 56-70. doi:https://doi.org/10.1016/j.jbusres.2019.06.013
- Shneor, Rotem, & Munim, Z. H. (2019). Reward crowdfunding contribution as planned behaviour: An extended framework. *Journal of Business Research*, 103(August 2018), 56-70. doi:https://doi.org/10.1016/j.jbusres.2019.06.013
- Silverman, E. (2009). Philanthropy can begin at home. *Bottom Line*, 22(3), 93-94. doi:https://doi.org/10.1108/08880450910999677
- Skirnevskiy, V., Bendig, D., & Brettel, M. (2017). The influence of internal social capital on serial creators' success in crowdfunding. *Entrepreneurship: Theory and Practice*, 41(2), 209-236. doi:https://doi.org/10.1111/etap.12272
- Sulek, M. (2010). On the modern meaning of philanthropy. *Nonprofit and Voluntary Sector Quarterly*, 39(2), 193-212. doi:https://doi.org/10.1177/0899764009333052
- Terry, D. J., Hogg, M. A., & White, K. M. (1999). The theory of planned behaviour: Self-identity, social identity and group norms. *British Journal of Social Psychology*, 38(8), 225-244.
- Upadhaya, G., & Chadha, P. (2019). Entrepreneurial motivations and barriers among management students in Himachal Pradesh: An empirical study. *Journal of Commerce and Accounting Research*, 8(2), 48-58. Retrieved from http://proquest.umi.com/login/athens?url=https://www.proquest.com/scholarly-journals/entrepreneurial-motivations-barriers-among/docview/2241044261/se-2?accountid=11979%0Ahttps://oneresearch.lancaster-university.uk/openurl/44LAN/44LAN_services_page?url_ver=Z
- Wang, N., Li, Q., Liang, H., Ye, T., & Ge, S. (2018). Understanding the importance of interaction between creators and backers in crowdfunding success. *Electronic Commerce Research and Applications*, 27, 106-117. doi:https://doi.org/10.1016/j.elerap.2017.12.004
- Wang, T., Li, Y., Kang, M., & Zheng, H. (2019). Exploring individuals' behavioral intentions toward donation crowdfunding: Evidence from China. *Industrial Management and Data Systems*, 119(7), 1515-1534. doi:https://doi.org/10.1108/IMDS-10-2018-0451
- Watson, J. B. (2011). Behaviorism. *The Psychological Record*, 61(3), 449-463.
- Whitchurch, J., & Comer, A. (2016). Creating a culture of philanthropy. *Bottom Line*, 29(2), 114-122. doi:https://doi.org/10.1108/BL-02-2016-0012
- Xu, L. Z. (2018). Will a digital camera cure your sick puppy? Modality and category effects in donation-based crowdfunding. *Telematics and Informatics*, 35(7), 1914-1924. doi:https://doi.org/10.1016/j.tele.2018.06.004
- Li, Y.-Z., He, T.-L., Song, Y.-R., Yang, Z., & Zhou, R.-T. (2017). Factors impacting donors' intention to donate to charitable crowd-funding projects in China: A UTAUT-based model. *Information, Communication & Society*, 4462(March). doi:https://doi.org/10.1080/1369118X.2017.1282530
- Zhang, X., Hu, W., & Xiao, Q. (2021). Influences of medical crowdfunding website design features on trust and intention to donate: Controlled laboratory experiment. *Journal of Medical Internet Research*, 23(5). doi:https://doi.org/10.2196/25554

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/361675704>

Prediction of crop yield using climate variables in the south-western province of India: a functional artificial neural network modeling (FLANN) approach

Article in Environment Development and Sustainability · July 2022

DOI: 10.1007/s10668-022-02517-x

CITATIONS

14

4 authors:



Pradyot Ranjan Jena

National Institute of Technology Karnataka

72 PUBLICATIONS 1,761 CITATIONS

SEE PROFILE



Rajesh Kalli

National Institute of Technology Karnataka

13 PUBLICATIONS 213 CITATIONS

SEE PROFILE

READS

1,103



Babita Majhi

Guru Ghasidas University

104 PUBLICATIONS 2,666 CITATIONS

SEE PROFILE



Ritanjali Majhi

National Institute of Technology, Warangal

42 PUBLICATIONS 1,259 CITATIONS

SEE PROFILE



Prediction of crop yield using climate variables in the south-western province of India: a functional artificial neural network modeling (FLANN) approach

Pradyot Ranjan Jena¹ · Babita Majhi² · Rajesh Kalli³ · Ritanjali Majhi¹

Received: 16 March 2021 / Accepted: 9 June 2022

© The Author(s), under exclusive licence to Springer Nature B.V. 2022

Abstract

To meet the demand of the growing population, there exists pressure on food production. In this context, appropriate prediction of crop yield helps in agricultural production planning. Given the inability of the traditional linear models to provide satisfactory prediction performance, there is a need to develop a crop yield prediction model that is simple in complexity, accurate in prediction, and less time-consuming during training and validation phases. Keeping these objectives in view, the present paper focuses on building an adaptive, low complexity, and accurate nonlinear model for the prediction of crop yield. A time series dataset for the period 1991–2012 of Karnataka, a southwestern state of India, is used for yield prediction. An empirical nonlinear relation between crop yield and the four independent attributes has been obtained from the proposed ANN model. The independent attributes employed are total rainfall, the cumulative distribution of temperature, the proportion of irrigated land, and the average amount of fertilizer used. It is demonstrated that the developed model exhibits better prediction accuracy, less root mean square error in the range of 0.07–0.14, less mean square error in the range of 0.01–0.04, and mean absolute error in the range of 0.07–0.15 compared to its corresponding linear regression model. It is recommended that the proposed ANN model can also be applied to predict other agricultural products of the same or other geographical regions of the globe.

Keywords Yield prediction · Functional link artificial neural network · Panel regression · Climate change · Karnataka

✉ Pradyot Ranjan Jena
pradyotjena@nitk.edu.in

¹ School of Management, National Institute of Technology Karnataka, Surathkal 575025, India

² Department of CSIT, Guru Ghasidas Vishwavidyalaya, Central University, Bilaspur 495009, India

³ Presidency University, Bangalore, India

1 Introduction

Agriculture production needs to grow at a faster rate to keep pace with the rising population (Godfray et al., 2010; Gregory & George, 2011). The global population is estimated to increase to 9.3 billion by 2050, which requires farm production to grow by 70–100% to meet the food demand (Tian et al., 2021). Rising temperature and uneven rainfall cause a potential threat to crop production (Carleton, 2017; Kalli & Jena, 2021; Mendelsohn, 2014). The changing climate patterns have made agriculture a highly vulnerable sector leading the researchers to predict yield for planning appropriate policy response. However, crop yield prediction is a difficult task because both the farmers' decisions or activities (such as irrigated water, land, and crop rotation) and the natural factors (such as weather) are involved. The crop yield varies both spatially and temporally with a nonlinear behavior (Drummond et al., 2003). The crop simulation and data-driven models are the widely adopted methods to estimate the effect of various inputs on agricultural yield.

The crop simulation models are considered as robust and efficient models for yield prediction due to their site-specific experimental data, regional calibration, and plot-level observations. But, they are available only for some crops with development time and the cost being extremely large (Drummond et al., 2003). Furthermore, these on-station experimental results face challenges when upscaled into the farmers' fields because the behavior of farmers, cropping patterns, and land characteristics are heterogeneous. In addition, the calibration of crop simulation models requires a large amount of data with repeated experiments. Alternatively, to address these challenges, data-driven models are adopted to predict crop yield (Tantalaki et al., 2019; Dang et al., 2020; Gopal and Bhagavi, 2019). Previous studies suggest that data-driven models have better adaptability for agricultural planning than the crop growth methods due to the former's easier implementation and higher performance (Irmak et al., 2006). Data-driven models predict the sensitivity of crop yields to climate variables based on historical observations about how yields vary with climate change over a period. These models can be broadly classified into linear and nonlinear models. Linear models emphasize employing parametric statistical models to estimate the impact of climate change scenarios on crops (Kalli & Jena, 2022; Kalli & Jena, 2020; Arshad et al., 2017; Lobell and Bruke, 2010; Sanghi & Mendelsohn, 2008; Sultan et al., 2014; Wang et al., 2014). In practice, the statistical approach employs the historical dataset to predict the impact at a global, national, and regional scale. These models produce a single estimated parameter for the relationship within the whole sample period, which is a matter of concern since the relationship between climate and crop yields is not constant over time. In addition, the estimates from the statistical models could be biased and thus have lower prediction accuracy. Nonlinear models, on the other hand, include machine learning (ML) techniques and artificial neural network (ANN) models (Drummond et al., 2003; Fortin et al., 2011; Irmak et al., 2006). Comparisons between linear and nonlinear models for crop yield production show an advantage in favor of the latter (Drummond et al., 2003; Fortin et al., 2011).

Machine learning techniques address the nonlinear relationship between climate and crop yields through mathematical expansion of the objective function. The most commonly used ML technique is ANN (Drummond et al., 2003; Fortin et al., 2011; Irmak et al., 2006; Roel & Plant, 2004), which employs a nonparametric structure. Despite the high site dependency, neural networks are widely recognized as robust models, obtaining good results for crop yield prediction (Fortin et al., 2011). Safa and Samarasinghe (2011) predicted energy consumption in wheat production using the ANN and

the regression models and they found that the ANN model predicted more accurately than the linear regression model. Similar results were found in paddy yield in Iran (Taheri-Rad et al., 2017). Abrougui et al. (2019) estimated the prediction behavior of potato yield using tillage systems and soil properties using the ANN and multiple linear regression methods. Their result shows that the neural network model has higher accuracy in determining the relationship between potato yield, tillage, and soil properties. Other studies have employed ANN models in agriculture data to predict wheat yield (Alvarez, 2009), essential oil yield in turmeric (Akbar et al., 2018), and apricot yield (Blagojevic et al., 2016). With increased exposure to uneven climate events, linear models have become less suitable. Some of the previous studies have adopted a modular neural network with two hidden layers, a multilayer feed-forward neural network model, and a hybrid MLR–ANN model (Safa & Samarasinghe, 2011; Akbar et al., 2018; Gopal and Bhagavi, 2019).

The present study focuses on three major crops cultivated in the Karnataka State such as rice, maize, and finger millet. Apart from rice cultivation, in the northern dry region, maize, oil seeds, cotton, and sugarcane are highly cultivated. In southern region, millet-based cropping system is dominant. The area under the millets (sorghum, finger millet, and small millet) has significantly declined and has mostly been reallocated for maize cultivation (Saxena et al., 2018). According to the agriculture census report (2011–12) of Karnataka, the total area under cereal cultivation was 50 lakh hectares in 2011, out of which, 14 lakh hectares of area was under rice cultivation, 13.5 lakh hectare under maize, and 7 lakh hectare under finger millet cultivation. Nearly 70% of the total cereals is cultivated in the kharif season.

The present study develops a novel approach using a functional link artificial neural network (FLANN) model with robust prediction features. This model is a simple feed-forward network with a single layer and single neuron. Since it has a single neuron, the computational complexity is less as compared to other types of neural network models and makes it feasible for real-life applications. The influential studies in the literature of crop yield prediction, such as Mendelsohn et al. (1994), Schlenker et al., (2005, 2006), Mendelsohn (2008), Schlenker and Roberts (2009), and Fisher et al. (2012) have shown that the climate variables, namely, temperature and rainfall have decisive role to play in predicting the crop yield. Although a similar approach is used in the current study, it employs the FLANN model for crop prediction. As far as we are aware, this model is not used in the crop yield prediction studies, but has been used to predict other outcome indicators. Majhi et al. (2009) have used this model to predict short-term stock prices and have shown high level of prediction accuracy. In addition, they concluded that this model is structurally simple and requires less computation during training and testing as the model contains only one neuron and one layer. Jena and Majhi (2021) used the FLANN model to classify the Kenyan farmers based on their adoption intensity of different agricultural technologies.

The present study makes several contributions to the crop yield prediction literature. First, an ANN-based functional link artificial neural network (FLANN) model is developed using the climate variables and agricultural inputs as inputs and crop yield as the target output. The prediction accuracy of this model is compared with the statistical model such as fixed effects panel regression. Second, the developed FLANN model can be employed using other datasets at the regional or global level. By simulating the temperature and rainfall values, future crop yield can be forecasted. Thirdly, as the FLANN is a single-neuron single-layer model the complexity of this model is low and hence it can be implemented easily for real-life problems.

2 Methodology

As discussed in the previous section, we adopt fixed effect panel regression and FLANN models to predict the crop yields and compare the prediction accuracy between the two models. A detailed description of the methods is given in the subsequent section. To predict future crop yields, we use climate data, input, and output data of three crop yields (rice, millet, and maize). A detailed discussion on the variables employed is provided in the following section.

2.1 Study area

The present study focuses on the southwestern state of India, namely Karnataka which is a tropical semiarid region. Karnataka is a southwestern state of India that lies between 12° to $18^{\circ} 45'$ north latitude and 74° to $78^{\circ} 50'$ east longitude. Several episodes of high-intensity drought and significant variation in monsoon rainfall have been observed in Karnataka (Guhathakurta et al., 2015). Agriculture in Karnataka is highly dependent on monsoon rainfall; 26.5% area is irrigated while the remaining depends on rainfed cultivation (Bhende, 2013). Reliance on monsoon for agriculture and significant variation in climate makes it a highly vulnerable state. The state has a varied topographical character ranging from coastal plains to gentle slopes and the heights of the Western Ghats. The present study considers three major crops cultivated in the state for analysis, namely rice, maize, and finger millet. Due to its distinct topographic characteristic, we divide the state into four divisions—coastal Karnataka, Malnad Karnataka, south interior, and north interior Karnataka. Figure 1 shows the four divisions and the districts under each of these divisions for the Karnataka State. This classification of the divisions is based on the similarity of climate features within the region. The present study provides the stepping stone in analyzing the climate-yield response function employing both FLANN and regression methods for different crops under different climate divisions (Table 1).

2.2 Datasets

2.2.1 Climate variables

The most common variables employed in the evaluation of climate change impact studies include temperature and rainfall (Carleton, 2017; Mendelsohn, 2014). In line with the above studies, the present study employs rainfall and temperature as the key climate variables. The information on temperature and rainfall was obtained from the Indian Meteorological Department (IMD). We use a fine-scale daily grid dataset of $0.25^{\circ} \times 0.25^{\circ}$ for rainfall and $1^{\circ} \times 1^{\circ}$ for temperature that was interpolated from unevenly distributed station-wise data using the Shepard interpolation method (Pai et al., 2015; Srivastava et al., 2009). For rainfall, the grid points within the district boundaries were averaged daily and then summed up for the season. Growing degree days are employed as the temperature indicator, which captures the nonlinear effects of temperature over the growing season. The effect of heat on relative plant growth is cumulative over time, and that yield is proportional to total growth. The cumulative effect of temperature over time shows that the temperature effect is additive over the growing season. Degree days are constructed with the cumulative sum of temperature observations between two bounds. The upper and lower bounds of temperature are rooted in agronomy. The upper and lower bounds of temperature in the

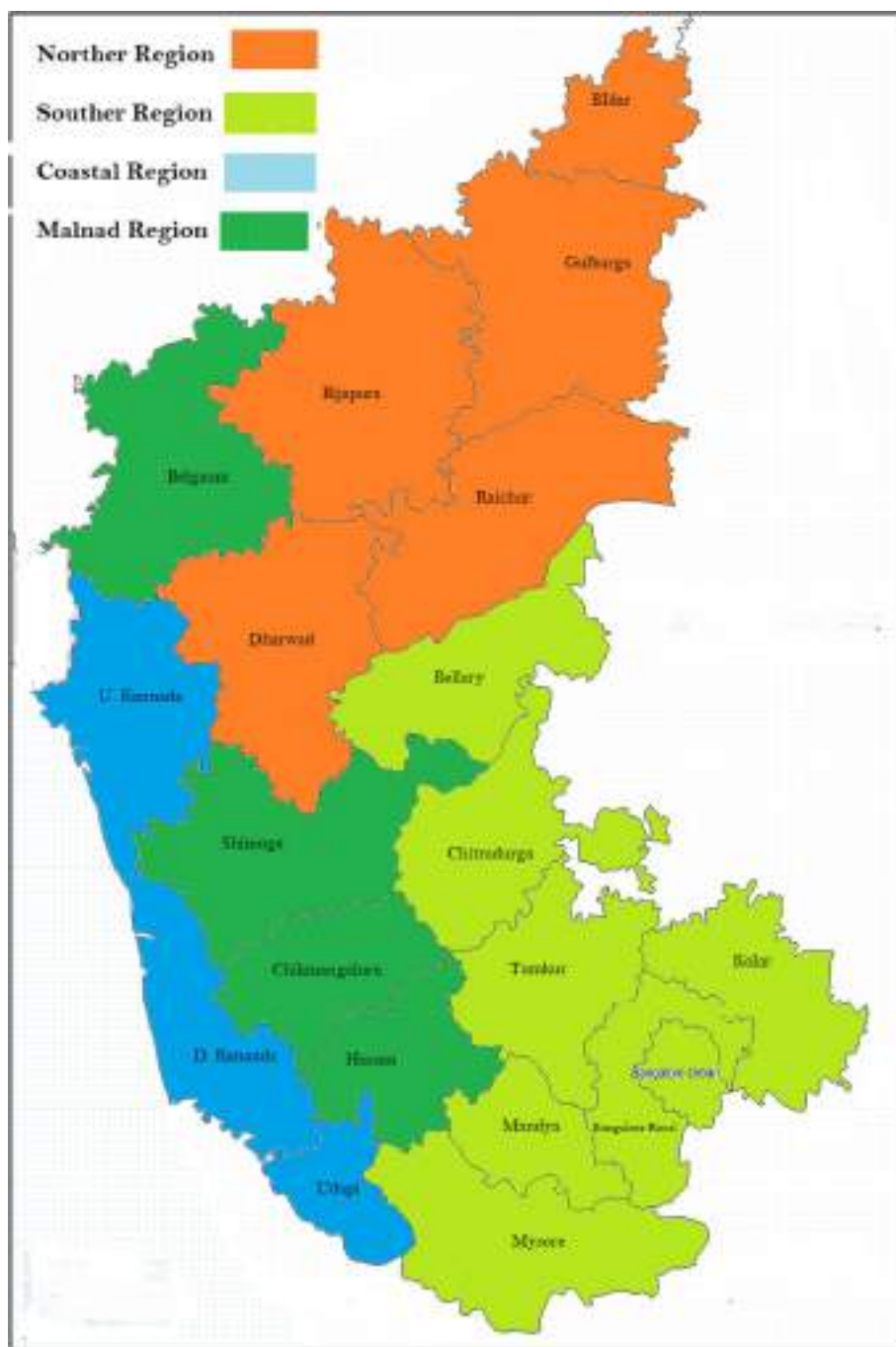


Fig. 1 Four divisions classified for the Karnataka State

Table 1 Four divisions and districts considered under each division and crop

Crop/Region	Southern region	Malnad region	Northern region	Coastal region
Rice	Mandya	Belgaum	Bellary	D Kannada
	Mysore	Chikmagalur	Dharwad	Kodagu
	Tumkur	Hassan	Gulbarga	U Kannada
Maize		Shimoga	Raichur	
	Chitradurga	Belgaum	Bellary	
	Kolar	Hassan	Bijapura	
	Mysore	Shimoga	Dharwad	
Finger Millet			Raichur	
	Bangalore- Rural	Chikmagalur		
	Bangalore—Urban	Hassan		
	Chitradurga	Shimoga		
	Kolar			
	Mandya			
	Mysore			
	Tumkur			

present study are fixed based on the crop and the climate characteristics of the region. To formulate degree days, the upper bound threshold is differenced from the actual maximum temperature of a particular day and then summed over the growing season (Gupta et al., 2017; Schlenker et al., 2006). If the daily maximum temperature is found to be higher than the upper bound threshold in a day, then the growing degree days for that day is 26 °C. Crops may have different thresholds. However, most of the crops below 8 °C cannot absorb heat, and above 34 °C, the plant growth diminishes. Thus, growing degree days are the special case of our model where the above bounds are represented as:

$$g(h) = \begin{cases} 0 & \text{if } h \leq 8 \\ h - 8 & \text{if } 8 < h < 34 \\ 26 & \text{if } 34 \leq h \end{cases}$$

2.2.2 Agricultural input and output variables

The study uses district-level data from the Directorate of Economics and Statistics, Karnataka (DES, Karnataka). DES, Karnataka publishes annual reports on the estimates of principal crops at the district level. The data on agriculture yield is collected through cross-cutting experiments conducted each year during the harvest season. Stratified multistage random sampling has been adopted to accumulate data with the village as the primary level, and later aggregated to the district level. These reports describe the in-depth district-level data on area, production, and yield for all major crops. The report also presents district-wise data on area, production, and yield for all major crops for both irrigated and unirrigated cultivation. The dependent variable is the average yield generated per hectare of land whereas the yield employed in the past studies is in the form of district-wise production divided for each crop. This indicator measure does not reflect the land quality and

the dynamics of the region in the crop cultivation. Rice, maize, and finger millet are the three major Kharif crops considered for the study. These are the major food crops widely cultivated among the districts studied. The districts under maximum cultivation of each crop have been considered in the study. For rice, the 14 districts that constitute more than 90% area under rice cultivation have been considered. A similar approach has been followed for other crops as well; 10 major districts under finger millet and maize cultivation are used in the study.

2.3 Data analysis

The study focused on predicting the effect of climate change on agriculture yields of three important crops, *i.e.*, rice, maize, and finger millet in the region of Karnataka. The study employs two distinct methodologies; FLANN and regression methods. Figure 2 describes the step-wise methodology used in the present study for the development of FLANN-based prediction model. The first step involves data collection and preprocessing of the data. The normalized data is then divided into training and testing sets. The training set is employed to develop the prediction model using an error correction method. It uses a supervised learning process where the target or desired value is known. Once the model is developed, validation of the model is done using the testing data and the mean square error (MSE), root mean square error (RMSE), mean absolute error (MAE), and coefficient of determination (R^2) values are calculated.

2.3.1 Regression framework

The regression technique is the most widely used methodology in predicting the climate change impact on agriculture. Cross section, time series, and panel regression modeling are widely employed, however, the fixed effect panel regression model produces more accurate estimates when compared to other methods of statistical modeling (Lobell and Bruke, 2010). The present study adopts a fixed effect panel regression model to evaluate the prediction behavior of the linear models. The model assumes that maximum crop yield

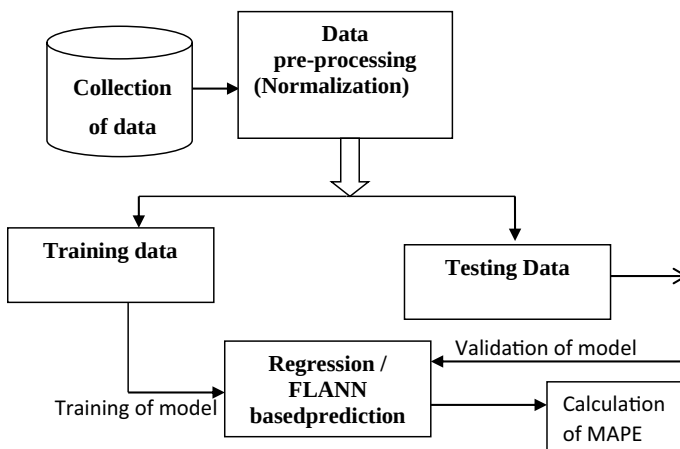


Fig. 2 Steps involved in the prediction of crop yield

is obtained with the application of necessary input components that affect the output, i.e., soil variables, climatic variables, farm management practices, purchased inputs for land, and socioeconomic factors. These are the input drivers that enhance the maximum yield output. The general form of this can be given by:

$$Q_{it} = f(S, C, N, E) \quad (1)$$

where Q_i represents the production output of crop i and region t . This is the function of the vectors of soil variables (S), climatic variables (C) including natural factors such as rainfall and temperature, input choices (N) under given environmental conditions like fertilizer, irrigation, seeds, technological advancements, etc., and economic factors (E) that influence the output. The empirical model to estimate the response function is of the form:

$$\log Y_{it} = c_i + \beta_0 + \beta_1 \text{Rain}_{it} + \beta_2 \text{GDD}_{it} + \beta_3 \text{Irrigation}_{it} + \beta_4 \text{Fertilizer}_{it} + \gamma_t + \varepsilon_{it} \quad (2)$$

where Y_{it} is log yield in district i and year t . c_i is the district fixed effect that controls for time-invariant factors (for example soil characteristics). γ_t is the linear trend which captures the growth in technological advancement and capital expenditure. Rain_{it} is total rainfall in Kharif season, GDD_{it} is the cumulative distribution of the temperature referred to as growing degree days for the Kharif season, Irrigation_{it} refers to the proportion of irrigated land in Kharif season, Fertilizer_{it} refers to the average fertilizer used per hectare of land. The dependent variable and the independent variables of the model are expressed in a log-linear specification.

2.3.2 Functional link artificial neural network (FLANN)

The FLANN model is inherently nonlinear because of the trigonometric expansion of input attributes, which enhances the prediction performance. Hence in the current study, the FLANN model with the trigonometric expansion is used. The FLANN technique is proposed by Pao (1989) who defines it as a single-layer ANN structure equipped for forming arbitrarily complex decisions by making nonlinear decision boundaries. Due to its less computational complexity, it is favored as a substitute to the conventional multilayer ANN (MLANN). The basic structure of the FLANN-based predictor is presented in Fig. 3(a). The technique has been effectively utilized for various applications (Jena & Majhi, 2021; Patra et al., 1999). In the FLANN model, an input pattern is extended utilizing nonlinear functions such as power, exponential, Legendre, Chebyshev, or trigonometric series which surge the pattern dimension space. These extended values are utilized as input to an adaptive linear combiner and the weights are being restructured according to the gradient-based least mean square (LMS) algorithm (Widrow and Stearns, 2002).

The FLANN consists of three different phases such as the functional expansion phase, the computation phase, and finally the adaptation phase. By using the functional expansion, it is undertaking the nonlinear mapping of the input data to output. In Fig. 3(a), let $x(n) = x_1(n), x_2(n), x_3(n), \dots, x_N(n)$ represent the input vector for the n^{th} input pattern, where N is the number of inputs. Using h number of basis functions ϕ_i , for $i = 1, 2, 3, \dots, h$, the functional expansion block produces an expanded input vector for each input. Let $\phi(x(n))$ represent the expanded values associated with any n^{th} input pattern and given as follows

$$\phi(x(n)) = \phi_1(x_1(n)), \phi_1(x_2(n)), \phi_1(x_3(n)), \dots, \phi_i(x_N(n)). \quad (3)$$

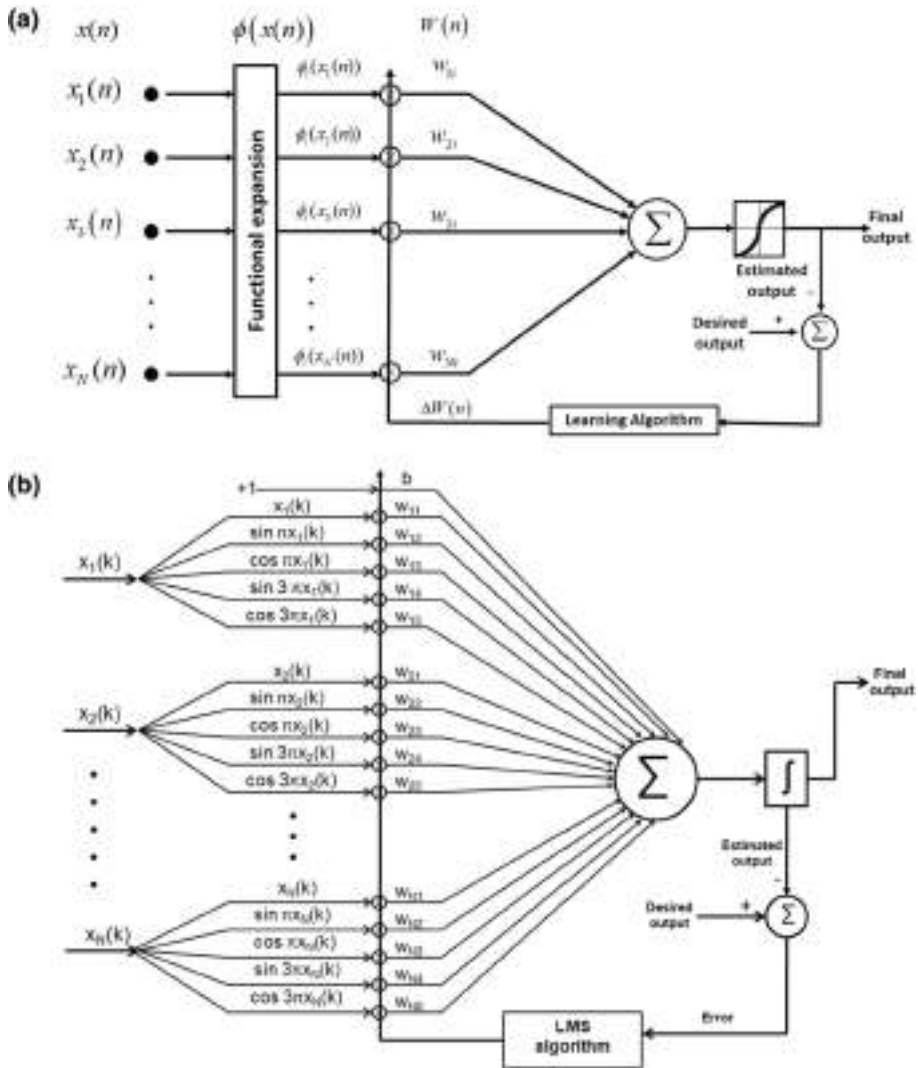


Fig. 3 **a** Block diagram of functional link artificial neural network (FLANN)-based predictor. **b** Yield prediction model using FLANN with trigonometric expansions

Figure 3(b) shows the FLANN predictor using trigonometric expansion. All connecting weights are randomly initialized. Let $W(n)$ represent the weight vector associated with n^{th} expanded input pattern written as follows:

$$W(n) = w_{1i}(n), w_{2i}(n), w_{3i}(n), \dots, w_{N_i}(n). \quad (4)$$

The computation process is simply a linear combiner. The nonlinear expanded data are linearly weighted and summed to produce the output, $S(n)$ as

$$S(n) = \phi(x(n))W(n)^T. \quad (5)$$

The final output of the FLANN model is obtained as

$$y(n) = f(S(n)) \quad (6)$$

where $f(\cdot)$ is the activation function at the output neuron. During the adaptive process, the error and the expanded input data are used to update the weights of the model using the LMS algorithm. The error value is obtained by comparing the estimated output with the desired output. The weights are updated using Eqs. (7) and (8).

$$\Delta W(n) = \frac{\sum_{n=1}^P 2\eta e(n)\phi(x(n))^T}{P} \quad (7)$$

$$W(n+1) = W(n) + \Delta W(n) \quad (8)$$

where P =total no. of input patterns, n =represents the n^{th} input pattern, $\Delta W(n)$ =average change in weight, η =convergence coefficient lies between 0 and 1. $e(n)$ =error corresponding to the n^{th} input pattern, $\phi(x(n))=n^{th}$ expanded input vector, $W(n)$ =represents the weight vector for n^{th} expanded input vector.

The LMS algorithm updates the weights and the further iterations go on until it becomes no longer possible to minimize the error. The final weights are then frozen and the model is ready for validation which predicts the final output that is the crop yield in this case.

3 Simulation

The simulation of the FLANN-based crop yield prediction model is conducted referring to Fig. 3(b) and using MATLAB 2016 software. The steps are explained in the following section.

3.1 Data collection and preprocessing

The objective of this research is to ascertain the effect of climate change on yields by focusing on seasonal cultivation. Unlike the past studies, we fix the growing season to months from June to September rather than employing the annual data. Kharif is predominantly the significant cultivation period in Karnataka State where it is highly dependent on the south-west monsoon rainfall.

The data of all the parameters are normalized to a range of 0–1 by using the min–max normalization method as given in (9).

$$x' = \frac{x - \min(A)}{\max(A) - \min(A)} \times (new \max(A) - new \min(A)) + new \min(A) \quad (9)$$

where A =the attribute data, $\min(A)$, $\max(A)$ =minimum and maximum values of A , x' =new value of the attribute A , x =old value of the attribute A , $new \min(A)$, $new \max(A)$ =new ranges of attribute A .

Large differences between observations in the data cause problems during calibration. Data normalization helps to overcome this problem during the development of the model and increase the convergence speed. After normalization, the data is divided into training and testing sets. Of the total data patterns or input patterns, randomly 80% are used to train the model, and the remaining 20% are used to test the model. We carried out the training

and testing of the FLANN model using different data splits like 70/30, 80/20, and 90/10 percentage. The 80/20 percentage split is finally used as we obtained the best result using this split. The total number of training and testing data patterns used for the simulation are given in Table 2.

3.2 Training of the model

A supervised method of learning is used for the development of FLANN-based yield prediction model. There are four inputs in this study, temperature (represented by GDD), rainfall, irrigated land, and fertilizer. These four input values represent one data pattern or input pattern. The first two inputs are the climate inputs of agricultural production. The statistical studies estimate a linear relationship between climate variables and crop yield, while the relationship is nonlinear. Thus, adaptive nonlinear FLANN models are best suitable to estimate the nonlinear effect of climate variables on crop yield. To estimate the nonlinear relation, the trigonometric expansion of the inputs is done. For every input pattern, the target value is known. Here the yield value is the target value. The parameters of the FLANN model used for simulation are shown in Table 3. The first input pattern of the training set (containing 80% of data) is supplied to the model. Each of the values of the pattern is then trigonometrically expanded to five terms. As there are four values in the input pattern, 20 terms are obtained after expansion. Including the input to bias (which is always 1), the terms are 21. These expanded inputs are multiplied with the corresponding weights, added together, and passed through the activation function to produce single estimated output using Eqs. (5) and (6). The output is then compared with the desired value to calculate the error as

$$e(n) = t(n) - est(n) \quad (10)$$

where $t(n)$ = target value of n th input pattern, $est(n)$ = estimated output of the model.

Initially, the 21 weights are randomly chosen between -0.5 to 0.5 . Using the error and LMS update equation, the weights are updated according to (7) and (8). Then the second pattern is applied to the model and the same process is repeated for all the training patterns. Once all 80% of input patterns are exhausted, it completes one experiment. The old weights are updated adding the average of the change in weights to it. The experiments are repeated until the mean squared error is minimized. The number of experiments is 3000 in

Table 2 Number of data patterns used

	Total samples	No. of training data (80%)	No. of testing data (20%)
Rice—Region 1	84	67	17
Region 2	84	67	17
Region 3	63	50	13
Region 4	63	50	13
Millet—Region 1	147	118	29
Region 2	63	50	13
Maize—Region 1	84	67	17
Region 2	63	50	13
Region 3	63	50	13

Table 3 Parameters of FLANN used in simulation

Parameters	Number
Number of inputs	04
Number of output	01
Number of expansions	05
Type of functional expansion	Trigonometric
Total no. of expanded inputs	20
Input to bias	1
Type of activation function	Tanh
Value of learning parameter(mu)	0.1
No. of weights	20
No. of bias weight	01

this study with the value of the learning parameter being 0.1. The final weight values of the predictor are presented in Table 11.

3.3 Testing or validation of the model

Testing or validation of the model is done using 20% of the input or data patterns that are not used during the training process. The testing patterns are given to the trained model sequentially and the output is obtained after weighting, adding, and being passed through the activation function. Each of the outputs of the model is compared with the available target value to calculate the MSE, RMSE, MAE using (11–13). The R^2 or Coefficient of determination value is also calculated using (14). Lower is the MSE, RMSE, and MAE values better is the prediction model.

$$\text{MSE} = \left(\frac{\sum_{i=1}^n (\text{Out}_{\text{obs}} - \text{Out}_{\text{est}})^2}{n} \right) \quad (11)$$

$$\text{RMSE} = \text{sqrt} \left(\frac{\sum_{i=1}^n (\text{Out}_{\text{obs}} - \text{Out}_{\text{est}})^2}{n} \right) \quad (12)$$

$$\text{MAE} = \left(\frac{\sum_{i=1}^n |\text{Out}_{\text{obs}} - \text{Out}_{\text{est}}|}{n} \right) \quad (13)$$

$$R^2 = \frac{\left(\sum_{i=1}^n (\text{out}_{\text{obs}} - \overline{\text{out}_{\text{obs}}}) (\text{out}_{\text{est}} - \overline{\text{out}_{\text{est}}}) \right)^2}{\sum_{i=1}^n (\text{out}_{\text{obs}} - \overline{\text{out}_{\text{obs}}})^2 \sum_{i=1}^n (\text{out}_{\text{est}} - \overline{\text{out}_{\text{est}}})^2} \quad (14)$$

where Out_{obs} and Out_{est} represent the desired and estimated yield values, respectively. The total number of testing patterns is n . R^2 can take any value between 0 and 1. It indicates how well the model fits the data. A higher R^2 value indicates a better fit for the model. The value of MSE, RMSE, MAE, and R^2 is shown in Tables 4, 5, 6, 7, 8, 9, and 10, respectively.

The comparison plots of the actual and estimated yield values for rice, maize, and millet are exhibited in Fig. 4(a)–(i).

4 Results and discussion

The prediction accuracy of the FLANN model is compared with the fixed effects panel regression model in Tables 4, 5, 6, 7, 8, 9, and 10. The prediction behavior of FLANN and fixed effect panel regression models is assessed using the MSE, RMSE, MAE, and R^2 values. Among the three crops namely, rice, maize, and millet that are analyzed, rice is cultivated in most parts of the state. So, the state is divided into four rice-growing regions based on their climatic features. Maize and millet are cultivated in lesser districts; thus, they are divided into 3 and 2 regions, respectively.

4.1 Comparison of MSE, RMSE, and MAE values

The RMSE values for all three crops are presented in Tables 4, 6, and 8, respectively, while the MSE and MAE values are shown in Tables 5, 7, and 9. For all 3 crops, the FLANN model predicted the yield with significantly higher accuracy compared to the fixed effects panel regression as depicted by the lower RMSE values for the former, both during training and testing phases. In case of rice, the training phase RMSE for the Regions 1, 2, 3, and 4 are found to be 0.07, 0.08, 0.09, and 0.09, respectively, using the FLANN model. On the other hand, the RMSE in the fixed effect panel model were 0.29, 0.25, 0.12, and 0.10, respectively, for Regions 1, 2, 3, and 4. A previous study by Gopal and Bhagavi (2019) found the RMSE values between 0.05 and 0.09 by using various ANN models for rice yields. The prediction of rice yield using the calibrated YELDCAST Model in the Sahel region of Africa produced an RMSE of 0.19 (Traore et al., 2020).

For maize, the training phase RMSE for the Regions 1, 2, and 3 were 0.15, 0.09, and 0.13, respectively, using the FLANN model, whereas the same for the fixed effect panel model was 0.19, 0.34, and 0.19, respectively). In a similar study, Adisa et al. (2019) found the RMSE values lying between 0.034 and 0.047 by employing the neural network models for maize yield prediction in South Africa (. Finally, in both the regions under millet cultivation, the FLANN model predicted the crop yield with higher accuracy compared to the fixed effects model. It is observed that the computed RMSE values in the current study and other similar studies have a small difference—this difference can arise due to changes in the variable specification and the quality of the dataset employed.

4.2 Comparison of R^2 values

The R^2 value which is a measure for goodness of fit of an estimated model is presented in Table 10. The R^2 values for the FLANN model in rice cultivating regions are in the range between 0.76 and 0.88 whereas the same for the regression model are in the range between 0.16 and 0.42; Traore et al. (2020) reported R^2 value of 0.93 for predicting rice yields using the neural network models. A comparison of R^2 values for maize and millet regions also shows that the FLANN model has achieved higher goodness of fit than the regression model. In a similar study, Adisa et al. (2019) reported the adjusted R^2 values lying in the range between 0.67 and 0.82 for various regions, using the neural network

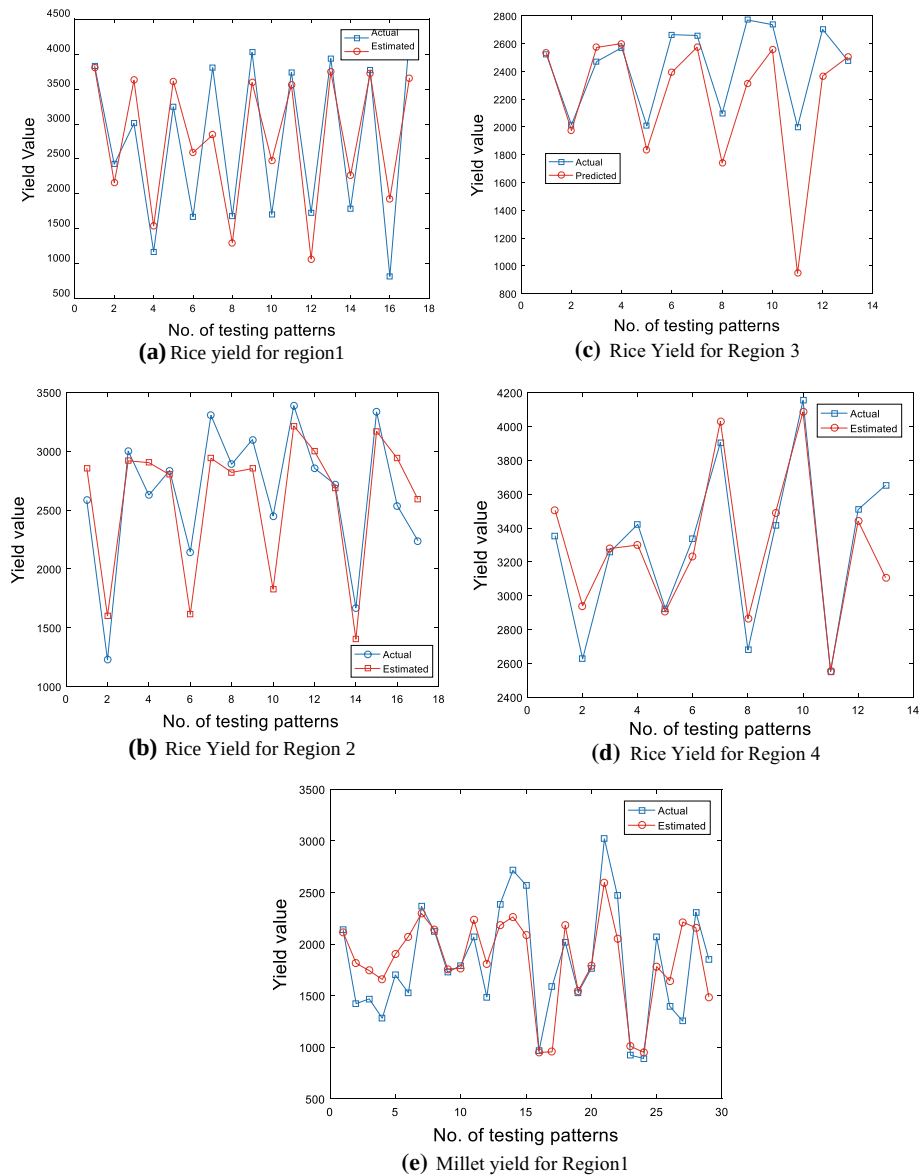


Fig. 4 a–i Comparison of actual and predicted de-normalized crop yield values during testing phase of FLANN model

model for maize yield prediction. Overall, it can be construed that there is nonlinearity in the relationship between crop yield and the inputs, especially climate inputs such as temperature and rainfall. This nonlinearity in crop yield relationship was first flagged by Schlenker and Roberts (2006). The neural network model could predict this nonlinear relation with higher accuracy than the linear statistical model.

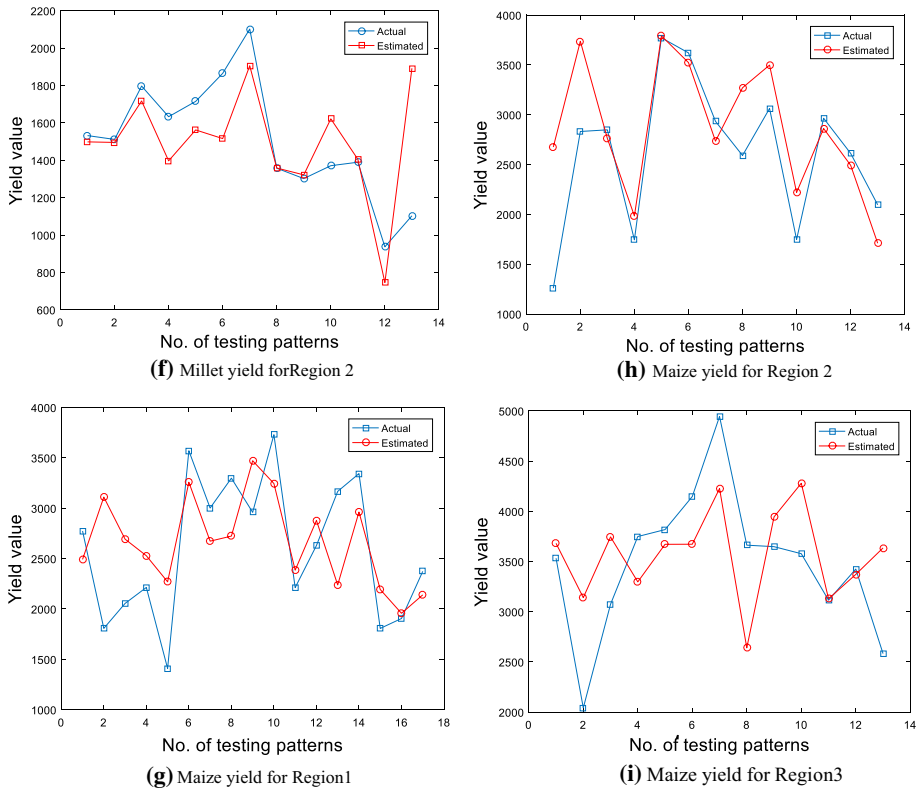


Fig. 4 (continued)

4.3 Yield prediction using the results from FLANN

There are four inputs for yield prediction and each input has been trigonometrically expanded five times. So, we obtain 20 (5×4) final weights for each of the regions under the 3 crops and the bias weight making it 21 weights in total. Table 11 presents the magnitude of the 21 final weights for each region and each crop after the completion of the training phase along with the bias weight. Using these weights, the nonlinear relation between four input factors and the predicted yield is given as follows -

$$\begin{aligned}
 y = & w_0 + (x_1 w_1 + \sin \pi x_1 * w_2 + \cos \pi x_1 * w_3 + \sin 3\pi x_1 * w_4 + \cos 3\pi x_1 * w_5) \\
 & + (x_2 w_6 + \sin \pi x_2 * w_7 + \cos \pi x_2 * w_8 + \sin 3\pi x_2 * w_9 + \cos 3\pi x_2 * w_{10}) \\
 & + (x_3 w_{11} + \sin \pi x_3 * w_{12} + \cos \pi x_3 * w_{13} + \sin 3\pi x_3 * w_{14} + \cos 3\pi x_3 * w_{15}) \\
 & + (x_4 w_{16} + \sin \pi x_4 * w_{17} + \cos \pi x_4 * w_{18} + \sin 3\pi x_4 * w_{19} + \cos 3\pi x_4 * w_{20})
 \end{aligned}
 \quad (15)$$

There are both positive and negative weights in Table 11. The weights are essentially reflecting how important the input is. The negative or positive weight in an ANN model means that this weight value has been found suitable by the learning algorithm to satisfy the assigned objective of the prediction task. We have predicted the yield of all three crops for the different regions by inputting the relevant weight values in Eq. 15. This prediction is

Table 4 RMSE for rice yield using FLANN and panel regression model

Model	Region 1		Region 2		Region 3		Region 4	
	RMSE during training	RMSE during testing	RMSE during training	RMSE during testing	RMSE during training	RMSE during testing	RMSE during training	RMSE during testing
FLANN	0.0776	0.1114	0.0808	0.1107	0.0987	0.1169	0.0906	0.1295
Panel Regression	0.2919	0.3542	0.2522	0.2549	0.1209	0.1642	0.1085	0.1993

Table 5 MSE and MAE during testing for rice yield

Model	Region 1		Region 2		Region 3		Region 4	
	MSE	MAE	MSE	MAE	MSE	MAE	MSE	MAE
FLANN	0.0124	0.0716	0.0122	0.0935	0.0136	0.1653	0.0167	0.0879
Panel Regression	0.1254	-0.086	0.0649	0.087	0.0269	0.134	0.0397	0.089

Table 6 RMSE for maize yield using FLANN and panel regression model

Model	Region 1		Region 2		Region 3	
	RMSE during training	RMSE during testing	RMSE during training	RMSE during testing	RMSE during training	RMSE during testing
FLANN	0.1528	0.2129	0.0952	0.1454	0.1306	0.1752
Panel Regression	0.1914	0.2304	0.3488	0.3107	0.1984	0.2268

Table 7 MSE and MAE during testing for maize yield

Model	Region 1		Region 2		Region 3	
	MSE	MAE	MSE	MAE	MSE	MAE
FLANN	0.0453	0.2200	0.0211	0.2010	0.0306	0.1631
Panel Regression	0.0530	0.126	0.0965	-0.075	0.0514	0.1401

Table 8 RMSE for millet yield using FLANN and panel regression model

Model	Region 1		Region 2	
	RMSE during training	RMSE during testing	RMSE during training	RMSE during testing
FLANN	0.1164	0.1257	0.1146	0.1319
Panel Regression	0.3653	0.5434	0.2119	0.2926

Table 9 MSE and MAE during testing for millet yield

Model	Region 1		Region 2	
	MSE	MAE	MSE	MAE
FLANN	0.0158	0.1144	0.0173	0.1504
Panel Regression	0.2952	-0.070	0.0856	0.06

primarily done in the testing phase of the model. Figure 4(a) to (i) presents the comparison between the actual and predicted yields of the three crops. The model produces the normalized predicted values, however, these values have been de-normalized and compared with the actual yield values. The accuracy between the de-normalized yield values and actual

Table 10 Comparison of R^2 values for different crops

	Region 1	Region 2	Region 3	Region 4
<i>Rice</i>				
FLANN	0.8756	0.7335	0.7322	0.7611
Panel Regression	0.2329	0.4170	0.1632	0.2686
<i>Maize</i>				
FLANN	0.6252	0.6480	0.6892	
Panel Regression	0.3417	0.1535	0.1113	
<i>Millet</i>				
FLANN	0.6737	0.6904		
Panel Regression	0.27	0.3426		

yield values are 99%, 97%, and 99% for rice, maize, and millet, respectively, using FLANN model.

The calibrated simulation model can also be used to forecast the future values of the yield of crops, provided the future values of the inputs such as temperature, rainfall, and other physical inputs are available.

In a similar study, Amaratunga et al. (2020) developed three neural network algorithms to predict the paddy yield taking climatic factors as determinants in Sri Lanka. The three training algorithms such as Levenberg–Marquardt (LM), Bayesian regularization (BR), and scaled conjugated gradient (SCG) were used to train the developed neural network model, and the performance indicators were compared against each other to find the best training algorithm. Using the correlation coefficient (R) and mean squared error (MSE) they found that the LM training algorithm has outperformed the other two algorithms in determining the relationships between climatic factors and paddy yield with less computational time.

Crane-Droesch (2018) used a semiparametric variant of a deep neural network model to predict the corn yield in US Midwest. His approach is a hybrid of deep neural network and parametric statistical model. He claims to have achieved superior prediction accuracy over both neural network-based prediction models and parametric statistical models. Similar results are observed from Gopal and Bhagavi (2019) who compared the computation of conventional ANN model and hybrid multiple regression-based ANN model and found that the hybrid MLR–ANN model yielded better results. Gonzalez-sanchez (2014) reviewed several studies based on the most common data-driven modeling techniques applied to yield prediction. Multiple linear regression, step-wise linear regression, regression trees, and ANN models were ranked. Three accuracy metrics were used to validate the models: the root relative square error (RRSE), relative mean absolute error (RMAE), and correlation factor (R). They showed that the ANNs are more consistent obtaining the lowest average RRSE (86.04%), lowest average RMAE (8.75%), and the highest average correlation factor (0.63). Similar results were found by Ji et al. (2007).

Khaki and Wang (2019) developed a deep neural network (DNN) using large datasets from the Syngenta that had recorded the genotype and yield performances of 2,267 maize hybrids to predict the crop yield. Their model was found to have a high prediction accuracy with a RMSE being 12% of the average yield and 50% of the standard deviation for the validation dataset using predicted weather data. With perfect weather data, the RMSE would be reduced to 11% of the average yield and 46% of the standard deviation. Furthermore, the deep learning methods employed in crop yield prediction have generated superior performance outcomes compared to the statistical parametric models and process-based models (Shook et al., 2021). These studies show that the deep neural network models

Table 11 Optimum weight or coefficient values (21nos) of FLANN-based yield prediction model

	Region 1	Region 2	Region 3	Region 4
<i>Rice</i>				
	0.4376	0.5416	0.6908	0.2969
	0.5637	0.0846	−0.6299	0.565
	−0.1640	−0.0529	−0.1935	−0.1239
	−0.1689	0.0476	−0.2449	0.0708
	0.3902	0.0197	0.0831	0.1785
	0.0226	0.0494	0.1052	0.0051
	0.1951	0.8766	−0.1287	0.426
	0.3002	0.3062	0.791	−0.0878
	0.1271	0.0912	0.0481	−0.0275
	−0.3055	−0.1912	−0.0112	0.1095
	0.1959	−0.0642	0.0908	−0.0534
	0.7174	0.2795	−0.2914	0.633
	−0.1175	−0.3547	−0.4670	−0.1693
	−0.1042	0.3068	0.0106	−0.0624
	−0.0060	−0.2296	−0.2399	0.1332
	−0.0934	0.0844	−0.1179	0.1496
	−0.3303	−0.3492	0.9215	0.8884
	−0.2530	−0.1748	0.2653	−1.0051
	−0.0506	0.0141	−0.0199	0.1645
	−0.3398	−0.3231	0.1685	−0.3748
	0.0582	0.0213	−0.1446	−0.1979
<i>Millet</i>				
	−0.3192	0.1056		
	0.8949	0.3964		
	−0.1897	0.1902		
	−0.0861	0.2133		
	0.2894	0.597		
	−0.0044	0.1996		
	0.0554	−0.6732		
	0.3897	0.5151		
	0.0271	0.2914		
	0.0842	0.0078		
	−0.0535	0.1312		
	0.4728	1.0753		
	−0.2718	−0.2374		
	0.1054	0.0146		
	−0.2034	0.1797		
	−0.0960	−0.0127		
	0.9007	−0.9795		
	−0.2107	−0.3789		
	−0.0898	0.3609		
	0.377	−0.0308		
	0.0392	−0.3649		

Table 11 (continued)

	Region 1	Region 2	Region 3	Region 4
<i>Maize</i>				
	-0.0283	0.2457	0.0783	
	0.4651	0.0622	0.4716	
	0.0647	0.0079	-0.1340	
	-0.0242	0.0077	0.1286	
	0.33	0.3091	0.3444	
	0.1154	0.0763	0.1008	
	-0.0567	0.4309	0.6002	
	-0.1496	0.1208	0.1415	
	0.1992	-0.0950	0.1241	
	0.2823	0.5336	0.1388	
	-0.0103	-0.1058	-0.0581	
	0.1256	0.2494	0.8127	
	-0.2895	-0.0564	-0.4133	
	-0.1513	0.0109	-0.1467	
	0.2503	-0.0207	0.3508	
	-0.0753	-0.0238	-0.0814	
	0.5007	0.0201	-0.4106	
	-0.0635	-0.2959	0.9616	
	-0.0604	0.1243	-0.4728	
	0.0428	-0.2074	0.0786	
	0.0196	-0.3579	-0.2782	

have achieved higher prediction accuracy. However, deep neural networks are complex algorithms which require substantial computation time and monetary cost. In contrast, the FLANN model developed in this study is a low-complex model with a single neuron and a single layer which requires less computational time and yet produces higher prediction accuracy similar to the deep neural networks. Hence, these models can be developed into a full-fledged predictive software to be used for real-time predictions.

The study focused on the Kharif season (June–November), which is the important cropping season in the Indian sub-continent. The negative impact of temperature is observed during the crop prediction estimation from both the FLANN and regression models for all three crops, while the average rainfall has significant positive impact on the crop yields for the state of Karnataka. Rice and maize cultivation is highly irrigated, the damages from temperature rise can be high without such adaptation practices. Finger millet on the other hand, being a heat-resistant crop is generally cultivated in relatively dry land. The predictions show that yield of this crop may decline in the future mainly due to the negative effect of temperature rise. This can possibly happen due to a shift in the cultivation preference by the farmers, where most fertile land is allocated for paddy and maize cultivation leaving behind the relatively infertile marginal land for finger millet cultivation in the state. Though the observed crop loss is primarily due to an increase in the frequency of extreme temperature, there could be several other factors associated with the extent of loss in crop yields.

5 Conclusion

In the FLANN model developed in this study, the input (predictor) variables expand trigonometrically to make the relationship nonlinear with the output (predicted) variable. This mathematical expansion of inputs in an iterative process helps obtain the optimal weights for the convergence of the relationship. The key contribution of this study from the agricultural planning and policy perspective is that the developed FLANN model can be used for forecasting yields of key crops in any region based on the actual or simulated values of the climate parameters. Since this is an adaptive model with low complexity, it is easier to predict the future yield level accurately with less computational time. However, to implement this research idea for real policy making, there is a need to build a crop yield simulation software package integrating this simulation model. This software can simulate the future yield when the key input values are provided to it in real time. Given its low computational requirement and high level of accuracy, it can equip policy makers with information for future food supply and food gap.

Given that climate change-induced extreme events are more regular at a global level, crop yield prediction holds significant value as it provides indications of future yield in climate-sensitive regions. Karnataka is a climate-sensitive region as a large part of the state is drought-prone and the frequency of dry spells has been experienced in the recent past. In that perspective, the model developed in the paper can be used to predict the yield of different crops to gauge the food availability metrics in the state. This model can be enriched by increasing the data points and the number of inputs and can be out-scaled for other regions of the country.

The present study acts as a stepping stone for further in-depth study on several crops employing the nonlinear models. Finger millet being a sustainable crop in dry conditions should be promoted as a possible alternative adaptation strategy in the long run to reduce the dependency on irrigation. However, the shift toward economically profitable crops like rice has led to unsustainable use of groundwater and thereby worsening the water scarcity situation in future. The adoption of efficient irrigation practices and also cultivation of suitable crops based on the regional geography may intensify higher productivity.

Funding This study is funded by Scheme for Promotion of Academic Research and Collaboration (SPARC) project, Ministry of Education, Government of India (Grant No. P-302).

Data availability The data used in this study can be available upon request.

Declarations

Conflict of interest The authors have no conflict of interest.

Ethical approval Not Applicable.

References

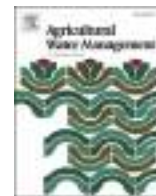
- Abrougui, K., Gabsi, K., Mercatoris, B., Khemis, C., Amami, R., & Chehaibi, S. (2019). Prediction of organic potato yield using tillage systems and soil properties by artificial neural network (ANN) and multiple linear regressions (MLR). *Soil and Tillage Research*, 190, 202–208.

- Adisa, O. M., Botai, J. O., Adeola, A. M., Hassen, A., Botai, C. M., Darkey, D., & Tesfamariam, E. (2019). Application of artificial neural network for predicting maize production in South Africa. *Sustainability*, 11(4), 1145.
- Akbar, A., Kuanar, A., Patnaik, J., Mishra, A., & Nayak, S. (2018). Application of artificial neural network modeling for optimization and prediction of essential oil yield in turmeric (*Curcuma longa* L.). *Computers and Electronics in Agriculture*, 148, 160–178.
- Alvarez, R. (2009). Predicting average regional yield and production of wheat in the Argentine Pampas by an artificial neural network approach. *European Journal of Agronomy*, 30(2), 70–77.
- Amaratunga, V., Wickramasinghe, L., Perera, A., Jayasinghe, J., & Rathnayake, U. (2020). Artificial neural network to estimate the paddy yield prediction using climatic data. *Mathematical Problems in Engineering*, 2020, 1–11.
- Arshad, M., Amjath-Babu, T. S., Krupnik, T. J., Aravindakshan, S., Abbas, A., Kachele, H., & Müller, K. (2017). Climate variability and yield risk in South Asia's rice–wheat systems: Emerging evidence from Pakistan. *Paddy and Water Environment*, 15(2), 249–261.
- Bhende, M. J. (2013). Agricultural profile of Karnataka state. Agricultural Development and Rural Transformation Centre Institute for Social and Economic Change, Bangalore.
- Blagojević, M., Blagojević, M., & Ličina, V. (2016). Web-based intelligent system for predicting apricot yields using artificial neural networks. *Scientia Horticulturae*, 213, 125–131.
- Carleton, T. A. (2017). Crop-damaging temperatures increase suicide rates in India. *Proceedings of the National Academy of Sciences*, 114(33), 8746–8751.
- Crane-Droesch, A. (2018). Machine learning methods for crop yield prediction and climate change impact assessment in agriculture. *Environmental Research Letters*, 13(11), 114003.
- Dang, C. Liu, Y. Yue, H. Qian, J. and Zhu, R. 2020. Autumn Crop Yield Prediction using Data-Driven Approaches:-Support Vector Machines, Random Forest, and Deep Neural Network Methods. Canadian Journal of Remote Sensing. 1–20.
- Drummond, S. T., Sudduth, K. A., Joshi, A., Birrell, S. J., & Kitchen, N. R. (2003). Statistical and neural methods for site-specific yield prediction. *Transactions of the ASAE*, 46(1), 5.
- Fisher, A. C., Hanemann, W. M., Roberts, M. J., & Schlenker, W. (2012). The economic impacts of climate change: Evidence from agricultural output and random fluctuations in weather: Comment. *American Economic Review*, 102(7), 3749–3760.
- Fortin, J. G., Anctil, F., Parent, L., & Bolinder, M. A. (2011). Site specific early season potato yield forecast by neural network in Eastern Canada. *Precision Agriculture*, 12(6), 905–923.
- Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. *Science*, 327(5967), 812–818.
- Gonzalez-Sanchez, A., Frausto-Solis, J., & Ojeda-Bustamante, W. (2014). Attribute selection impact on linear and nonlinear regression models for crop yield prediction. *The Scientific World Journal*, 2014, 1–10.
- Gopal, P. M., & Bhargavi, R. (2019). A novel approach for efficient crop yield prediction. *Computers and Electronics in Agriculture*, 165, 104968.
- Gregory, P. J., & George, T. S. (2011). Feeding nine billion: The challenge to sustainable crop production. *Journal of Experimental Botany*, 62, 5233–5239.
- Guhathakurta, P., Rajeevan, M., Sikka, D. R., & Tyagi, A. (2015). Observed changes in southwest monsoon rainfall over India during 1901–2011. *International Journal of Climatology*, 35(8), 1881–1898.
- Gupta, R., Somanathan, E., & Dey, S. (2017). Global warming and local air pollution have reduced wheat yields in India. *Climatic Change*, 140(3), 593–604.
- Irmak, A., Jones, J. W., Batchelor, W. D., Irmak, S., Boote, K. J., & Paz, J. O. (2006). Artificial neural network model as a data analysis tool in precision farming. *T ASABE*, 49(6), 2027–2037.
- Jena, P. R., & Majhi, R. (2021). An application of artificial neural network classifier to analyze the behavioral traits of smallholder farmers in Kenya. *Evolutionary Intelligence*, 14(2), 281–291.
- Ji, B., Sun, Y., Yang, S., & Wan, J. (2007). Artificial neural networks for rice yield prediction in mountainous regions. *The Journal of Agricultural Science*, 145(3), 249–261.
- Kalli, R., & Jena, P. R. (2020). Impact of climate change on crop yields: Evidence from irrigated and dry land cultivation in semi-arid region of India. *Journal of Environmental Accounting and Management*, 8(1), 19–30.
- Kalli, R., & Jena, P. R. (2021). Combining agriculture, social and climate indicators to classify vulnerable regions in the Indian semi-arid regions. *Journal of Water and Climate Change*, 13(2), 542–556.
- Kalli, R., & Jena, P. R. (2022). How large is the farm income loss due to climate change? Evidence from India. *China Agricultural Economic Review*, 14(2), 331–348.

- Khaki, S., & Wang, L. (2019). Crop yield prediction using deep neural networks. *Frontiers in Plant Science*, 10, 621.
- Lobell, D. B., & Burke, M. B. (2010). On the use of statistical models to predict crop yield responses to climate change. *Agricultural and Forest Meteorology*, 150(11), 1443–1452.
- Majhi, R., Panda, G., & Sahoo, G. (2009). Development and performance evaluation of FLANN based model for forecasting of stock markets. *Expert Systems with Applications*, 36(3), 6800–6808.
- Mendelsohn, R. (2008). The impact of climate change on agriculture in developing countries. *Journal of Natural Resources Policy Research*, 1(1), 5–19.
- Mendelsohn, R. (2014). The impact of climate change on agriculture in Asia. *Journal of Integrative Agriculture*, 13(4), 660–665.
- Mendelsohn, R., Nordhaus, W. D., & Shaw, D. (1994). The Impact of global warming on agriculture: A Ricardian analysis. *The American Economic Review*, 84(4), 753–771.
- Pai, D. S., Sridhar, L., Badwaik, M. R., & Rajeevan, M. (2015). Analysis of the daily rainfall events over India using a new long period (1901–2010) high resolution (0.25× 0.25) gridded rainfall data set. *Climate Dynamics*, 45(3–4), 755–776.
- Pao, Y. 1989. Adaptive pattern recognition and neural networks.
- Patra, J. C., Pal, R. N., Chatterji, B. N., & Panda, G. (1999). Identification of nonlinear dynamic systems using functional link artificial neural networks. *IEEE Transactions on Systems, Man and Cybernetics, Part B (Cybernetics)*, 29(2), 254–262.
- Roel, A., & Plant, R. E. (2004). Factors underlying yield variability in two California rice fields. *Agronomy Journal*, 96, 1481–1494.
- Safa, M., & Samarasinghe, S. (2011). Determination and modelling of energy consumption in wheat production using neural networks: “A case study in Canterbury province, New Zealand.” *Energy*, 36(8), 5140–5147.
- Sanghi, A., & Mendelsohn, R. (2008). The impacts of global warming on farmers in Brazil and India. *Global Environmental Change*, 18(4), 655–665.
- Saxena, R., Vanga, S. K., Wang, J., Orsat, V., & Raghavan, V. (2018). Millets for food security in the context of climate change: A review. *Sustainability*, 10(7), 2228.
- Schlenker, W., & Roberts, M. J. (2006). Nonlinear effects of weather on corn yields. *Review of Agricultural Economics*, 28(3), 391–398.
- Schlenker, W., & Roberts, M. J. (2009). Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change. *Proceedings of the National Academy of Sciences*, 106(37), 15594–15598.
- Schlenker, W., Hanemann, W. M., & Fisher, A. C. (2005). Will U.S. agriculture really benefit from global warming? Accounting for irrigation in the hedonic approach. *American Economic Review*, 95(1), 395–406.
- Schlenker, W., Hanemann, W. M., & Fisher, A. C. (2006). The impact of global warming on US agriculture: An econometric analysis of optimal growing conditions. *Review of Economics and Statistics*, 88(1), 113–125.
- Shook, J., Gangopadhyay, T., Wu, L., Ganapathysubramanian, B., Sarkar, S., & Singh, A. K. (2021). Crop yield prediction integrating genotype and weather variables using deep learning. *PLoS ONE*, 16(6), e0252402.
- Srivastava, A. K., Rajeevan, M., & Kshirsagar, S. R. (2009). Development of a high resolution daily gridded temperature data set (1969–2005) for the Indian region. *Atmospheric Science Letters*, 10(4), 249–254.
- Sultan, B., Guan, K., Kouressy, M., Biasutti, M., Piani, C. H., & GL. and Lobell, DB. (2014). Robust features of future climate change impacts on sorghum yields in West Africa. *Environmental Research Letters*, 9(10), 104006.
- Taheri-Rad, A., Khojastehpour, M., Rohani, A., Khoramdel, S., & Nikkhah, A. (2017). Energy flow modeling and predicting the yield of Iranian paddy cultivars using artificial neural networks. *Energy*, 135, 405–412.
- Tantalaki, N., Souravlas, S., & Roumeliotis, M. (2019). Data-driven decision making in precision agriculture: The rise of big data in agricultural systems. *Journal of Agricultural & Food Information*, 20(4), 344–380.
- Traore, S., Zhang, L., Guven, A., & Fipps, G. (2020). Rice yield response forecasting tool (YIELD-CAST) for supporting climate change adaptation decision in Sahel. *Agricultural Water Management*, 239, 106242.
- Tian, X., Engel, B. A., Qian, H., Hua, E., Sun, S., & Wang, Y. (2021). Will reaching the maximum achievable yield potential meet future global food demand? *Journal of Cleaner Production*, 294, 126285.
- Wang, P., Zhang, Z., Song, X., Chen, Y., Wei, X., Shi, P., & Tao, F. (2014). Temperature variations and rice yields in China: Historical contributions and future trends. *Climatic Change*, 124(4), 777–789.

Widrow, B., & Stearns, S. (2002). *Adaptive signal processing* (p. 2002). Pearson Education.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Effect of irrigation on farm efficiency in tribal villages of Eastern India

Rajesh Kalli^a, Pradyot Ranjan Jena^{b,*}, Raja Rajendra Timilsina^{c,1}, Dil Bahadur Rahut^{c,2}, Tetsushi Sonobe^{c,3}

^a School of Commerce and Management Studies, Dayananda Sagar University, Bengaluru, Karnataka 560078, India

^b School of Humanities Social Sciences and Management, National Institute of Technology Karnataka, Mangalore 575025, India

^c Asian Development Bank Institute (ADBI), Kasumigaseki, Chiyoda-ku, Tokyo 100-6008, Tokyo, Japan

ARTICLE INFO

Handling Editor - Dr Z Xiyang

Keywords:

Irrigation
Climate change
Agricultural productivity
Technical efficiency
Data Envelopment Analysis

ABSTRACT

Irrigation is an important adaptation strategy to cope with climate change which reduces vulnerability to water stress and improves crop productivity to feed millions. There is evidence of crop yield stagnation in many developing countries, and irrigation efficiency is claimed to increase crop productivity. Therefore, this paper uses data envelopment analysis to evaluate the farmer's productivity through technical efficiency (TE), i.e., the relationship between resource inputs and outputs of 513 paddy farmers in Eastern India. The results show that the farms are, on average operating at 14% TE, leaving a considerable scope to improve up to 86% to reach the optimal level. A significant difference is observed between irrigated and rain-fed paddy farmers, such that 10% of the irrigated farms achieved efficiency scores over 40% and only 2% of rain-fed farms achieved the same. The tobit and beta fit regression models are estimated to find out the factors that influence the TE. Both surface water and groundwater sources of irrigation are used as predictors, along with other socio-demographic factors. Access to surface water irrigation is identified to be a significant determinant of farm efficiency, however, surface water irrigation, such as canal irrigation, is accessible only to farmers living on plain land. Farmers living on highlands need to explore other sources of irrigation practices, such as drip and sprinkler, that can increase TE and farm productivity. Therefore, this paper calls for government intervention to provide extensive training and facilities for these micro-irrigation practices.

1. Introduction

Global undernourishment has increased from 19.6% in 2016 to 21.8% in 2020, and improving food production under climate stress to feed the rising population is a global primary goal (Voroosmarty et al., 2000; Schewe et al., 2013; WHO, 2018; Chen et al., 2021). Agricultural inputs, such as fertilizer and mechanization, have brought a massive transformation in crop productivity. However, productivity growth in agriculture is still lower among Sub-Saharan African and South Asian economies compared to East Asia; for instance, the average paddy production per hectare in India is 3590 kg, much lower compared to 6686 kg per ha. in China. The agricultural sector is usually more vulnerable to climate change because water-intensive crop production consumes over 70% of global water and is highly sensitive to water variability (Duinen et al., 2014; Tuong et al., 2005; Pourzand et al., 2020; Sang et al., 2023).

Irrigation plays a crucial role in offsetting the impact of rising temperatures and acts as a viable adaptation strategy to climate change (BIRTHAL et al., 2021). The increasing threat of climate change will likely amplify the adverse effects of water shortage and further aggravates global food security in the future (Dinar et al., 2019; Hanjra and Qureshi, 2010). The demand for irrigation water for crop production has been projected to increase sharply in the next few decades (Sabbaghi et al., 2020; Tran et al., 2022).

Governments in developing economies are focusing on the expansion of the irrigation infrastructure as a key to promoting the development of agriculture (Kirpich et al., 1999; Calow et al., 2009; Ward, 2010). These large-scale irrigation projects are capital-intensive and demand heavy subsidization by the government. If the government lacks the capacity to subsidize, only farmers with access to irrigation possess the ability to adapt to climate shocks (Scheierling et al., 2006; Medellin-Azuara et al.,

* Corresponding author.

E-mail address: pradyotjena@nitk.edu.in (P.R. Jena).

¹ <https://orcid.org/0000-0001-9916-4934>

² <https://orcid.org/0000-0002-7505-5271>

³ <https://orcid.org/0000-0002-9961-9764>

2012; Li et al., 2021). In India, paddy, wheat, and maize are major crops cultivated in more than half of the total farm areas (Panigrahy et al., 2010). However, nearly 40% of the cultivated areas are rain-fed, and the average efficiency of farms is only 38%, which is much below the desired level, i.e., 70% conveyance efficiency level (Watto and Mugeru, 2014).

Against this backdrop, the present study estimates the efficiency of agricultural productivity in Eastern India among paddy cultivators. Technical efficiency is part of productivity efficiency, and it is affected by the flow of information, better infrastructure, availability of credit markets, and farmers' managerial capabilities (Abdallah, 2016). This study examines the overall technical efficiency, pure technical efficiency, and scale efficiency using the data envelopment analysis (DEA) for rain-fed and irrigated paddy cultivation in the eastern province of India. Further, the study explores the factors determining agricultural technical efficiency using Tobit and Betafit regression methods. This study provides useful information and practical suggestions to policymakers for the allocation and extension of the irrigation infrastructure to improve agricultural productivity. Our study, therefore, makes three potential contributions to the existing literature. First, by comparing farm efficiency scores between rain-fed and irrigated paddy cultivators, the importance of enhancing micro-irrigation systems in disadvantaged terrains is reinforced. Second, our results are robust regardless of the techniques used, and the factors that are identified to be affecting farm efficiency in a tribal province of India are reliable. Finally, using an impact evaluation technique, the study estimates the impact of irrigation facilities on farm efficiency.

The remainder of this paper is organized as follows. Section 2 presents an extensive review of related literature. Section 3 describes the sampling technique, data collection, and the specification of the econometric models used. Section 4 reports the "results and discussion". Finally, the conclusions with policy implications are provided in Section 5.

2. Literature review

Past literature has well documented that water scarcity is mainly influenced by climate change, weather variabilities, and human activities, such as industrial development, mining, and agriculture (Silalertruksa and Gheewala, 2018; Çetin & Kara, 2019; Sabbaghi et al., 2020; Surendran et al., 2021; Dhaliwal et al., 2022). Aeschbach-Hertig and Gleeson (2012) claim that groundwater is critically essential for irrigation, accounting for 80% of net water consumption in major countries like India, China, and the United States. Jain et al., (2015, 2021) use both primary and secondary data from survey and census of India and identify that cropping intensity is expected to drop by 20% in India due to groundwater depletion. Ray et al. (2015) use worldwide detail crop statistics time series data to examine climate variability and crop yields and find that global climate change contributes to nearly 32–39% of yield differences, i.e., known as production risk. Mishra et al. (2018) suggest that excessive groundwater pumping in India leads to rapid groundwater depletion and propose low-cost intervention for irrigation based on soil moisture information as the solution. Sidhu et al. (2019) use experiments to compare water use efficiency in rice and wheat farming, revealing that sub-surface drip irrigation can save 50% of water while resulting in exact yield compared to conventional water management such as flood irrigation systems. Mitter and Schmid (2021) analyze stochastic climate scenarios on agricultural adaptation and irrigation water use and suggested that an efficient groundwater policy is needed to sustain groundwater availability in semi-arid regions, particularly under climate change. Overall, overuse of groundwater and water-saving techniques for irrigation systems shall be essential to overcome the shortfall in agricultural production while coping with climate change and food security.

Past studies have claimed that to improve agricultural productivity, irrigation and water-saving agricultural practices shall be pivotal to enhancing farm productivity and efficiency (Houshyar et al., 2019;

Parthasarathi et al., 2018; Carracelas et al., 2019; Çetin & Kara, 2019; Comas et al., 2019; Zhang et al., 2021; Surendran et al., 2021; Wang et al., 2022; Dhaliwal et al., 2022). Dhungana et al. (2004) find that rice farmers in Nepal have average pure technical and scale inefficiencies of 18% and 7%, respectively. Chauhan et al. (2006) and Masuda (2019) suggest introducing proper machinery and implementing economies of scale to improve energy efficiency in rice cultivation in India and Japan, respectively. Sharma and Majumdar (2021) use the slack-based measure (SBM) data envelopment analysis (DEA) model to measure efficiency in rice production and claim that over 50% of Asian countries are environmentally inefficient. Comas et al. (2019) find the importance of deficit irrigation for mitigating maize yield losses and improving productivity in Northern Colorado.

Parthasarathi et al. (2018) report that drip irrigation improves aerobic rice yield and achieves water savings of 50% and 29%, respectively, in India. Zheng et al. (2021) conduct a meta-analysis to understand water productivity through water-saving practices and report that plastic mulch, deep tillage, straw incorporation into the soil, and ridge planting could significantly increase farmland productivity in China. Dhaliwal et al. (2022) and Jing et al. (2021) conduct a study on the deep tillage impact on soil water balance and productivity of maize-wheat cropping and suggested that water productivity can be substantially boosted by planting drought-tolerant wheat varieties. The past literature has proposed several strategies and water management practices. However, such strategies might also erode the field environment and decrease crop yield (Zheng et al., 2021). These studies provide insights into different aspects of efficiency and crop production, including technical efficiency, energy efficiency, water-saving strategies, and environmental impacts.

Previous studies have indicated that climate change-induced droughts have negative impacts on agricultural productivity (Kuwayama et al., 2018; Senapati et al., 2019; Sabbaghi et al., 2020; Liu et al., 2022; Arunrat et al., 2022). The efficiency of crop production is closely linked to inputs used by farmers, such as fertilizers, improved seeds, and access to irrigation water (Bandyopadhyay et al., 2009; Wang, 2010). Implementing irrigation systems, soil, and water conservation practices, and constructing bunds can enhance resource-use efficiency by creating synergies between water and other inputs (Sidhu et al., 2019; Abdulai and Huffman, 2014). Bravo-Ureta (2020) suggests that advancements in irrigation technology have increased the production potential for beneficiaries, and integrating multiple inputs offers significant advantages in mitigating production losses caused by climate change. Addressing these factors is crucial in ensuring sustainable and resilient crop production in the face of changing climatic conditions.

Agricultural economists have used stochastic frontier analysis and data envelopment analysis (DEA) to measure farm productivity and growth (Battese and Coelli, 1992; Wadud and White, 2000; Banker and Natarajan, 2008; Alene, 2010; Kumar and Managi, 2010; Cobanoglu, 2013; Olesen and Petersen, 2016; Liu et al., 2023). Technical efficiency and inefficiency are associated with either the ability or deviations from producing at the frontier isoquant, respectively (Abdallah, 2016). The relationship between technical efficiency and agricultural inputs has been widely studied with different estimation methods, such as propensity score matching. Asante et al. (2014) suggest that productivity and efficiency in the agricultural sector can be improved as inputs are well tailored toward the needs of farmland by encouraging farmers to adopt better technologies and inputs. Chavas et al. (2005) investigate economic efficiency at the household level for capturing the importance of off-farm activities and claim that nonfarm employment contributes to significant allocative inefficiency. González and Lopez (2007) estimate farm-level technical efficiency and its determinants and find that productivity is lower in areas with high political violence, mainly due to disruptions in rural labor markets. Rodríguez-Ferrero et al. (2010) conduct empirical analyses through DEA measurements for 156 irrigated areas of Andalusia and suggest that it is crucial to take into account economic efficiency and to pinpoint the factors responsible for

variations in efficiency to achieve optimal water management. Watto and Muger (2014) employ DEA to estimate the technical and irrigation efficiency of rice farms in the Punjab Province of Pakistan using a cross-sectional dataset of 80 rice growers, 45 tube-well owners, and 35 water buyers and suggest that groundwater management policies should be designed with knowledge of crop water consumption for enhancing efficiency. Gutiérrez et al., (2017) assess the efficiency of organic and conventional rain-fed cereal crops grown in Southern Spain and find that conventional production is more inefficient than organic production, and farm size is positively related to inefficiency. Nandy et al. (2021) conduct a meta-analysis to understand the sustainability of different agricultural production systems by analyzing input variables used for calculating DEA and reveal that the mean technical efficiency across studies significantly affects agricultural products such as vegetables, fruits, flowers, and livestock. Overall, DEA has been intensively used to study agricultural efficiency concerning several inputs, such as water, fertilizer, and irrigation techniques and methods.

3. Methods and materials

The methodology adopted in this study is divided into three stages. First, the farm efficiency scores are measured using the DEA. Furthermore, these scores are classified under irrigated and rain-fed paddy farms to ascertain the effect of irrigation on farm efficiency. Second, we regress the efficiency scores against household demographic and farm-specific variables to explore the determinants of efficiency by using the Tobit and Betafit models. Finally, we employ the endogenous switching regression to compare the expected efficiency of irrigated farmers with the expected efficiency in a counterfactual hypothetical case in which paddy cultivation is rain-fed.

3.1. Data envelopment analysis (DEA)

Agriculture productivity in the past literature has been estimated using two popular methods: Data envelopment analysis (DEA) and stochastic frontier analysis (SFA) (Sharma et al., 1997). Both of these approaches have their own advantages and challenges – the DEA approach is a non-parametric approach that requires no explicit functional form to be imposed on the data (Sakouvogui, 2020). DEA allows for a comprehensive assessment of efficiency by considering multiple inputs and outputs simultaneously. It provides a single efficiency score for each decision-making unit (DMU) based on its relative position to the best-performing units, considering all inputs and outputs (Odeck, 2001; Sengupta, 1998). The DEA is a linear programming method used to measure the efficiency of the production unit. The production frontier surface is constructed by analyzing the efficient frontier (which is equal to 1), and units below this frontier line are referred to as the inefficient space. Technical efficiency is a measure of the farmer's ability to produce the maximum feasible output from a given bundle of inputs or use minimum feasible amounts of inputs to produce a given level of output.

In the present study, we estimate the efficiency of paddy cultivation with one output and multiple inputs. Yield per hectare was employed as the output, and inputs such as labor, fertilizer, and compost were adopted to calculate the efficiency scores. The DEA method seeks to maximize the proportional increase in the output (yield). The technical efficiency of a farm is a measure to evaluate a farmer's choice of input use and the farm management skills to achieve the maximum possible output. The transformation of the input to output in the maximum potential framework is represented by the production possibility frontier (Efficiency score = 1). Any farmer who operates below this frontier is classified as technically inefficient. Overall technical efficiency (OTE) calculated under constant returns to scale (CRS) assumption helps to determine inefficiency due to input/output configuration. OTE mainly focuses on how well the farmers use different inputs and quantities of inputs to maximize the yield. OTE is decomposed into two parts – (a) pure technical efficiency (PTE) and (b) scale efficiency (SE). PTE is

estimated using the variable returns to scale (VRS) assumption, and it reflects the effectiveness of the managerial decisions/practices followed by the farmers to organize the inputs in a production process. The SE score measures the efficiency at the current level of scale of operation of a farmer. A SE score of 1 shows that the farmer is at the optimal scale and hence has no scope for improvement. However, a SE score of less than 1 could mean that the scale of operation is either going through increasing returns to scale or decreasing returns to scale.

The DEA model can be subdivided into an input-oriented model, which minimizes inputs at given output levels, and an output-oriented model, which maximizes outputs. Past literature has extensively applied the DEA model to measure efficiency in a wide range of sectors, such as manufacturing industries and service-providing banks (Kumar and Gulati, 2008). The DEA model is a set of functions, technically referred to as a decision-making unit (DMU). From the sample of decision-making units, the model establishes the relative efficiency of each DMU within a sample (Lee, 2009). DEA models are classified in terms of returns to scale with the addition of weight constraints. Charnes et al. (1978) originally proposed the efficiency measurement of the DMUs for CRS, also referred to as the CCR model. Later, Banker and Natarajan (2008) used the VRS efficiency measurement model, which is referred to as the BCC model.

Charnes et al. (1978) expanded Farrell's efficiency to generate the relative efficiency of each DMU in constant returns to scale. They generated an efficiency score using a linear combination to convert multiple outputs and inputs to a single virtual input and output, which is between 0 and 1. The efficiency value of 1 indicates it is efficient, otherwise, it is inefficient. The model is formulated as follows:

For a set of observed DMUs $\{DMU_p; p = 1, \dots, n\}$, the following problem is solved by applying the piece-wise linear frontier to the input requirement set.

$$\begin{aligned} \text{Maximize } E_p &= \frac{\sum_i y_{pi} w_i}{\sum_j x_{pj} v_j} \\ \text{subject to : } &\frac{\sum_i y_{ki} w_i}{\sum_j x_{kj} v_j} \leq 1 \text{ for } k = 1, 2, \dots, K \end{aligned}$$

where, E is equal to Efficiency ($p = 1, 2, \dots, K$).

$$w_i \geq \varepsilon, \text{ for } i = 1, 2, \dots, I$$

$$v_j \geq \varepsilon, \text{ for } j = 1, 2, \dots, J$$

x and y are the input and output DMU.

v_j and w_i are the weight of the input and output.

Banker et al. (1984) widened the CCR model by breaking down the efficiency score into pure technical efficiency and scale efficiency. They followed the VRS efficiency measurement. The study examines the overall technical efficiency, pure technical efficiency, and scale efficiency of rain-fed and irrigated paddy cultivation.

The BCC model evaluates the efficiency of DMU by solving the following (envelopment form) linear program. Table 1.

For a set of observed DMUs $\{DMU_p; p = 1, \dots, n\}$,

the objective function is $\min_{\theta, \lambda} \theta$.

subject to $-y_i + Y\lambda \geq 0$,

$$\theta_{xi} - X\lambda \geq 0,$$

$$e\lambda = 1$$

$$\lambda \geq 1$$

where e is a vector of ones and θ is a scalar.

A difference between the CCR and BCC models is present in the free variable MQ, which is the dual variable associated with the constraint

Table 1
Studies on rice production efficiency using DEA method.

Sl No.	Author	Country	Sample Size	Mean Efficiency Score	Variables adopted
1	Balcombe et al., (2008)	Bangladesh	295	0.59	Total production of rice as output and area, labor, Bullock cart, fertilizer, and seed
2	Balde et al. (2014)	Guinea	140	0.23	Fertilizer & pesticide cost, Hired labor cost, Depreciation cost of farm tools, Seed quantity, Family labors per family size and Farm area under mangrove rice cultivation
3	Kea et al., (2016)	Cambodia	301	0.34	Total production of rice as output and land, labor, fertilizer, pesticide, and other capital as input
4	Masuda (2018)	Japan	Panel data (2005–2011)	0.73 - 0.98	Rice yield, energy inputs of fossil fuels, electricity, seeds and seedlings, chemical fertilizers, purchased manure, pesticides, land improvement and irrigation, agricultural services, buildings, motor vehicles, and agricultural machinery.
5	Paltasingh et al. (2022)	India	360	0.54	Profit as output; fertilizer use (kg/ha), labor cost (₹/ha), seeds use (kg/ha), area under rice (ha) as inputs
6	Najafabadi (2022)	Iran	286	0.7	Grain yield, Human labor, Machinery, Diesel, Fertilizer, Chemical and Irrigation

Source: Compilation by the authors

eA = 1 in the envelopment model that also does not appear in the CCR model. Table 2 provides a detailed explanation of the OTE and its constituents, namely, PTE and SE.

3.2. Tobit regression

Crop productivity is not only affected by the agricultural input variables but also by other farm characteristics and farmers’ behavioral characteristics. A Tobit regression model is used to analyze the factor influencing the efficiency of paddy cultivation. Tobit regression is considered a suitable alternative to the least squares method, as the dependent variable in the present study is truncated between 0 and 1. The Tobit regression model is also referred to as the “limited dependent variable model”, which is widely used to measure the factors that affect efficiency (Wooldridge, 2002). The factors used to explain the efficiency scores are the demographic characteristics of the households, access to irrigation, farming experience, and the area under farming.

Table 2
Efficiency Measures in DEA Analysis.

Different Efficiency Measures	Definition and Explanation
Overall Technical Efficiency (OTE)	Farm productivity depends on multiple inputs such as fertilizer, agriculture machinery, soil fertility, and seed choice. This overall combination of inputs is transformed to outputs. Overall Technical efficiency estimates the best input transformation frontier and assigns the efficiency score 1 to farmers that lie on the frontier. This method follows proportionate change in the input leads to proportionate change in the output.
Pure Technical Efficiency (PTE)	Pure Technical efficiency scores are estimated with the assumption of VRS. This method follows an increase or decrease in input, or output does not result in a proportional change in the outputs or inputs, respectively. This transformation usually happens due to managerial efficiency or decision by farmers. The common management practices/decision made by farmers in paddy cultivation is irrigation applied at regular intervals, leveling of the farm, seed quality, and appropriate nutrient and weed management practices.
Scale Efficiency	The relationship SE = OTE/PTE provides a measure of scale efficiency. The SE score of 1 represents the farm is at the optimal scale, meaning that efficiency under CRS and VRS is equal. If the technical efficiency under CRS is not equal to the efficiency under VRS, but the efficiency score under VRS and non-increasing returns to scale are equal, then the utility is operating under decreasing returns to scale (DRS). If the efficiency scores are equal under CRS and non-increasing returns to scale, but less than VRS, then the utility is operating in the range of increasing returns to scale. (See Kumar and Managi, 2010)

Source: Compilation by the authors

3.3. Beta fit regression

Linear models traditionally follow the least squares (LQ) regression, which is semi-parametric. However, in the present study, the dependent variable is efficiency scores which are measured continuously on the standard unit interval, i.e., $y \in (0, 1)$. Therefore, in such cases, the beta distribution is flexible as it is bounded between 0 and 1. The approach uses a parameterization, where the mean of the dependent variable is given by a linear predictor. (See for detailed analysis Ferrari and Cribari-Neto, 2004).

3.4. Endogenous switching regression (ESR)

Causal analysis with cross-sectional data is typically plagued by self-selection bias. Although the propensity score matching method reduces the bias due to observable variables, it has been criticized for the hidden bias arising from unobserved variables. We performed the ESR analysis to address the hidden bias. ESR defines two regimes – the first consists of farm households that used irrigation, and the second consists of those who did not. The latent variable model is estimated as follows:

$$A_i^* = Z_i\alpha + v_i \text{ where } A_i = \begin{cases} 1 & \text{if } Z_i\alpha + v_i > 0 \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

A household i uses irrigation when its predicted benefit is greater than that of non-participation. Let A_i^* be a latent variable that captures the benefit of use by the i th household. Z_i is a vector of explanatory variables that describes the selection of the regimes. The parameter vector is α , and the error term is v_i . The outcome equation is then estimated in the second step. The observations from the first-stage selection equation are used to determine which of the two regimes to join. The following are the outcome equations for two regimes: users of irrigation and non-users corrected for endogenous participation:

$$\text{Regime1} : Y_{1i} = X_{1i}\beta_1 + \sigma_{1u1i}\hat{\lambda}_{1i} + u_{1i} \text{ if } A_i = 1 (\text{Users}) \quad (2a)$$

$$\text{Regime2} : Y_{2i} = X_{2i}\beta_2 + \sigma_{2u2i}\hat{\lambda}_{2i} + u_{2i} \text{ if } A_i = 0 (\text{Non-users}) \quad (2b)$$

where Y_{1i} and $Y_{2i}, i = 1, \dots, N$, represent the dependent variables in each of the two regimes. X_{1i} and X_{2i} are the explanatory variables relevant to each regime, β_1 and β_2 are the parameters that need to be estimated, and the corresponding error terms are u_{1i} , u_{2i} . λ_{1i} and λ_{2i} are the inverse Mill’s ratios (IMR) estimated from the equation of first stage selection, and are included for correction for selection bias in the Eqs. (2a) and (2b).

Four estimates are computed by the second-stage outcome regressions, such as (a) real scenario outcome from users, (b) real scenario outcome from non-users, (c) counterfactual outcome scenario from users (i.e., what would have happened if the users had opted not to use) and (d) counterfactual outcome scenario for non-users (i.e., what would

have happened if the non-users had opted to use). Scenarios (a) and (b) are based on survey data and therefore are true scenarios, whereas (c) and (d) are the hypothetical scenarios (counterfactual scenarios) where the treated were found to be untreated, and the untreated were found to be treated. The average treatment effect on the treated (ATT) is computed as (a)–(c), and the average treatment effect on the untreated (ATU) is computed as (b)–(d).

3.5. Data and variables

The present study analyzed the farm efficiency of one of the eastern states of India, namely Odisha. The state is an agrarian economy, with most of its population living below the poverty line. The state produces various crops, including fruits and vegetables, with rice being the major cultivation. However, the state is prone to extreme natural calamities like floods, cyclones, and droughts - a significant agricultural challenge. The total cultivated land of the state is 61.80 hundred thousand ha, out of which 29.14 hundred thousand ha (47%) is high land, 17.55 hundred thousand ha (28%) medium-high land, and 15.11 hundred thousand ha (25%) is low land.⁴ Nearly 55% of the cultivated land is irrigated, and the average size of land holding is nearly 1.04 ha. in this state. The present study chose Koraput district, one of the districts with the highest tribal settlement in the state. The primary livelihood occupation in Koraput is agriculture, with about 90% or more of the inhabitants involved in agriculture or allied activities. A multi-stage sampling approach was used to conduct the household survey. First, we purposefully selected the Koraput district in the state, which consists of tribal farmers with a large belt of rice cultivation. In the next stage, we randomly selected 6 blocks and 22 villages. Finally, 513 farm households were randomly selected from those villages in proportion to the village size. A structured questionnaire was used to collect data on the selected farmers' socio-economic status and farm characteristics with particular reference to paddy cultivation from the selected farmers. The sampling design of the study is presented in Fig. 1.

The efficiency measurement is constructed by determining the major input and output variables – in general, paddy yield generated per hectare (*ha*) is the widely adopted output construct (Kea et al., 2016; Gutiérrez et al., 2017; Paltasingh et al., 2022). In the case of input constructs, multiple variables are considered based on the objective of the study - the most common input choices among the researchers for efficiency calculations are labor, fertilizer (NPK), and compost (Kea et al., 2016; Paltasingh et al., 2022; Najafabadi, 2022). Based on the literature review and the availability of the data, the study adopted yield

(tonnes per ha) as the output and labor (person in days per ha), fertilizer (kg per ha), and compost (kg per ha) as the desirable inputs to calculate the efficiency scores in the eastern region of India. Further, several demographic and household characteristics also influence the efficiency of agriculture production. The common factors that are considered in the literature are the age of the household head, education of the household head, farming experience, seed source, and irrigation methods (Balde et al., 2014; Abdallah, 2016; Kea et al., 2016; Paltasingh et al., 2022).

We incorporate the involvement of farmers in the consumption of psychoactive substances, explicitly smoking and drinking, as a factor to measure its impact on efficiency scores. This approach is supported by several previous studies, including Chiteji (2010), Cobb-Clark et al. (2014), Beauchamp and Johannesson (2017), and Hernuryadin et al. (2020), which have suggested that the consumption of psychoactive substances can affect investment decision-making and input management among farmers. By including these factors, we aim to investigate the relevance of psychoactive substance influence on investment decision-making, particularly with input management. Thus, the rationale behind incorporating these factors is to explore the potential effect of psychoactive substances on farmers' decision-making processes, specifically in managing their inputs effectively. We hypothesize that farmers who are highly involved in psychoactive substance consumption are less likely to be efficient in their input management, and this behavior may have a negative relationship with their efficiency scores. Thus the overall selection of the constructs to calculate the efficiency scores and the factors used for modeling the efficiency scores is based on the extensive literature review and the suitability of the study area.

Table 3 presents the summary statistics of the variables used in the study. The study focused on the small-scale paddy farmers in the Koraput district of Odisha. We have compared the yield of paddy and the average quantity of inputs used for paddy cultivation in our sample with the state average during the same time period as in the study, i.e., 2021–22, to show the relative position of the study region in a broader

Table 3
Summary Statistics.

Variables	Variable Description	Mean	SD
Yield (tonnes per ha)	Total Paddy production (Tonnes per hectare)	2.89	1.52
Farm size (ha)	Farm size (hectare)	0.72	0.62
Labor in person-days	Total labor committed to the plot in male/female person days	81	51
Fertilizer (NPK) in kgs per ha	Total NPK fertilizer (kgs per hectare)	201	151
Compost in kgs per ha	Total compost used in cultivation (kgs per hectare)	698	981
Age of the HH in years	Household head age (years)	43	11
Education of the HH in years	Household head number of years of schooling (years)	3.8	3.9
Farming Experience of HH in years	Household head number of years of experience in farming (years)	22	10
Distance to seed/fertilizer market (km)	Distance to seed/fertilizer market (km)	10.76	6.61
Seed Source	The variables describe the source of seeds: Dummy = 1 if seeds are sourced from other sources, 0 = seeds from own source; 72% of the paddy cultivators source the seeds from other sources (Government organization and Seed dealers), and 28% of them used their own source for cultivation.		
Irrigation	The variables describe whether the paddy cultivation is rain-fed or irrigated: Dummy = 1 if farmland is irrigated, 0 otherwise; 28% of the paddy cultivators were irrigated and 72% were rainfed.		
Smoking & Drinking	The variables describe whether the farmer consumes alcohol and cigarette or not: Dummy = 1 if consumption, 0 otherwise; 37% of the paddy cultivators agreed on the consumption of alcohol and cigarette, and 63% of them didn't consume.		

Source: Authors' computation

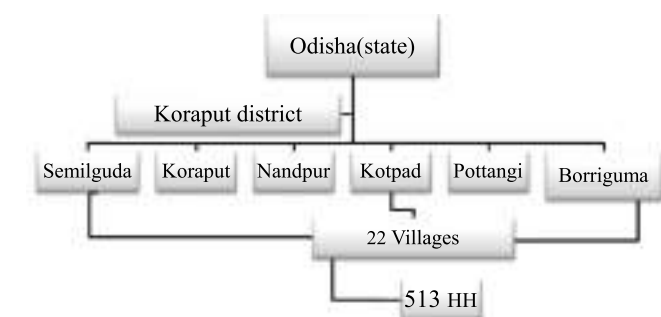


Fig. 1. Sampling design developed for the study. Note: The names of six blocks randomly selected for this study are – Semilguda, Nandpur, Pottangi, Koraput, Borriguma, and Kotpad.

⁴ Hectare is a special name for 10,000 square meters (m²) of land measurement, equivalent to 2.471 acres. Abbreviation: *ha*

agricultural context. The average paddy yield from the study sample is 2.9 tonnes/ha, while the average derived yield of paddy in Odisha is 4.4 tonnes/ha (DES, 2022). The inputs used, such as fertilizer (NPK) was around 201 Kg/ha for the sampled farmers; however, the average fertilizer consumption in the state is 131 Kg/ha (DES, 2022).⁵ The other major input, i.e., organic compost used was around 698 Kg/ha for sampled farmers, while the state average manure consumption was 1300 kg/ha (DES, 2022). Finally, the average labor person-days used is 81 days per hectare for the sampled farmers in the study region. The average size of the farm holding among the sampled farmers is about 0.72 ha. Fig. 2 presents the number of labor person-days used per ha, NPK in kg/ha, and compost in kg/ha under rain-fed and irrigated cultivation. Approximately 43 years is the average age of the household head, with an average of 3.80 years of schooling. In the study sample, 37% of the paddy cultivators reported that they consume alcohol and cigarettes, while 63% of them did not consume them. Fig. 3 shows the percentage of farmers consuming psychoactive substances under rain-fed and irrigated cultivation. Around 22 years is the average farming experience of the household head. Among the surveyed locations, it is found that 72% of the paddy cultivators source the seeds from other sources (Government organizations and seed dealers), and 28% use their source for cultivation. Only 28% of the paddy cultivators have irrigation facilities, and 72% are dependent on rain for paddy cultivation. This study introduces an unexplored aspect of the farming households of the study region, which is a tribal-dominated district.

4. Results and discussion

This section discusses the results from the three methods used in this study. Initially, we assessed the farming efficiency of paddy farmers in Eastern India, providing insights into the average operational efficiency of farming households. This information is crucial for understanding both farmers' knowledge and practices and determining the factors influencing effective farm management. Subsequently, Tobit and Beta fit regression models were employed to identify the key determinants influencing the efficiency scores obtained in the first stage. Finally, the ESR model was applied to evaluate the impact of irrigation on efficiency scores. Given the study's primary focus on investigating the contribution of irrigation access to on-farm efficiency, the ESR model was chosen for its ability to control for self-selection bias.

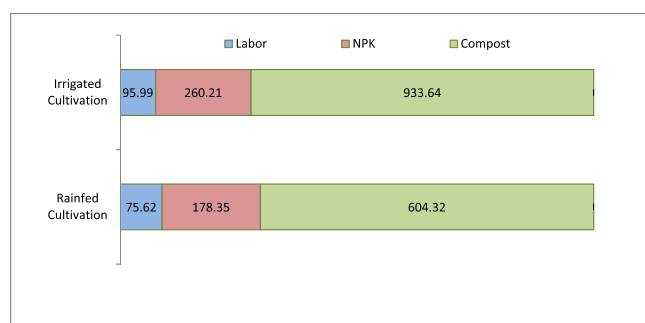


Fig. 2. Number of labor in person-days, NPK in kg/ha and Compost in kg/ha under rain fed and irrigated cultivation.

⁵ The slight differences observed between the state-level data and the collected sample could be attributed to several underlying reasons: State-level data may represent a different time period than the collected sample, leading to variations. The state-level data might encompass diverse regions with varying characteristics, which differ from the specific area covered by the sample. We have specifically focused on very remote and underdeveloped regions where the average falls below the state level.

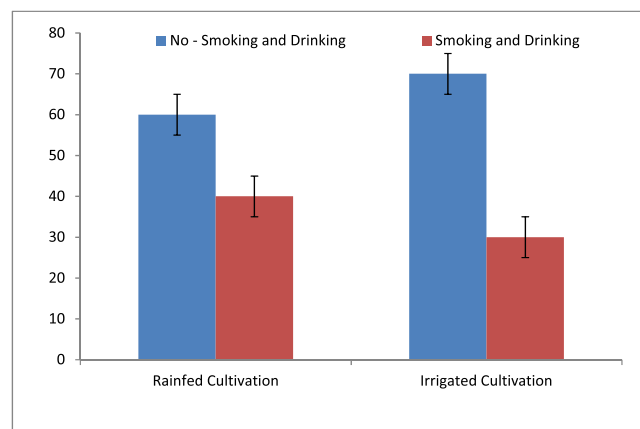


Fig. 3. Percentage of farmers consuming psychoactive substance under rain-fed and irrigated cultivation. Error bars in the Figure shows the standard errors.

4.1. Efficiency analysis

Tables 4 and 5 present the efficiency scores measured using the DEA model. From the sample of 513 paddy cultivators, only 1% were under the efficient category with the assumption of CRS. The input resource utilization is most efficient for 1% of sampled farmers and can be considered the reference benchmark. More than 80% of the paddy cultivators were at a low level of farming efficiency in the region. The overall technical efficiency of the paddy cultivators varied from 0.02 to 1, with a mean efficiency score of 0.14, i.e., average efficiency of 14%, which reflects the acute inefficiency in the input resource utilization, which could be the reason for low paddy yield per hectare compared to the state average. Thus, there is a scope for improvement in the farmers' crop input management strategies by nearly 86%. The efficiency scores in the literature are heterogeneous due to varied characteristics, both physical environment and farmers' choice of cultivation. A study by Balde et al. (2014) shows estimated average technical efficiency scores of 23% among the Mangrove rice production system in the Guinean coastal region. Similarly, an average efficiency of 34% was found in the Battambang Province of Cambodia (Kea et al., 2016). Paltasingh et al. (2022) estimated a technical efficiency score of 54% among the tenant farming group in the Cuttack district of Odisha, an eastern Indian state. However, the current study region is a hilly area that is mostly inhabited by the tribal communities of the state and they have low socio-demographic and economic indicators (Khosla and Jena, 2020). Hence, a relatively lower average technical efficiency among the paddy farmers is not surprising.

The pure technical efficiency, which reflects the farm management efficiency, is estimated using the VRS assumption and is optimal for about 1.5% of the farmers. The average pure technical efficiency is 35%,

Table 4

Efficiency scores, technical efficiency, and scale efficiency of paddy cultivation.

Efficiency Level	Overall Technical Efficiency	Pure Technical Efficiency	Scale Efficiency
1	2	8	24
0.8 – 1	0	17	34
0.6-0.8	5	49	58
0.4-0.6	15	72	86
0.2-0.4	76	225	225
0-0.2	415	142	86
Total Number of Farmers	513	513	513
Minimum	0.02	0.13	0.12
Maximum	1.00	1.00	1.00
Mean	0.14	0.35	0.41
SD	0.13	0.21	0.24

Source: Authors' computation

Table 5
Different Efficiency scores of rain-fed and irrigated paddy cultivation.

Efficiency Level	Rain-fed Paddy Cultivation			Irrigated Paddy Cultivation		
	Overall technical efficiency	Pure technical efficiency	Scale efficiency	Overall technical efficiency	Pure technical efficiency	Scale efficiency
1	0	1	9	2	7	15
0.8 - 1	0	11	17	0	6	14
0.6-0.8	0	21	52	5	28	6
0.4-0.6	7	46	71	8	26	16
0.2-0.4	48	170	159	28	55	59
0-0.2	313	119	60	102	23	35
Total Number of Farmers	368	368	368	145	145	145
Minimum	0.02	0.13	0.12	0.03	0.17	0.12
Maximum	0.47	1.00	1.00	1.00	1.00	1.00
Mean	0.12	0.31	0.41	0.19	0.44	0.42
SD	0.09	0.18	0.22	0.19	0.24	0.29

Source: Authors' computation

where the scope for improvement is 65% by adopting more effective agricultural management practices. Finally, the scale efficiency measure shows that among 513 paddy cultivators, 24 have scale efficiency values equal to 1, indicating that they are at optimal scale production. Less than optimal scale efficiency happens due to the presence of increasing and decreasing returns to scale. 470 cultivators out of 489 were found to be increasing returns to scale, which indicates that the farm is producing at the sub-optimum scale size or has the advantage of economies of scale. The remaining 19 farmers are at the diseconomies of scale or producing at the above optimum scale.

Further, we classify the efficiency scores under irrigated and rain-fed paddy cultivation. Based on the overall technical efficiency scores, 10% of the farmers had efficiency scores of more than 0.4 in the case of irrigated paddy cultivation and only 2% in rain-fed cultivation. The mean efficiency scores of the rain-fed and irrigated farms were 0.12 and 0.19, respectively. It indicates that the farm input utilization under irrigated cultivation system is more efficient. Further, under the assumption of VRS, the mean pure technical efficiency was 0.31 for rain-fed paddy cultivation and 0.44 for irrigated cultivation. Technical efficiency results suggest that the irrigated paddy cultivators are able to

achieve higher overall efficiency than the rain-fed paddy cultivators by employing better farm management practices and exploiting the scale of operations more optimally. Overall, by comparing the two sources of overall efficiency, it is found that there is comparatively higher dispersion in the scale efficiency among the paddy cultivators.

The standard deviation for SE is higher than the same for pure TE, indicating a higher level of heterogeneity in the scale of farming among the smallholders. The heterogeneity in efficiency score is higher for the irrigated farmers compared to the rain-fed farmers, which is evident since irrigated farmers use different sources of irrigation, and the intensity of irrigation is also different among them, leading to varied efficiency outcomes. The pure technical efficiency arising from farm management efficiency is also quite heterogeneous among the irrigated paddy cultivators. Land quality heterogeneity is another source of heterogeneity that might cause large deviations in efficiency scores among farmers. Although variations in soil quality and the slope of the farmer land plots can lead to diverse efficiency outcomes, we did not account for this source of heterogeneity in our study. This decision was made because the study region is predominantly semi-mountainous, and we assumed there would be no significant heterogeneity in soil type.

Table 6
Results from Tobit and Beta fit regression models estimating the determinants of efficiency.

Variables	Tobit Regression results				Betafit Regression			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Farm size	-4.07*** (0.00)	-4.56*** (0.00)	-4.59*** (0.00)	-3.93*** (0.00)	-0.26*** (0.00)	-0.29*** (0.00)	-0.029*** (0.00)	-0.32*** (0.00)
Age of the HH	-0.49 (0.33)	-0.059 (0.397)	-0.02 (0.77)	-0.13 (0.03)	-0.003 (0.221)	-0.002 (0.494)	-0.001 (0.91)	-0.01* (0.08)
Education of the HH	-0.19 (0.18)	-0.15 (0.28)	-0.14 (0.35)	-0.30 (0.02)	-0.008 (0.35)	-0.005 (0.54)	-0.01 (0.557)	-0.02** (0.04)
Smoking & Drinking ^{a,b}	-3.58*** (0.002)	-3.00*** (0.007)	-2.76*** (0.001)	0.07 (0.27)	-0.17*** (0.008)	-0.15*** (0.001)	-0.14*** (0.04)	-0.9*** (0.01)
Farming experience of HH	-	0.025 (0.73)	-0.03 (0.008)	0.07 (0.27)	-	-0.00003 (0.99)	-0.004 (0.44)	0.004 (0.43)
External seed source ^{a,c}	-	0.23 (0.83)	-0.15 (0.89)	0.47 (0.61)	-	0.40 (0.54)	0.002 (0.78)	0.06 (0.37)
Irrigation ^{a,d}	-	6.51*** (0.00)	-	-	-	0.28*** (0.00)	-	-
Surface irrigation ^{a,e}	-	-	7.91*** (0.00)	-	-	-	0.36*** (0.00)	-
Groundwater Irrigation ^{a,f}	-	-	-	2.28 (0.16)	-	-	-	0.08 (0.47)
Intercept	21.24*** (0.00)	18.72*** (0.00)	18.98*** (0.00)	20.13*** (0.00)	-1.36*** (0.00)	-1.56*** (0.00)	-1.57 (0.00)	-
Number of observations	513	513	477	404	513	513	477	404
LR chi ²	37.34	67.41	39.87	46.70	32.40	50.36	53.11	42.14

Note: Standard errors are shown in parentheses. Statistical significance is denoted by *** at the 1% level, ** at the 5% level, and * at the 10%. ^a dummy variable; ^bbase category is do not smoke and drink; ^c own stored seed used; ^d base category: do not use irrigation, ^e base category: other than surface irrigation; ^f base category: other than groundwater irrigation

4.2. Determinants of technical efficiency

Table 6 provides the Tobit and Betafit regression results using the efficiency scores as the dependent variable. The exogenous variables used in the study are socio-demographic characteristics of the households, access to irrigation, farming experience, and farm size. The coefficient of exogenous variables that are significant shows the same sign across all the models, suggesting consistency in the results. We estimate four models to establish the relationship between efficiency scores and various exogenous variables. In the first model, we include variables such as farm size, age of household head, education, and habits of alcohol consumption and smoking. Alcohol consumption and smoking are psychoactive substances that influence individual decision-making and work performance (Hashemi et al., 2022). Past studies clearly indicate that farmers consuming alcohol had higher debts, lower access to credit, emotional issues, and could not manage their finances productively (Nagtham et al., 2011; Alves et al., 2021). Furthermore, past research has also indicated that individuals exhibiting higher levels of alcohol consumption tend to be impatient with high future discount rates (Story et al., 2014). Based on the current study's perspective, a farmer consuming any psychoactive substance would have lower productivity at work and allocate less capital investments in agriculture management practices.

The second model includes agricultural adaptation strategies (seed sources, farming experience, and access to irrigation). Finally, in the third and fourth models, surface water irrigation and groundwater irrigation variables are included, respectively, to assess how these sources of irrigation affect technical efficiency. Model 3 focuses on surface irrigation (canal irrigation), while Model 4 examines the effect of groundwater irrigation (sprinkler and drip irrigation combined). In Model 3, we construct a dichotomous variable for surface irrigation, where if the farmer used surface irrigation, then a value of 1 is assigned, while the farmers with rain-fed cultivation are assigned a value of 0. In Model 4, we construct a dichotomous variable for groundwater irrigation, where farmers using either drip or sprinkler are assigned a value of 1, and the farmers without any irrigation are assigned a value of 0. Using different sample sizes, these models enable us to analyze the influence of groundwater irrigation on technical efficiency.

The Tobit and the Betafit regression models show that the area under cultivation negatively impacts the efficiency scores. This indicates that farmers cultivating paddy in small plots are more efficient. Smaller farms tend to have a higher labor-to-land ratio and easily allocate more labor per unit of land. This allows for better management and utilization of resources, leading to increased efficiency in farming operations. Smaller farms also tend to have a closer connection between the farmer and the land, resulting in more personalized attention and care for the crops or livestock. Farmers holding larger areas require higher capital to purchase machinery, seeds, fertilizer, and other modern mechanism. To explain the relationship between plot size and farm efficiency further, we plotted farm efficiency in three types of plot sizes: less than 0.8 ha (small farmers), between 0.8 ha and 2 ha (medium farmers), and above 2 ha (large farmers). Fig. 4 shows that the farm efficiency is highest among medium farmers, i.e., plot sizes between 0.8 ha and 2 ha, and lowest among large farmers, i.e., plots above 2 ha. There is also past evidence of lower input usage in India compared to other industrialized countries (Omara et al., 2019). Therefore, applying appropriate inputs for more efficient production is a scope for expansion.

The demographic factors, such as the household head's age and education level, are statistically insignificant because the average education status among the sampled households is 3.6, indicating a low level of literacy among all the farmers. We hypothesize that if a farmer consumes alcohol and tobacco, that would negatively affect his/her farm efficiency, and most farmers in this region consume locally bred alcohol and tobacco-related products. The estimated coefficient of this dummy variable is negative and statistically significant, confirming our hypothesis that consumption of alcohol or tobacco-related products leads

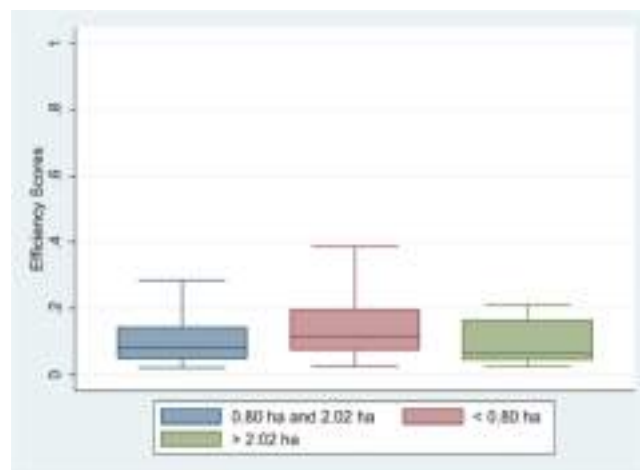


Fig. 4. Box plot of farm efficiency scores based on the farmers' land holding.

to lower crop productivity. Further, the study includes adaptation-related variables, like farming experiences, to measure their relationship with the efficiency scores. However, it is statistically insignificant, indicating that there is no variation and all farmers are affected equally by the uncertainty in the climate change events that have created significant risks for them. Farmers may purchase seeds from multiple sources, such as government agencies, seed dealers, neighbors, and their saved seeds from the last harvest. In our model, we use the dummy variable (1 = if the seed is purchased from the government or seed dealer and 0 if the farmers used their own stored seed), and the result is also statistically insignificant.

The coefficient of irrigation, which is the primary variable of interest in this study, is positive and statistically significant. The results illustrate a positive relationship between irrigation and crop productivity. Accordingly, the results indicate that the rain-fed paddy cultivation system significantly increases crop inefficiency. To explore the importance of different sources of irrigation, surface irrigation, and groundwater irrigation were used to establish the association with efficiency scores in models 3 and 4. Surface (canal) irrigation shows a positive association with paddy cultivation. An increase in access to surface irrigation can significantly improve paddy productivity. Groundwater (drip and sprinkler) also shows a positive association with efficiency scores, but the coefficient remains statistically insignificant. The possible reason for this insignificant result could be due to the lower representation of sprinkler and drip irrigation users in the sample.

We classify the irrigated cultivators by the sources of irrigation and explore their respective efficiency scores (see Table 7). The paddy cultivators adopted three sources of irrigation: canal, sprinkler, and drip

Table 7
Source of irrigation and other characteristics by types of irrigation methods.

Variables	Canal	Sprinkler	Drip
Nos of HH with efficiency scores ($\geq 60\%$)	6	-	2
Nos of HH with efficiency Scores ($\geq 40\%$ & $< 60\%$)	7	-	-
Nos of HH with efficiency scores ($< 40\%$)	96	12	22
Total #no of paddy cultivators	109	12	24
Yield (tonnes per ha)	3.02	3.13	2.93
Farm size (ha)	0.83	0.83	0.69
Labor (person-days)	102	62.00	82
Fertilizer (NPK) (kgs per ha)	270	185.63	250
Compost kgs per ha	1084	389.25	521
Age of the HH in year	43.39	42.17	41.92
Education of the HH in years	3.8	2.58	3.38
If member smoke & drink (=1)	0.34	0.21	0.21
Farming experience of HH (in years)	22.47	23.58	22.96

Source: Authors' computation

irrigation. Out of 145 irrigated paddy cultivators, 109 (75%) of the farmers adopted canal irrigation, 24 (16.5%) adopted drip irrigation, and 12 (8.5%) had sprinkler irrigation. Canal irrigation was found to be more efficient compared to sprinkler and drip irrigation. The most efficient paddy farms with an efficiency score of 1 under constant returns to scale belonged to canal irrigation. Out of 145 sampled households with irrigation, 8 had an efficiency score of more than 60% (6 from canal irrigation and 2 from drip irrigation). Canal irrigation systems are large-scale projects mainly developed by the government in which farmers contribute very little to the infrastructural and operational costs. Farmers must usually extend the irrigation lines to their plots using their resources. On the other hand, micro-irrigation practices such as drip and sprinkler irrigation require the farmers to bear the entire cost. In India, the efficiency of the conventional surface irrigation practices at the field is only about 35–50%, and particularly in the areas of eastern India, the overall irrigation efficiency is even less, i.e., ranging from 20% to 35% (Srivastava, and Shah et al., 2010, 2011). The estimated conveyance loss in canal irrigation is nearly 45%, resulting in a considerable gap between irrigation projects' actual and potential benefits. Drip irrigation helps save electricity, utilizes water more efficiently, and improves aerobic rice production by 29% over surface irrigation (Parthasarathi et al., 2018). Fertigation using subsurface drip irrigation saved 20% of N fertilizer compared to flood irrigation in rice-wheat systems (Sidhu et al., 2019). Sprinkler irrigation systems provide more uniform water distribution in the field. However, due to the small sample of paddy cultivators under drip and sprinkler irrigation, this study could not measure a clear outcome. The efficiency of the farms also depends on other farm-specific and demographic factors. There was a significant difference in the other input choices – labor, fertilizer, and compost. The major inputs, i.e., labor and fertilizer, were high among the paddy cultivators in the canal irrigation compared to the sprinkler and drip irrigation. The reason might be that canal irrigation usually relies on a continuous flow of water, leading to the leaching of nutrients and an increased need for input application to compensate for losses.

4.3. Impact of irrigation on technical efficiency

In the final stage of the empirical analysis, the precise impact of irrigation on farm efficiency is measured through the endogenous switching regression (ESR) which is detailed in Section 2.4. The farm efficiency which is used as the outcome variable in the ESR is the technical efficiency scores of each farmer estimated in the DEA analysis. We used the TE score in the ESR to examine whether irrigation can complement and ameliorate the input-output combination of rice farming. In addition, we also used productivity (crop yield) as the dependent variable to measure the average treatment effect of irrigation. As discussed in the earlier section, endogenous switching regression is a two-stage process. First, we model the determinants of the adoption of irrigation among the farmers. In the second stage, we model the effect of irrigation on the efficiency scores of the two regimes, i.e., irrigated and rainfed systems.

Table 8 presents the first step probit results of determinants of the adoption of irrigation, based on the efficiency scores. The Wald chi-square test statistic (20.23) indicates that the explanatory variables are jointly statistically significant ($p < 0.1$). Farmers with large agricultural land holdings are more likely to adopt irrigation. Interestingly, we also found that the farmers employing self-saved seeds had a higher probability of investing in the irrigation infrastructure. Farmers with the habit of smoking or drinking are less likely to adopt irrigation facilities. The coefficient of the distance to the seed/fertilizer market was statistically significant and negative, indicating that the larger the distance to the inputs market less likely the farmers would adopt irrigation for agriculture. Age, experience in farming activities, and education level of household heads did not significantly influence the decision to adopt irrigation. This probit model is the selection equation stage of the ESR,

Table 8

Probit model results to estimate the determinants of adoption of irrigation.

Variable	Coefficient
Farming experience of HH in years	0.0037 (0.66)
Smoking or Drinking ^{a,b}	-0.34*** (0.008)
Education (years of schooling of HH)	-0.02 (0.25)
Age of HH (in years)	-0.01 (0.5)
Farm size (in ha)	0.23*** (0.01)
If the seed is sourced from external sources ^{a,c}	0.22** (0.05)
Distance to seed/fertilizer market (in Km)	-0.02*** (0.01)
Constant	-0.68* (0.10)
Log likelihood	-295
Wald chi-square	20.23
Prob > chi-square	0.005

Note: Standard errors are shown in parentheses. Statistical significance is denoted by *** at the 1% level, ** at the 5% level, and * at the 10%. ^a dummy variable, ^bbase category: HH member does not smoke or drink; ^cbase category: use own seed

which is not meant to explain the dynamics of the adoption of irrigation among farmers but rather to account for the unobserved heterogeneity that could bias the impacts derived from the outcome equations. To account for any unobserved heterogeneity, we included an instrument (the average distance from households to the fertilizer/seed market) in the selection equation which is excluded from the outcome equations. This is known as the exclusion restriction in ESR. The results of the outcome equation are presented in Table A1 in Appendix.

Table 9 presents the estimated mean treatment effect (ATT) of adopting irrigation on paddy farming efficiency. The results show that the causal impact of irrigation adoption is about 6.5%, meaning that if the irrigated farmers had not adopted irrigation infrastructure, their farm efficiency would have decreased by 6.5%. Similarly, the average treatment effect on untreated (ATU) farmers is found to be 6.4%, which means that if the non-adopters had decided to adopt the irrigation infrastructure, their paddy cultivation efficiency could have increased by 6.4%. Further, the productivity model using the crop yield as the outcome variable is estimated, and the first-stage and second-stage regression results are presented in the Appendix as Tables A2 and A3, respectively. The ATT and ATU results of this model are given in A4. The covariates from the first stage probit productivity model also exhibited similar results to the efficiency model. Correspondingly, the average treatment effect also suggested that the farmers with irrigation access are better off than their counterfactual non-irrigation farmers. Similarly, the farmers without any irrigation would have benefitted in terms of productivity had they obtained access to irrigation.

5. Conclusion

Global agriculture faces multiple challenges to meet the growing population's demand with ongoing climate change and resource

Table 9

Average Treatment Effect on Treated (Endogenous Switching Regression).

	To adopt	Not to adopt	Average Treatment Effect
Irrigated Farm	A: 0.186 (0.004)	C: 0.120 (0.002)	0.065***
Non-Irrigated Farm	D: 0.188 (0.002)	B: 0.123 (0.001)	0.064***

Note: Standard errors are shown in parentheses. Statistical significance at the 1% level is denoted by ***.

depletion, where the imperative for enhancing agricultural efficiency through strategic input allocation becomes evident. This study focuses on paddy cultivation in semi-mountainous lands of eastern India by employing an output-oriented DEA model to examine three critical dimensions: efficiency analysis, efficiency determinants, and irrigation's impact on efficiency. The study finds that irrigated paddy cultivators outperform their rain-fed counterparts, and factors such as farm size and farmers' habits of consuming psychoactive substances exhibit a negative relationship with technical efficiency, but surface irrigation shows a positive association. Additionally, the determinants influencing farmers' adoption of irrigation practices include external seed sourcing and proximity to extension services, indicating potential avenues for targeted interventions. The study also shows the pivotal role of irrigation, such that farms under irrigated cultivation, mainly through canal irrigation, manifest superior efficiency, followed by drip and sprinkler methods. This revelation prompts a call for specific policies tailored to the region's challenging geographical terrains, emphasizing optimal resource utilization to bolster farm efficiency. Expansion of irrigation systems in upland altitude regions, characterized by scanty rainfall and limited access to surface water, emerges as a potential strategy to address lower efficiency among tribal farmers. The study advocates a dual-focused approach, striving to enhance farm efficiency and reduce water consumption, and necessitates further research on different irrigation practices and farmers' adoption mechanisms, alongside exploring advanced irrigation techniques to mitigate losses due to evaporation, run-off, and deep percolation. We acknowledge the limitation that this study is primarily centered on efficiency analysis, determinants, and the impact of irrigation. Future research endeavors could shift the focus towards exploring government subsidy and intervention programs. However, our study emphasizes the importance of tailoring specific policies to address challenges arising from geographical disparities and optimize resource usage in the studied region. Overall, we propose a nuanced policy framework aligned with the unique needs of the tribal region in eastern India. This framework advocates interventions such as subsidizing essential farm inputs, imparting training on modern farming practices, and fostering awareness about optimal input utilization. This

targeted approach aims to enhance yield and efficiency in paddy cultivation, emphasizing sustainable and region specific agricultural development.

CRedit authorship contribution statement

Jena Pradyot Ranjan: Project design, conceptualization, methodology, data curation and management, validation, writing - original draft, review & editing. **Kalli Rajesh:** Conceptualization, methodology, data curation and management, analysis, validation, writing - original draft, review & editing. **Timilsina Raja Rajendra:** Project design, conceptualization, methodology, data curation and management, validation, writing - original draft, review & editing. **Rahut Dil Bahadur:** Project design, conceptualization, methodology, data curation and management, validation, review & editing, and supervision. **Tetsushi Sonobe:** Project Design, Conceptualization, methodology, validation, review & editing, and supervision.

Declaration of Competing Interest

I, the corresponding author, on behalf of all the co-authors, state that we have no conflict of interest while preparing this manuscript.

Data availability

Data will be made available on request.

Acknowledgements

The authors express their gratitude to the editor and two anonymous referees for meticulous feedback and valuable suggestions. This is a part of the Asian Development Bank Institute (ADBI) project on soil health (R2139-1, R2215, R2303). The views expressed here are those of the authors and do not necessarily reflect those of the authors' institutions, and the usual disclaimer applies. Finally, we thank the Asian Development Bank Institute and National Institute of Technology Karnataka.

Appendix

Table A1

The second stage determinants of efficiency scores.

Variable	Irrigated	Non-Irrigated
Farming experience (in years)	0.0009 (0.003)	-0.00005 (0.001)
If HH member smoke or drink	-0.065 (0.051)	-0.021* (0.013)
Education in years	0.00022 (0.005)	-0.0026*** (0.001)
Age in years	-0.00013 (0.002)	-0.0007 (0.001)
Farm size (ha)	-0.052 (0.036)	-0.035*** (0.009)
If seed is sourced from external source (=1)	0.016 (0.047)	0.0024 (0.010)
Constant	0.15 (0.29)	0.2*** (0.038)
ρ_1	0.036 (0.18)	
ρ_0		0.017** (0.05)
N	145	368

Note: Standard errors are shown in parentheses. Statistical significance is denoted by *** at the 1% level, ** at the 5% level, and * at the 10%.

Table A2
Probit model results for the productivity (yield) model.

Variable	Coefficient
Farming experience of HH in years	0.004 (0.67)
If member smoke or drink	-0.34*** (0.01)
Education in years	-0.02 (0.25)
Age of HH	-0.01 (0.50)
Farm size (ha)	0.23*** (0.02)
If seed is purchased from external source (=1)	0.22** (0.06)
Distance to seed/fertilizer market (km)	-0.02*** (0.01)
Constant	-0.68* (0.10)
Log likelihood	-295.9
Wald chi-square	20.23
Prob > chi-square	0.005

Note: Standard errors are shown in parentheses. Statistical significance is denoted by *** at the 1% level, ** at the 5% level, and * at the 10%.

Table A3
The second stage determinants of productivity (yield) model.

Variable	Irrigated	Non-Irrigated
Farming experience in years	0.03 (0.16)	-0.0005 (0.97)
If member smoke or drink (=1)	0.57 (0.21)	0.16 (0.44)
Education (schooling in years)	-0.03 (0.47)	0.002 (0.92)
Age of HH in years	-0.01 (0.52)	0.01 (0.65)
Farm size (ha)	0.29 (0.39)	0.25 (0.13)
If the seed is purchased from external source (=1)	-0.12 (0.74)	-0.34** (0.03)
Constant	2.11 (0.36)	3.26*** (0.00)
ρ_1	0.67 (0.64)	
ρ_0		0.25 (0.80)
N	145	368

Note: Standard errors are shown in parentheses. Statistical significance is denoted by *** at the 1% level, ** at the 5% level, and * at the 10%.

Table A4
Average Treatment Effect on Treated model for productivity (yield) model.

	To adopt	Not to adopt	Average Treatment Effect
Irrigated Farm	A: 3.01 (0.03)	C: 2.83 (0.02)	0.18***
Non-Irrigated Farm	D: 3.08 (0.02)	B: 2.85 (0.01)	0.23***

Note: Standard errors are shown in parentheses. Statistical significance at the 1% level is denoted by ***

References

- Abdallah, A.-H., 2016. Agricultural credit and technical efficiency in Ghana: is there a nexus? *Agric. Financ. Rev.* 76, 309–324.
- Aeschbach-Hertig, W., Gleeson, T., 2012. Regional strategies for the accelerating global problem of groundwater depletion. *Nat. Geosci.*
- Alene, A., 2010. Productivity growth and the effects of Rand D in African agriculture. *Agric. Econ.* 41, 223–238.
- Alves, R.M., Santos, E.G.D.O., Barbosa, I.R., 2021. Abuse of alcohol among farmers: prevalence and associated factors. *PLoS One* 16, e0254904.
- Arunrat, N., Sereenonchai, S., Chaowiwat, W., Wang, C., 2022. Climate change impact on major crop yield and water footprint under CMIP6 climate projections in repeated drought and flood areas in Thailand. *Sci. Total Environ.* 807, 150741.
- Asante, B.O., Wiredu, A.N., Martey, E., Sarpong, D.B., Mensah-Bonsu, A., 2014. NERICA adoption and impacts on technical efficiency of rice producing households in Ghana: implications for research and development. *J. Exp. Agric. Int.* 244–262.
- Balde, B., Kobayashi, H., Nohmi, M., Ishida, A., Esham, M., Tolno, E., 2014. An analysis of technical efficiency of mangrove rice production in the Guinean coastal area. *J. Agric. Sci.* 6.
- Bandyopadhyay, K.K., Misra, A.K., Ghosh, P.K., Hati, K.M., Mandal, K.G., Moahnty, M., 2009. Effect of irrigation and nitrogen application methods on input use efficiency of wheat under limited water supply in a Vertisol of Central India. *Irrig. Sci.* 28, 285–299.
- Banker, R.D., Natarajan, R., 2008. Evaluating contextual variables affecting productivity using data envelopment analysis. *Oper. Res.* 56, 48–58.
- Battese, G.E., Coelli, T.J., 1992. Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India. *J. Product. Anal.* 3, 153–169.
- Beauchamp, J.P., Cesarini, D., Johannesson, M., 2017. The psychometric and empirical properties of measures of risk preferences. *J. Risk Uncertain.* 54, 203–237.
- Birthal, P.S., Hazrana, J., Negi, D.S., Pandey, G., 2021. Benefits of irrigation against heat stress in agriculture: evidence from wheat crop in India. *Agric. Water Manag.* 255, 106950.
- Bravo-Ureta, B.E., Higgins, D., Arslan, A., 2020. Irrigation infrastructure and farm productivity in the Philippines: a stochastic Meta-Frontier analysis. *World Dev.* 135, 105073.
- Calow, R.C., Howarth, S.E., Wang, J., 2009. Irrigation development and water rights reform in China. *Int. J. Water Resour. Dev.* 25, 227–248.
- Çetin, O., Kara, A., 2019. Assessment of water productivity using different drip irrigation systems for cotton. *Agric. Water Manag.* 223, 105693.

- Charnes, A., Cooper, W.W., Rhodes, E., 1978. Measuring the efficiency of decision making units. *Eur. J. Oper. Res.* 2, 429–444.
- Chaudhan, N.S., Mohapatra, P.K.J., Pandey, K.P., 2006. Improving energy productivity in paddy production through benchmarking: an application of data envelopment analysis. *Energy Convers. Manag.* 47, 1063–1085.
- Chavas, J.-P., Petrie, R., Roth, M., 2005. Farm household production efficiency: evidence from the Gambia. *Am. J. Agric. Econ.* 87, 160–179.
- Chen, L., Chang, J., Wang, Y., Guo, A., Liu, Y., Wang, Q., Zhu, Y., Zhang, Y., Xie, Z., 2021. Disclosing the future food security risk of China based on crop production and water scarcity under diverse socio-economic and climate scenarios. *Sci. Total Environ.* 790, 148110.
- Chiteji, Ngina, 2010. Time preference, noncognitive skills and well being across the life course: do noncognitive skills encourage healthy behavior? *Am. Econ. Rev.* 100, 200–204.
- Cobanoglu, F., 2013. Measuring the technical efficiency of cotton farms in Turkey using stochastic frontier and data envelopment analysis. *Outlook Agric.* 42, 125–131.
- Cobb-Clark, D.A., Kassenboehmer, S.C., Schurer, S., 2014. Healthy habits: the connection between diet, exercise, and locus of control. *J. Econ. Behav. Organ.* 98, 1–28.
- Comas, L.H., Trout, T.J., DeJonge, K.C., Zhang, H., Gleason, S.M., 2019. Water productivity under strategic growth stage-based deficit irrigation in maize. *Agric. Water Manag.* 212, 433–440.
- DES. (2022). Directorate of Economics and Statistics. Ministry of Agriculture and Farmers Welfare. Government of India. (https://eands.dacnet.nic.in/Cost_of_Cultivation.htm).
- Dhaliwal, Kahlon, M.S., Kukal, S.S., 2022. Deep tillage and irrigation impact on soil water balance and water productivity of maize-wheat cropping system in north-west India. *Arch. Agron. Soil Sci.* 68, 166–179.
- Dhungana, B.R., Nuthall, P.L., Nartea, G.V., 2004. Measuring the economic inefficiency of Nepalese rice farms using data envelopment analysis. *Aust. J. Agric. Resour. Econ.* 48, 347–369.
- Dinar, A., Tieu, A., Huynh, H., 2019. Water scarcity impacts on global food production. *Glob. Food Secur.* 23, 212–226.
- Duinen, R., Filatova, T., Geurts, P., Veen, A., 2014. Coping with drought risk: empirical analysis of farmers' drought adaptation in the south-west Netherlands. *Reg. Environ. Change* 15, 1081–1093.
- Ferrari, S., Cribari-Neto, F., 2004. Beta regression for modelling rates and proportions. *J. Appl. Stat.* 31, 799–815.
- González, M.A., Lopez, R.A., 2007. Political violence and farm household efficiency in Colombia. *Econ. Dev. Cult. Change* 55, 367–392.
- Hanjra, M.A., Qureshi, M.E., 2010. Global water crisis and future food security in an era of climate change. *Food Policy* 35, 365–377.
- Hashemi, N.S., Skogen, J.C., Sevic, A., Thørrisen, M.M., Rimstad, S.L., Sagvaag, H., Ripper, H., Aas, R.W., 2022. A systematic review and meta-analysis uncovering the relationship between alcohol consumption and sickness absence. When type of design, data, and sickness absence make a difference. *PLOS ONE* 17, e0262458.
- Hernuryadin, Y., Kotani, K., Saijo, T., 2020. Time preferences of food producers: does “Cultivate and Grow” matter? *Land Econ.* 96, 132–148.
- Houshyar, E., Chen, B., Chen, G.Q., 2019. Environmental impacts of rice production analyzed via social capital development: an Iranian case study with a life cycle assessment/data envelopment analysis approach. *Ecol. Indic.* 105, 675–687.
- Jain, M., Naeem, S., Orlove, B., Modi, V., DeFries, R.S., 2015. Understanding the causes and consequences of differential decision-making in adaptation research: adapting to a delayed monsoon onset in Gujarat, India. *Glob. Environ. Change* 31, 98–109.
- Jain, M., Fishman, R., Mondal, P., Galford, G.L., Bhattarai, N., Naeem, S., Lall, U., Singh, Balwinder, DeFries, R.S., 2021. Groundwater depletion will reduce cropping intensity in India. *Sci. Adv.* 7, eabd2849.
- Jing, Q., McConkey, B., Qian, B., Smith, W., Grant, B., Shang, J., Liu, J., Bindraban, P., Luce St., M., 2021. Assessing water management effects on spring wheat yield in the Canadian Prairies using DSSAT wheat models. *Agric. Water Manag.* 244, 106591.
- Kea, S., Li, H., Pich, L. (2016). An Analysis of Technical Efficiency for Household's Rice Production in Cambodia: A Case Study of Three Districts in Battambang Province (No. 2016100135). Preprints. (<https://www.preprints.org/manuscript/201610.0135/v1>).
- Khosla, S., Jena, P.R., 2020. Switch in livelihood strategies and social capital have a role to play in deciding rural poverty dynamics: evidence from panel data analysis from Eastern India. *J. Asian Afr. Stud.* 55, 76–94.
- Kirpich, P.Z., Haman, D.Z., Styles, S.W., 1999. Problems of irrigation in developing countries. *J. Irrig. Drain. Eng.* 125, 1–6.
- Kumar, S., Gulati, R. (2008). An Examination of Technical, Pure Technical, and Scale Efficiencies in Indian Public Sector Banks using Data Envelopment Analysis. *Eurasian Journal of Business and Economics*.
- Kumar, S., Managi, S., 2010. Service quality and performance measurement: evidence from the Indian water sector. *Int. J. Water Resour. Dev.* 26, 173–191.
- Kuwayama, Y., Thompson, A., Bernknopf, R., Zaitchik, B., Vail, P., 2018. Estimating the impact of drought on agriculture using the U.S. drought monitor. *Am. J. Agric. Econ.* 101, 193–210.
- Lee, C.-C., 2009. Analysis of overall technical efficiency, pure technical efficiency and scale efficiency in the medium-sized audit firms. *Expert Syst. Appl.* 36, 11156–11171.
- Li, C., Jiang, T., Luan, X., Yin, Y., Wu, P., Wang, Y., Sun, S., 2021. Determinants of agricultural water demand in China. *J. Clean. Prod.* 288, 125508.
- Liu, X., Kong, M., Tong, D., Zeng, X., Lai, Y., 2022. Property rights and adjustment for sustainable development during post-productivist transitions in China. *Land Use Policy* 122, 106379.
- Liu, X., Li, Z., Fu, X., Yin, Z., Liu, M., Yin, L., Zheng, W., 2023. Monitoring house vacancy dynamics in the Pearl River Delta region: a method based on NPP-VIIRS night-time light remote sensing images. *Land* 12, 12.
- Masuda, K., 2018. Energy efficiency of intensive rice production in Japan: an application of data envelopment analysis. *Sustainability* 10, 120.
- Masuda, K., 2019. Eco-efficiency assessment of intensive rice production in Japan: joint application of life cycle assessment and data envelopment analysis. *Sustainability* 11, 5368.
- Medellin-Azuara, J., Howitt, R., Harou, J., 2012. Predicting farmer responses to water pricing, rationing and subsidies assuming profit maximizing investment in irrigation technology. *Agric. Water Manag.* 108, 73–82.
- Mishra, V., Asoka, A., Vatta, K., Lall, U., 2018. Groundwater depletion and associated CO₂ emissions in India. *Earth's Future* 6, 1672–1681.
- Mitter, H., Schmid, E., 2021. Informing groundwater policies in semi-arid agricultural production regions under stochastic climate scenario impacts. *Ecol. Econ.* 180, 106908.
- Nagthan, S., Poddar, R., Kunnal, I.B., Basvaraja, H., Banakar, B. (2011). A probe into socio-economic and psychological profile of farmers' suicide in Karnataka. *Karnataka Journal of Agricultural Sciences*.
- Nandy, A., Singh, P.K., Singh, A.K., 2021. Systematic review and meta-regression analysis of technical efficiency of agricultural production systems. *Glob. Bus. Rev.* 22, 396–421.
- Odeck, J., 2001. Comparison of data envelopment analysis and deterministic parametric frontier approaches: an application in the norwegian road construction sector. *Transp. Plan. Technol.* 24, 111–134.
- Olesen, O.B., Petersen, N.C., 2016. Stochastic data envelopment analysis: a review. *Eur. J. Oper. Res.* 251, 2–21.
- Omara, P., Aulal, L., Oyebiyi, F., Raun, W.R., 2019. World cereal nitrogen use efficiency trends: review and current knowledge. *Agrosyst. Geosci. Environ.* 2, 180045.
- Paltasingh, K.R., Basantary, A.K., Jena, P.K., 2022. Land tenure security and farm efficiency in Indian agriculture: revisiting an old debate. *Land Use Policy* 114, 105955.
- Panigrahy, S., Upadhyay, G., Ray, S.S., Parihar, J.S., 2010. Mapping of cropping system for the Indo-Gangetic Plain using multi-date SPOT NDVI-VGT data. *J. Indian Soc. Remote Sens.* 38, 627–632.
- Parthasarathi, T., Vanitha, K., Mohandass, S., Vered, E., 2018. Evaluation of drip irrigation system for water productivity and yield of rice. *Agron. J.* 110, 2378–2389.
- Pourzand, F., Noy, I., Sağlam, Y., 2020. Droughts and farms' financial performance: a farm-level study in New Zealand. *Aust. J. Agric. Resour. Econ.* 64, 818–844.
- Ray, D.K., Gerber, J.S., MacDonald, G.K., West, P.C., 2015. Climate variation explains a third of global crop yield variability. *Nat. Commun.*
- Rodriguez-Ferrero, N., Salas-Velasco, M., Sánchez-Martínez, M.T., 2010. Assessment of productive efficiency in irrigated areas of Andalusia. *Int. J. Water Resour. Dev.* 26, 365–379.
- Sabbaghi, M.A., Nazari, M., Araghinejad, S., Soufizadeh, S., 2020. Economic impacts of climate change on water resources and agriculture in Zayandehroud river basin in Iran. *Agric. Water Manag.* 241, 106323.
- Sakouovogui, K., 2020. A comparative approach of stochastic frontier analysis and data envelopment analysis estimators: evidence from banking system. *J. Econ. Stud.* 47, 1787–1810.
- Sang, L., Zhu, G., Xu, Y., Sun, Z., Zhang, Z., Tong, H., 2023. Effects of agricultural large- and medium-sized reservoirs on hydrologic processes in the arid Shiyang River Basin, Northwest China. *Water Resour. Res.* 59 (2).
- Scheierling, S.M., Young, R.A., Cardon, G.E., 2006. Public subsidies for water-conserving irrigation investments: hydrologic, agronomic, and economic assessment. *Water Resour. Res.* 42.
- Schewe, J., Heinke, J., Gerten, D., Haddeland, I., Arnell, N.W., Clark, D.B., Dankers, R., Eisner, S., Fekete, B.M., Colón-González, F.J., Gosling, S.N., Kim, H., Liu, X., Masaki, Y., Portmann, F.T., Satoh, Y., Stacke, T., Tang, Q., Wada, Y., Kabat, P., 2013. Multimodel assessment of water scarcity under climate change. *Proc. Natl. Acad. Sci.* 111, 3245–3250.
- Senapati, N., Brown, H.E., Semenov, M.A., 2019. Raising genetic yield potential in high productive countries: Designing wheat ideotypes under climate change. *Agric. For. Meteorol.* 271, 33–45.
- Sengupta, J.K., 1998. Stochastic data envelopment analysis: a new approach. *Appl. Econ. Lett.* 5, 287–90.
- Shah, T. (2011.). Past, Present, and the Future of Canal Irrigation in India (India Infrastructure Report, pp. 70–87) [Report]. Retrieved February 14, 2023, from (<https://studylib.net/doc/18906843/past-present-and-the-future-of-canal-irrigation-in-india>).
- Sharma, K.R., Leung, P., Zaleski, H.M., 1997. Productive efficiency of the swine industry in Hawaii: stochastic frontier vs. data envelopment analysis. *J. Product. Anal.* 8, 447–59.
- Sharma, S., Majumdar, K., 2021. Efficiency of rice production and CO₂ emissions: a study of selected Asian countries using DDF and SBM-DEA. *J. Environ. Plan. Manag.* 64, 2133–2153.
- Sidhu, H.S., Jat, M.L., Singh, Y., Sidhu, R.K., Gupta, N., Singh, P., Singh, P., Jat, H.S., Gerard, B., 2019. Sub-surface drip fertigation with conservation agriculture in a rice-wheat system: a breakthrough for addressing water and nitrogen use efficiency. *Agric. Water Manag.* 216, 273–283.
- Silalertruksa, T., Gheewala, S.H., 2018. Land-water-energy nexus of sugarcane production in Thailand. *J. Clean. Prod.* 182, 521–528.
- Srivastava, R.C., Mohanty, S., Singandhuppe, R.B., Mohanty, R.K., Behera, M.S., Ray, L. I., Sahoo, D., 2010. Feasibility evaluation of pressurized irrigation in canal commands. *Water Resour. Manag.* 24, 3017–3032.

- Story, G.W., Vlaev, I., Seymour, B., Darzi, A., Dolan, R.J., 2014. Does temporal discounting explain unhealthy behavior? A systematic review and reinforcement learning perspective. *Front. Behav. Neurosci.* 8, 76.
- Surendran, U., Raja, P., Jayakumar, M., Subramoniam, S.R., 2021. Use of efficient water saving techniques for production of rice in India under climate change scenario: a critical review. *J. Clean. Prod.* 309, 127272.
- Tran, D.D., Park, E., Tuoi, H.T.N., Thien, N.D., Tu, V.H., Ngoc, P.T.A., Van, C.T., Long, P. K., Ho, H.L., Quang, C.N.X., 2022. Climate change impacts on rice-based livelihood vulnerability in the lower Vietnamese Mekong Delta: empirical evidence from Can Tho City and Tra Vinh Province. *Environ. Technol. Innov.* 28, 102834.
- Tuong, P., Bouman, B., Mortimer, M., 2005. More rice, less water—integrated approaches for increasing water productivity in irrigated rice-based systems in Asia. *Plant Prod. Sci.* 8, 231–241.
- Voroosmarty, C.J., Green, P., Salisbury, J., Lammers, R.B., 2000. Global water resources: vulnerability from climate change and population growth. *Science* 289, 284–288.
- Wadud, A., White, B., 2000. Farm household efficiency in Bangladesh: a comparison of stochastic frontier and DEA methods. *Appl. Econ.* 32, 1665–1673.
- Wang, X., 2010. Irrigation water use efficiency of farmers and its determinants: evidence from a survey in Northwestern China. *Agric. Sci. China* 9, 1326–1337.
- Wang, X., Wang, T., Xu, J., Shen, Z., Yang, Y., Chen, A., Piao, S., 2022. Enhanced habitat loss of the Himalayan endemic flora driven by warming-forced upslope tree expansion. *Nat. Ecol. Evol.* 6 (7), 890–899.
- Ward, F.A., 2010. Financing irrigation water management and infrastructure: a review. *Int. J. Water Resour. Dev.* 26, 321–349.
- Watto, M.A., Muger, A.W., 2014. Measuring production and irrigation efficiencies of rice farms: evidence from the Punjab province, Pakistan. *Asian Econ. J.* 28, 301–322.
- WHO. (2018). The state of food security and nutrition in the world 2018: Building climate resilience for food security and nutrition. Food & Agriculture Organization.
- Zhang, G., Zhao, Z., Yin, X., Zhu, Y., 2021. Impacts of biochars on bacterial community shifts and biodegradation of antibiotics in an agricultural soil during short-term incubation. *Sci. Total Environ.* 771, 144751.
- Zheng, J., Fan, J., Zhang, F., Guo, J., Yan, S., Zhuang, Q., Cui, N., Guo, L., 2021. Interactive effects of mulching practice and nitrogen rate on grain yield, water productivity, fertilizer use efficiency and greenhouse gas emissions of rainfed summer maize in northwest China. *Agric. Water Manag.* 248, 106778.
- Gutiérrez, E., Aguilera, E., Lozano, S., Guzmán, G.I., 2017. A two-stage DEA approach for quantifying and analysing the inefficiency of conventional and organic rain-fed cereals in Spain. *Journal of cleaner productio* 149, 335–348. <https://doi.org/10.1016/j.jclepro.2017.02.104>.
- Banker, R.D., Charnes, A., Cooper, W.W., 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management science* 30 (9), 1078–1092.
- Carracelas, G., Hornbuckle, J., Rosas, J., Roel, A., 2019. Irrigation management strategies to increase water productivity in *Oryza sativa* (rice) in Uruguay. *Agricultural water management* 222, 161–172. <https://doi.org/10.1016/j.agwat.2019.05.049>.
- Abdulai, A., Huffman, W., 2014. The adoption and impact of soil and water conservation technology: An endogenous switching regression application. *Land economics* 90 (1), 26–43.
- Balcombe, K., Fraser, I., Latruffe, L., Rahman, M., Smith, L., 2008. An application of the DEA double bootstrap to examine sources of efficiency in Bangladesh rice farming. *Applied Economics* 40 (15), 1919–1925. <https://doi.org/10.3390/economics4040022>.
- Najafabadi, M.M., Sabouni, M., Azadi, H., Taki, M., 2022. Rice production energy efficiency evaluation in north of Iran; application of Robust Data Envelopment Analysis. *Cleaner Engineering and Technology* 6, 100356. <https://doi.org/10.1016/j.clet.2021.100356>.

Comparative Analysis of Employability Perceptions among MBA and PGDM Students: Factors Influencing Career Readiness and Job Market Preparedness

Dr. Balachandar S¹, Dr. S. Prabakar², Mr. Kiran Kumar B.³, Dr. Dayana Das⁴, Dr. Nila A Chotai⁵, Dhananjai E Rao,⁶

1. Associate Professor, ISBR Business School

2. Associate Professor, Dayanand Sagar University

3. Senior Faculty (L&D), CIR, Amrita Vishwa Vidyapeetham, Amritapuri Campus.

4. Vice-Principal and HOS, Research Head, ASHC, Amrita Vishwa Vidyapeetham, Amritapuri

5. Academic Director, ISBR Business School

6. Assistant professor, ISBR Business School

Abstract:

This study investigates the employability perceptions among Master of Business Administration (MBA) and Post Graduate Diploma in Management (PGDM) students, focusing on factors influencing career readiness and job market preparedness. Drawing on a quantitative approach, data collected through a structured questionnaire are analysed using statistical techniques such as independent sample t-tests and correlation analysis. The findings reveal significant differences in perceptions related to internships' impact on employability, networking activities, satisfaction with institution career services, and the effect of academic success on job confidence between MBA and PGDM students. However, no significant differences are observed in confidence levels regarding securing desired industry jobs, readiness for the job market and honed skills, the impact of a volatile job market on employability, the enhancement of employability through project learning, and advocacy for rigorous career readiness training. These findings underscore the nuanced perspectives of MBA and PGDM students on factors shaping their employability, offering valuable insights for educational interventions and policy development to enhance graduate

Keywords: Employability, Perceptions, Career Readiness, Job Market Preparedness, Training Programs, MBA, PGDM, Independent Sample t-test, Correlation Analysis

Introduction:

Management emerged as a pivotal innovation during the twentieth century, marking a significant shift in the organization of industrial production and distribution. As noted by Chandler (1990), while earlier centuries witnessed remarkable scientific discoveries, their impact on society remained limited until the rise of the modern corporation. This revolution in organizational structure paved the way for the widespread application of scientific advancements, shaping the modern landscape of manufacturing and management as a profession.

However, despite these advancements, employability has remained a pressing concern for management institutes. According to the Merit Trac MBA Employability Study 2011-2012, only one in five MBA graduates were deemed employable. To address this challenge, institutes must establish stronger connections with industry to validate and enhance MBA and PGDM programs. Today, an MBA or PGDM degree has become essential for employment, attracting ambitious students with the promise of opportunities and prestige. (Mavoothu, D., & Ramachandra, P. P. 2006) underscores the importance of business schools in reframing the purpose of firms in society and shaping the role of business leaders. To remain relevant and impactful, business schools must foster healthy companies with a clear societal purpose. The reputation of companies directly impacts the relevance and attractiveness of business schools, affecting their ability to attract top talent and industry partnerships. The employability of management graduates is closely tied to the reputation and quality of the institute they attend. While top-tier institutions enjoy strong placement records, lesser-known colleges must strive to emulate their success by observing and adapting to their practices. In today's dynamic and competitive global economy, the pursuit of employability stands as a critical endeavor for both individuals and institutions. Employability, defined as the possession of skills, knowledge, and attributes that enable individuals to secure and retain meaningful employment, has garnered increasing attention from educators, policymakers, and employers alike (Fugate et al., 2004). As the landscape of work continues to evolve, the ability of graduates to navigate the complexities

of the job market and adapt to changing demands becomes paramount. Against this backdrop, understanding the factors that shape students' perceptions of their employability is essential for informing educational practices and fostering successful transitions into the workforce.

Influence of Training: Training plays a crucial role in enhancing employability by equipping individuals with the necessary skills and knowledge demanded by the job market. As highlighted by Ajit and Deshmukh (2013), effective training programs in institutes help bridge the gap between theoretical learning and practical application, thereby enhancing students' readiness for employment. Practical training modules, such as simulated work environments or real-world projects, provide students with hands-on experience and enable them to develop critical competencies relevant to their chosen fields. Additionally, Gokuladas (2010) emphasizes the importance of both technical and non-technical education in improving the employability of graduates, suggesting that comprehensive training programs encompassing both aspects can better prepare individuals for the workforce. Furthermore, Misra and Mishra (2011) argue that the conceptualization and development of employability skills are intricately linked to effective training methodologies adopted by educational institutions. By integrating industry-relevant training into academic curricula, institutes can foster a culture of lifelong learning and adaptability among students, ensuring their sustained employability in an ever-evolving job market. Therefore, investing in high-quality training programs tailored to meet industry needs is essential for enhancing graduate employability and facilitating successful transitions into the workforce.

Employability in Higher Education: Within the realm of higher education, the cultivation of employability has emerged as a central tenet of academic programs across disciplines. Whether in traditional fields such as business administration or specialized domains like management, the emphasis on equipping students with the requisite skills and competencies for professional success is pervasive (Hillage & Pollard, 1998). Internship experiences, networking opportunities, academic achievements, and institutional support systems all play integral roles in shaping students' perceptions of their readiness for the job market (Chavan, M., & Carter, L. 2018).

Comparative Analysis of Employability Perceptions: While numerous studies have explored employability perceptions within specific academic programs, there remains a dearth of research that directly compares these perceptions across different domains. In particular, the comparison between Master of Business Administration (MBA) and Post Graduate Diploma in Management (PGDM) programs presents a compelling avenue for investigation. Both programs cater to individuals seeking advanced education in management disciplines, yet they often exhibit distinct curricular structures, pedagogical approaches, and institutional affiliations.

Rationale for Comparative Analysis: The rationale for comparing employability perceptions among MBA and PGDM students is multifold. Firstly, such a comparison provides insights into the effectiveness of different educational pathways in preparing students for the workforce. By examining the divergent experiences and outcomes associated with MBA and PGDM programs, educators and policymakers can identify best practices and areas for improvement in career development initiatives. Secondly, understanding the nuances of employability perceptions within specific academic contexts can inform strategic decision-making at both institutional and programmatic levels. Insights gleaned from this comparative analysis can guide curriculum design, pedagogical innovations, and student support services tailored to the needs of each student cohort.

Research Objectives:

Against this backdrop, the primary objective of this research is to conduct a comparative analysis of employability perceptions among MBA and PGDM students. Specifically, the study aims to:

- To explore the factors influencing career readiness and job market preparedness among MBA and PGDM students.
- To identify significant differences in employability perceptions between the two student cohorts.
- To examine the relationship between internship experiences, networking activities, academic performance, and institutional support and their impact on employability perceptions.

Literature Review:

Training Programs and Employability in Higher Education: Training programs offered by educational institutes play a crucial role in shaping students' employability by equipping them with the necessary skills and competencies demanded by the job market. Research by Kumar and Dash (2011) emphasizes the significance of management education in India, highlighting how training programs within institutes contribute to enhancing graduate employability. Similarly, Misra and Mishra (2011) stress the importance of employability skills and underscore the role of training in developing these skills among students. Furthermore, Ajit and Deshmukh (2013) discuss factors impacting employability skills of engineers, emphasizing the need for targeted training initiatives to bridge skill gaps and enhance employability. These studies collectively highlight the pivotal role of training programs within educational institutes in shaping students' readiness for the job market and underscore the importance of aligning curriculum and training initiatives with industry requirements to ensure the employability of graduates.

Historical Context and Global Trends in Business Education: The evolution of graduate business schools, primarily originating in the United States, has been characterized by significant milestones. The introduction of the first MBA program at the Tuck School of Business in 1905 marked the inception of a transformative era in business education (Conn, S. 2019). Over the decades, the demand for business education has surged worldwide, leading to the proliferation of institutions offering management programs. However, the quality and international standards of these programs, particularly in emerging economies like India, remain a subject of scrutiny.

Challenges and Opportunities in Business Education: The expansion of business education presents both challenges and opportunities for institutions. While the demand for business education remains strong, concerns persist regarding the alignment of curriculum and outcomes with industry needs (Connolly, 2003; Mintzberg, 2004). Additionally, the globalization of business education offers opportunities for institutions to differentiate themselves through innovative programs and global collaborations (Mintzberg, 2005).

Human Capital Theory and Graduate Employability: Human capital theory provides a theoretical framework for understanding the relationship between higher education attributes and labor market outcomes. Investment in education and training is posited to yield returns in terms of higher earnings, career progression, and broader labor market opportunities (Tran, 2015; Adrian, 2017). However, the pressure on higher education institutions to produce employable graduates underscores the need to define and enhance graduate employability attributes (Dacre Pool & Sewell, 2007; Dacre Pool, 2016).

Current Perspectives on Employability in Higher Education: The concept of employability has received significant attention in the literature, with scholars emphasizing its multifaceted nature and implications for individuals and societies (Hooley, 2017; Wharton et al., 2014). Employability is viewed as the competencies and abilities that enhance employment opportunities and contribute to economic and social development (Jeswani, 2016; Phago & Thwala, 2015). However, there remains a gap between student expectations and employer perceptions regarding graduate skills and readiness for the labor market (Tymon, 2013; Goodman & Tredway, 2016).

Empirical Studies and Regional Perspectives on Employability: Empirical studies offer insights into the factors influencing graduate employability and the effectiveness of interventions aimed at enhancing it. Researchers have highlighted the role of education in improving employment prospects and addressing skills deficits (Desai & Ramiserry, 2021; Perera, 2020). Regional perspectives, such as those from South Africa and India, shed light on the unique challenges and opportunities in addressing graduate employability issues (Lourens, 2016; Sharma, 2015).

The review of literature highlights the evolving landscape of business education, the importance of graduate employability, and the challenges faced by higher education institutions in preparing students for the labor market. While human capital theory provides a theoretical framework, empirical studies offer practical insights into interventions and strategies to enhance graduate employability. Regional perspectives underscore the contextual nuances and the need for tailored approaches to address employability issues effectively.

Research Methodology:

The research methodology for this study involves a quantitative approach to investigate employability perceptions among MBA and PGDM students. A structured questionnaire administered to collect data on employability perceptions, internship experiences, networking activities, academic achievements, and institutional support. The questionnaire designed based on existing literature and relevant constructs identified in the field of employability. Participants will include MBA and PGDM students selected through convenience sampling.

The collected quantitative data had undergone rigorous statistical analysis to derive meaningful insights. Statistical analyses will include independent sample t-tests to compare mean scores of employability perceptions between MBA and PGDM students. Additionally, correlation analysis will be conducted to explore relationships between different variables related to career readiness and job market preparedness.

In the independent sample t-test, hypotheses formulated to test for significant differences in employability perceptions between MBA and PGDM students. The t-tests conducted using statistical package for social sciences (SPSS) software, with significance levels set at $p < 0.05$. This analysis will provide insights into whether there are significant disparities in employability perceptions between the two groups of students.

Correlation analysis examined the strength and direction of relationships between variables such as internship experiences, networking activities, academic achievements, and employability perceptions. Pearson's correlation coefficient computed depending on the nature of the data. Significance testing performed to determine the statistical significance of observed correlations.

Integration of quantitative findings will provide a comprehensive understanding of graduate employability among MBA and PGDM students. The research outcomes will inform recommendations for educational interventions and policy development aimed at enhancing graduate employability. Ethical considerations, including informed consent and confidentiality, will be strictly adhered to throughout the research process to ensure the integrity and well-being of participants.

Data Analysis:**Pearson's Correlation:**

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Where

X and Y are individual data points for the two variables,

- A coefficient close to +1 indicates a strong positive linear relationship between the two variables.
- A coefficient close to -1 indicates a strong negative linear relationship.
- A coefficient close to 0 indicates no linear relationship between the variables.

Correlation Table

	Confident in securing desired industry job.	Ready for the job market. Skills honed.	Confident about career after program completion.	Internships boosted my employability significantly.	Networking activities enhance my employability greatly.	Satisfied with institution's career services.	Academic success boosts job confidence.	Volatile job market impacts employability.	Project learning enhances my employability.	Advocate for rigorous career readiness training.

Confident in securing desired industry job.	1									
Ready for the job market. Skills honed.	.617**	1								
Confident about career after program completion.	.602**	.461**	1							
Internships boosted my employability significantly.	0.090	.364**	0.189	1						
Networking activities enhance my employability greatly.	0.179	0.148	.342**	.350**	1					
Satisfied with institution's career services.	0.163	.476**	0.158	.462**	0.086	1				
Academic success boosts job confidence.	.278*	.605**	.340**	.526**	.333**	.457**	1			
Volatile job market impacts employability.	.336**	.269*	0.127	0.085	-0.066	0.162	0.135	1		
Project learning enhances my employability.	0.030	0.038	0.059	.296**	.421**	0.162	.349**	0.125	1	
Advocate for rigorous career readiness training	0.081	0.194	0.037	.375**	.323**	0.119	.264*	-0.079	.359**	1

Interpreting the correlations:

- "Advocate for rigorous career readiness training" has a moderate positive correlation with "Confident about career after program completion" (0.375) and "Networking activities enhance my employability greatly" (0.323), indicating that advocating for such training may relate to confidence and networking opportunities.
- The correlation between "Confident in securing desired industry job" and "Ready for the job market. Skills honed" is 0.617, indicating a strong positive relationship.
- Similarly, "Confident in securing desired industry job" and "Confident about career after program completion" have a strong positive correlation of 0.602.
- "Internships boosted my employability significantly" has a moderate positive correlation with "Ready for the job market. Skills honed" (0.364), "Confident about career after program completion" (0.461), and "Satisfied with institution's career services" (0.476).
- "Volatile job market impacts employability" has a moderate positive correlation with "Confident about career after program completion" (0.336) and "Academic success boosts job confidence" (0.269), suggesting that a volatile job market may affect confidence and job readiness.

These correlations provide insights into the relationships between different factors related to career readiness and employability, suggesting areas where efforts may have stronger impacts or where improvements may be necessary.

Independent Sample T Test:

$$t = \frac{X_1 - X_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$$

Using the above formula, we will be able to get the t value. In this formula:

X1, X2 — mean of the samples

S1, S2 — standard deviation of the sample

n — sample size

Then with the degree of freedom (n-1), we can check the T-distribution table to get the P-value.

In the context of determining statistical significance, if the obtained p-value is less than the predetermined significance level (commonly set at 0.05), the null hypothesis is rejected; conversely, if the p-value exceeds 0.05, the null hypothesis is retained.

This approach ensures that the statistical analysis conducted is clearly presented and interpretable within the context of the research study. Additionally, it provides a systematic method for evaluating the significance of observed differences between the sample groups.

S.No	H ₀ (Null Hypothesis)	H ₁ (Alternative Hypothesis)	P - Value	Accept or Reject H ₀
1	There is no significant difference in Confident in securing desired industry job between PGDM and MBA Students	There is significant difference in Confident in securing desired industry job between PGDM and MBA Students	0.185	Accept
2	There is no significant	There is significant difference	0.11	Accept

	difference Ready for the job market. Skills honed between PGDM and MBA Students	Ready for the job market. Skills honed between PGDM and MBA Students		
3	There is no significant difference Confident about career after program completion between PGDM and MBA Students	There is significant difference Confident about career after program completion between PGDM and MBA Students	0.19	Accept
4	There is no significant difference Internships boosted employability significantly between PGDM and MBA Students	There is significant difference Internships boosted employability significantly between PGDM and MBA Students	0.00	Reject
5	There is no significant difference Networking activities enhance employability greatly between PGDM and MBA Students	There is significant difference Networking activities enhance employability greatly between PGDM and MBA Students	0.01	Reject
6	There is no significant difference, Satisfied with institution's career services between PGDM and MBA Students	There is significant difference, Satisfied with institution's career services between PGDM and MBA Students	0.00	Reject
7	There is no significant difference, Academic success boosts job confidence between PGDM and MBA Students	There is significant difference, Academic success boosts job confidence between PGDM and MBA Students	0.01	Reject
8	There is no significant difference, Volatile job market impacts employability between PGDM and MBA Students	There is significant difference, Volatile job market impacts employability between PGDM and MBA Students	0.99	Accept
9	There is no significant difference, Project learning enhances my employability between PGDM and MBA Students	There is significant difference, Project learning enhances my employability between PGDM and MBA Students	0.31	Accept
10	There is no significant difference, Advocate for rigorous career readiness training between PGDM and MBA Students	There is significant difference, Advocate for rigorous career readiness training between PGDM and MBA Students	0.00	Reject

Interpretations:

The independent sample t-test results comparing perceptions between PGDM and MBA students reveal varied findings. While no significant differences were found in the confidence levels regarding securing desired industry jobs ($p = 0.185$), readiness for the job market and honed skills ($p = 0.11$), and confidence about career prospects post-program completion

($p = 0.19$), significant differences emerged in perceptions related to internships' impact on employability ($p = 0.00$), the effectiveness of networking activities in enhancing employability ($p = 0.01$), satisfaction with institution career services ($p = 0.00$), and how academic success boosts job confidence ($p = 0.01$). Conversely, perceptions regarding the impact of a volatile job market on employability ($p = 0.99$), the enhancement of employability through project learning ($p = 0.31$), and the advocacy for rigorous career readiness training ($p = 0.00$) displayed no significant differences. These results provide valuable insights into the distinct perspectives of PGDM and MBA students on various factors influencing their employability, indicating areas of alignment and divergence that may inform targeted interventions to enhance career readiness and job market preparedness among business graduates.

Conclusion:

This comparative analysis of employability perceptions among MBA and PGDM students sheds light on the multifaceted dynamics influencing career readiness and job market preparedness in business education. The findings underscore the importance of understanding the nuanced perspectives of students enrolled in different management programs, highlighting areas of alignment and divergence that warrant attention from educators, policymakers, and industry stakeholders. The significant differences observed in perceptions related to internships, networking activities, satisfaction with institution career services, and the effect of academic success on job confidence signify the diverse experiences and expectations of MBA and PGDM students. These disparities underscore the need for tailored interventions and support mechanisms to address the specific needs of each student cohort, thereby enhancing their employability prospects and facilitating successful transitions into the workforce. Moreover, the inclusion of training programs in career readiness initiatives emerges as a crucial factor influencing employability, with students advocating for rigorous career readiness training exhibiting higher confidence levels and perceiving networking activities as more beneficial. This highlights the pivotal role of structured training in equipping students with the necessary skills and competencies for navigating the complexities of the job market and enhancing their employability. Conversely, the absence of significant differences in certain aspects of employability perceptions across MBA and PGDM programs suggests commonalities that provide opportunities for collaborative initiatives and shared best practices aimed at bolstering overall graduate employability within the business education landscape. Overall, this research contributes to the ongoing discourse on graduate employability in higher education by offering empirical insights into the factors shaping employability perceptions among MBA and PGDM students and informing evidence-based strategies for enhancing graduate employability and fostering professional success in an ever-evolving global economy.

References:

1. Gokuladas, V.K. (2010). 'Technical and non-technical education and the employability of engineering graduates: an Indian case study', *International Journal of Training and Development*, Volume:14, Issue:2, online ISSN: 1360-3736, pp. 130-143.
2. Kumar, S., & Dash, M. K. (2011). *Management Education in India: Trends, Issues and Implications*, *Research Journal of International Studies*, Issue 18, January, pp.15-25.
3. Rothwell, A., Jewell, S., Hardie, M. (2009). Self-perceived employability: Investigating the responses of post-graduate students. *Journal of Vocational Behavior*, 75, 152-161.
4. Wang, Q. and Lowe, J. (2011). Young people's management of the transition from education to employment in the knowledge-based sector in Shanghai. *Journal of Education and Work*, Vol. 24, Nos. 1-2, February-April, Print ISSN: 1363-9080, 119-140.
5. Weligamage, S., and Siengthai, S. (2003). "Employer Needs and Graduate Skills: The Gap between Employer Expectations and Job Expectations of Sri Lankan University Graduates: paper presented at ninth International conference on Sri Lanka Studies, November 28-30.
6. Ying-Ju, P., Lung, L. (2011). Academic Performance and Perceived Employability of Graduate Students in Business and Management - An Analysis of Nationwide Graduate Destination Survey. *Procedia - Social and Behavioral Sciences*, 25, 91-103.
7. Kettunen, J., & Kettunen, T. (2019). Effects of university students' internships on their employability and personal development. *European Journal of Engineering Education*, 44(4), 569-582.
8. Aaron J. McKiml and Jonathan J. Velez (2015). Exploring the Relationship between Self-Efficacy and Career Commitment among Early Career Agriculture Teachers. *Journal of Agricultural Education*. 56(1), 127-140

9. Tandrayen-Ragoobur, Verena & Gokulsing, Deepa. (2021). Gender gap in STEM education and career choices: what matters?. *Journal of Applied Research in Higher Education*. ahead-of-print. 10.1108/JARHE-09-2019-0235.
10. Fugate, M., Kinicki, A. J., & Ashforth, B. E. (2004). Employability: A psycho-social construct, its dimensions, and applications. *Journal of Vocational Behavior*, 65(1), 14-38.
11. Chandler, A. D. Jr. (1990). *Scale and scope: The dynamics of industrial capitalism*. Harvard University Press.
12. Mintzberg, H. (2004). *Managers not MBAs: A hard look at the soft practice of managing and management development*. San Francisco, CA: Berrett-Koehler Publishers.
13. Ivory, G., et al. (2006). Innovations in business education: Challenges and opportunities. *Business Education Quarterly*, 7(2), 127-142.
14. Tran, T. (2015). Human capital theory: An overview of concepts and applications. *Journal of Economic Education*, 46(3), 236-250.
15. Adrian, H. (2017). The role of education in economic development: A comparative analysis. *International Journal of Educational Development*, 54, 78-89.
16. Dacre Pool, L., & Sewell, P. (2007). The key to employability: Developing a careerEDGE model. *Higher Education Research & Development*, 26(2), 147-166.
17. Dacre Pool, L. (2016). Enhancing graduate employability: Best practices and future directions. *Journal of Higher Education Policy and Management*, 38(4), 345-358.
18. Hooley, T. (2017). Understanding graduate employability: A comprehensive review of the literature. *Higher Education Quarterly*, 71(2), 132-157.
19. Wharton, J., et al. (2014). Employability and career readiness: A conceptual framework. *Journal of Career Development*, 41(3), 245-259.
20. Jeswani, S. (2016). Graduate employability in India: Trends, challenges, and opportunities. *Indian Journal of Higher Education*, 62(4), 398-412.
21. Phago, K., & Thwala, S. (2015). Exploring graduate employability: A South African perspective. *South African Journal of Higher Education*, 29(1), 103-118.
22. Tynon, T. (2013). Bridging the gap: A comparative analysis of student and employer perceptions of graduate employability. *Higher Education*, 65(4), 485-502.
23. Goodman, R., & Tredway, M. (2016). From classroom to career: The role of higher education in fostering graduate employability. *Journal of Applied Psychology*, 101(2), 297-310.
24. Mavoothu, D., & Ramachandra, P. P. (2006). *Career advancement of MBAs: a study on the effect of personal, professional, organisational and environmental variables* (Doctoral dissertation, Cochin University of Science and Technology).
25. Hillage, J., & Pollard, E. (1998). *Employability: Developing a framework for policy analysis*. Department for Education and Employment Research Report No. 85.
26. Chavan, M., & Carter, L. (2018). Management students—expectations and perceptions on work readiness. *International Journal of Educational Management*, 32(5), 825-850.
27. Conn, S. (2019). *Nothing succeeds like failure: The sad history of American business schools*. Cornell University Press.
28. Bandara, W., Chand, D., Chircu, A., Hintringer, S., Karagiannis, D., Recker, J., Rensburg, A., Usoff, C. and Welke, R., 2010. Business process management education in academia: Status, challenges, and recommendations. *Communications of the Association for Information Systems*, 27(1), pp.743-776.
29. Ajit, V., & Deshmukh, P. B. (2013). Factors Impacting Employability Skills of Engineers. *International Journal of Science and Research (IJSR)*, 2(4), 30-32.
30. Kumar, S., & Dash, M. K. (2011). *Management Education in India: Trends, Issues and Implications*. *Research Journal of International Studies*, (18), 15-25.
31. Misra, R., & Mishra, P. (2011). Employability Skills: The Conceptual Framework & Scale Development. *The Indian Journal of Industrial Relations*, 46(4), 650-661.
32. Gokuladas, V. K. (2010). Technical and non-technical education and the employability of engineering graduates: An Indian case study. *International Journal of Training and Development*, 14(2), 130-143.

**TAX PLANNING AND TAX AVOIDANCE IN PERMANENT ESTABLISHMENTS
UNDER DIRECT TAX LAWS IN EPC CONTRACTS-CREATING A SUSTAINABLE
FRAMEWORK -A PERSPECTIVE**

Mr. R. Ravichandran

Research Scholar School of Commerce and Management Studies

Dayananda Sagar University, Bangalore, India

Email : rchandrain@yahoo.com

ORCID id: 0000-0002-7499-8526

Dr. Laxmana Rao. G

Associate Professor School of Commerce and Management Studies

Dayananda Sagar University, Bangalore, India

Email : drlaxmanrao-scms@dsu.edu.in

ORCID id: 0000-0002-7911-7927

Mr. Lohith.N

Assistant Professor

School of Commerce and Management Studies

Dayananda Sagar University, Bangalore, India

Email : lohith-scms@dsu.edu.in

ORCID id: 0009-0003-7178-982X

Mr. Santosh Kumar. S

Assistant Professor School of Commerce and Management Studies Dayananda Sagar University,

Bangalore, India, Email : santosh-scms@dsu.edu.in

ORCID id: 0000-0002-2527-8100

Abstract

In the contemporary economic landscape, international collaboration is deemed essential due to the significant global impact of tax planning and avoidance. Previous research has shown that, particularly concerning sizeable contracts giving rise to Permanent Establishments, both tax avoidance and tax planning are widely acknowledged methods of conducting business on a global scale. Tax planning is lawful and acceptable and cannot be disputed by the courts or the legal system; tax avoidance can be identified and appropriately addressed. This is especially true in the case of EPC contracts because there is a chance that there may be numerous contracts with the same party or with parties that live in various jurisdictions. This research investigation examines prior studies within the domain, notable judicial rulings related to EPC agreements in India spanning from 2005–06 to 2022–23, and global norms. The approach adopted will involve a case analysis centered on noteworthy court verdicts originating from the SC, HC, ITAT, and assorted courts. It will also encompass the rationales presented by the courts concerning tax strategy and

evasion, along with the pertinent elements influencing these aspects. In this scenario, the authors scrutinize the close association between the manner in which EPC agreements enable effective tax strategizing and tax circumvention, owing to differences related to diverse tax percentages, funding origins, risk mitigation, and the implementation of possible frameworks. The authors also propose a possible framework in the context of sustainable tax-planning for EPC contracts.

Keywords: Allocation of Profits, BEPS, Digital-taxation, EPC Contracts, Permanent establishment, Tax planning Tax avoidance, Supply of equipment

Introduction

A permanent establishment (PE), is one which confines tax responsibility to the proportion of earnings or gains generated by the entity within the country and does not encompass the entire profits produced for the corporation, stands as a pivotal counsel in tax planning. As a result, the problem of profit allocation is thrust into the forefront, and the Indian Income-tax Law provides workable remedies. Certain factors are taken into consideration when allocating earnings to the PE, according to publicly published court decisions. A foreign company situated in another country is considered to have a Permanent Establishment (PE) if it constitutes a substantial, enduring, or prolonged element of the business there. What proportion of earnings were generated or originated in India is a crucial fact. Income primarily resulting from activities carried out exclusively within India can be considered as business revenue expected to arise or accumulate in India, as outlined in explanation appended to Indian Income Tax Act. Moreover, only upon the establishment of a Permanent Establishment (PE), the obligation for taxation may arise, necessitating a thorough assessment of the profits attributable to the PE.

Literature review

Ownership concentration and stock return

Existing research on evading taxes concentrates on theories surrounding organizational tax evasion apart from practical substitutes to evade tax. Various financial statement elements are employed to create several empirical representations of corporate tax avoidance. However, their suitability for businesses involved in compliant tax avoidance, a practice that reduces recorded plus assessable inflow, is limited. Havens for taxes and ambiguous fiscal benefits serve as substitute for more assertive tax evasion. This insight is derived from the 2015 work of Lee, Dobiyanki & Menton. The study explores the possibility of scale economies in tax planning, with larger, more successful multinational organizations in particular pay less in taxes than smaller businesses. The study observes international entities, particularly those international enterprises engaged in broader global activities, exhibit lesser Effective Tax Rates globally compared to other businesses. This aligns with the notion that multinational corporations may employ strategies to avoid income taxes in a manner not feasible for domestic-only enterprises. Consequently, heightened levels of income from overseas operations get linked to a rise in organizational tax avoidance and tax rates indicate possibilities of economies of scale in tax planning. The 2003 work by Rigo, asserts that evasion of tax encompasses a spectrum from illegal activities to legally reducing corporate tax rates. The objective is to summarize the principal discoveries related to evasion of tax in

accountancy and pecuniary domains spanning last decade. Considering interlinked challenges of quantifying tax evasion, understanding potential origins plus consequences stemming from organizational evasion of tax, this addresses theoretical advancements along with pertinent empirical discoveries. It also provides recommendations for further investigation into unexplored facets of tax evasion. In the 2020 work by Xu Wang, Sun, and Cullinan, a thorough statistical analysis is conducted on available existing studies investigating association of size of company with effective rate of tax, utilizing meta-regression analysis. The study reveals that the variability in the size-ETR relationship can be elucidated by Hofstede's theory of cultural dimensions, a corruption index, and a transparency index. It further concludes that factors related to tax planning can impact the size-ETR association, as indicated by 2019 findings in the research by Hagin Bilz, and Stefens. All MNEs produce their revenue using a particular organizational structure for the tasks carried out, the resources used, and the risks taken. However, the shifting economic conditions have led to a scenario where all governments are increasingly focused on boosting tax collections, while many MNEs are focused on reducing their taxable business income through a variety of strategies, one of which is transfer pricing. The goal of the study is to develop a general model that would allow MNEs to choose the optimum business model within the parameters of tax planning while also allowing for the quantification of the effects on the state budget as a result of that tax planning approach. Moreover, the comprehensive model establishes more accurate arm's length transfer pricing within the business framework compared to recommendations found in the OECD Transfer Pricing Guidelines, specifically through functional and comparability analyses (Nerudova, V. S. D.). The exploration of tax compliance involves a scrutiny of an individual's decision-making process in strategic tax management. An often-overlooked dimension of adhering to tax regulations is the influence of a social agreement on the moral outlook towards taxes. It is posited that an implicit agreement between the individual and the state, characterized by significant level of pecuniary liberty, strong measures against anticompetitive practices, substantial bourses, along with elevated ethical norms, would positively influence tax compliance. This research presents empirical evidence, drawn from data spanning thirty nations, indicating direct association between worldwide adherence to tax regulations and factors such as pecuniary liberty, prominent bourses, efficient competitive regulations, along with elevated ethical norms (Riahi-Belkai, 2004). Additionally, it is highlighted that tax planning can elevate an organization's financial intricacy while achieving the envisaged tax savings. The investigation explores whether businesses engaged in assertive taxation strategy experience an info milieu that lacks transparency. Concerns about transparency may arise when heightened financial complexity cannot be adequately clarified through interactions with external stakeholders like investors and analysts. The associations linking evasion of tax with info lopsidedness, inaccuracies in analyst forecasts, and the quality of profits indicate the linkage of assertive taxation strategy and diminished translucency in corporations. There is evidence suggesting entities involved in assertive taxation endeavor.. tackling such concerns through enhancing revelations pertaining to taxation aspects. Overall, findings indicate that businesses must choose between tax advantages and financial openness when determining how aggressively to manage their taxes. Balakrishnan,

K., Blouin, et al (2019): This research delves into the internal mechanisms of tax planning within United States multinational corporations (MNEs). The findings reveal that American multinationals employ varied tactics, motivated by inside drivers and exterior opportunities in legitimately reducing tax obligations. A unique hypothetical model is introduced to analyze the interplay of opportunities and motivations in taxation strategies of internationals (Cooper, & Nguyen, Q. T., 2019). Previous studies in the realm of Permanent Establishment (PE) within EPC contracts have provided a broad overview of cases and judicial outcomes. However, these studies have not thoroughly examined the connections between different components and the structure of EPC contracts, including the motivations and objectives behind them. Identifying this research gap, the study delves into various aspects such as organizational governance, taxation strategy, changes in taxation legislation, along with the structures involving Special Purpose Vehicles within the EPC contractual framework. Additionally, it posits a unique prototype addressing calculation of tax-risk rating which may prove valuable for corporations in assessing their risk of contract taxability and helping mitigate potential tax risk liability arising from the creation of a Permanent Establishment (PE). Jing V & Lina (2017) find leverage positively impacts tax avoidance activities, while Sopiayana M (2022) note that firm size and leverage do not have major impact on tax evasion. Kifli, F. M., & Juliarto, A. (2022) find that tax planning have negative effect on firm value, ETR does not have major effect on firm value, while book-tax difference increase company value. Aronmwan, E. J., & Okaiwele, I. M. (2020) look at patterns in tax avoidance strategies based on ETR, advise there are notable variations in metrics for tax avoidance, Firmansyah, F., Kuntadi, C., et al (2022) find that firm size, tax planning, leverage have negative impact on stock returns, that cannot be mitigated. Pangaribuan, H., Fernando HB et al (2021) finds that there is no significant relationship between transfer pricing and tax evasion, while significant relationship exists between tax evasion, leverage, sales growth and tax avoidance, while Anggraini, F. A. (2022) find tax evasion is impacted by profitability, and negatively impacted by age of firm, and Widyastuti, S. M., Meutia, I. et al (2022) find capital intensity variable, the board of commissioners, and the audit committee, as stand-ins for corporate governance, all demonstrate a favorable impact on tax evasion. Shams, S., Bose, S., et al (2022) find that tax evasion driven by empire building lowers corporate value, and strong correlation exist between managerial empire building and corporate tax dodging. Na'im, A. (2006) finds SPVs useful for tax planning, effective risk management, project financing and business restructuring, Feng, M., Gramlich, et al (2009) find that strong corporate governance reduce the use of SPVs except for tax, economic, reasons. Sainati, T., Brookes, N., & Locatelli et.al, (2017) offer explanation for use of SPVs in large mega projects and provide classification of SPV types. George, M. P., & Agarwal, P. (2010) suggest use of corporate structure for tax planning sparingly due to possible their being termed as colorable devices.

Data and variables**Study period and sample**

This investigation scrutinizes the tax implications of income across various cases adjudicated by diverse courts and the reasoning behind their decisions. The timeframe considered spans from

2007-08 to 2023, providing a comprehensive 15-year perspective on the evolution of judicial trends. For sample collection, the researchers utilized secondary data. The study explores existing literature concerning tax planning, tax avoidance, and the influencing factors, along with global practices in this domain. It adopts an exploratory approach, drawing insights from secondary data sources such as CA Journal, Itat-on-line.org, the Bombay CA Journal, decisions from ITAT, HC, Supreme Court, and Authority for Advance Rulings (AAR), encompassing judgments from several judicial establishments.

The timeframe considered ranges from the fiscal year 2007-08 to 2023, chosen for its 15-year span that provides valuable insights into the development of judicial trends, utilizing secondary data derived from cases documented of courts.

Research Objectives

- a) Investigating the involvement of tax evasion and tax optimization incentives in EPC contracts.
- b) Examining the significant aspects and components that exert substantial influence on the configuration of EPC contracts.
- c) Analyzing judicial decisions across various levels concerning the taxation of EPC contracts, utilizing specific cases and observing prevalent trends.
- d) Proposing a Sustainable framework -for EPC contracts

Methodology and model specifications

This research is investigative in nature and relies on secondary information as mentioned earlier. It encompasses insights from KPMG and E&Y reports, OECD reports, and working papers concerning digital taxation and Base Erosion and Profit Shifting (BEPS). The varied structures emerging in Engineering, Procurement, and Construction (EPC) contracts, along with diverse court rulings, are examined through case law analysis involving approximately ten sample cases. The recognition of the following nine pivotal elements is grounded in a comprehensive analysis of historical research and legal precedents, scrutinizing the rationales behind the design of EPC contracts: (i) SAA (Structural Arrangement of Agreements), (ii) LMS (Legal Methodologies and the Judicial System), (iii) OPMTU (Organizational Procedures for Managing Tax Uncertainties), (iv) SETGOM (Strategies for Evading Taxes and Governance Mechanisms), (v) EROTEC (Efficiency and Regulation of Tax Enforcement Controls), (vi) ITAME (Initiatives by Tax Authorities and Managerial Efficacy), (vii) CETA (Contribution of External Tax Advisors), (viii) DCMTU (Division of Contracts and Minimization of Tax Uncertainties), and (ix) SMRC (Scrutiny and Management of Regulatory Compliance). The authors advocate for a tax risk assessing model, offering practical utility for industry practitioners..

Model specifications

The research is investigative, and the authors suggest a framework wherein the ultimate tax risk score can be formulated as a regression equation. This equation is a function of the aforementioned nine constructs, serving as independent variables, denoted as provided above, where ETR signifies the Estimated Tax Risk. This score can be derived by completing a questionnaire administered to EPC corporations, serving as a valuable check to comprehend tax risk. The computation of this score can be applied either to individual entities or on an industry-wide basis.

$$\text{ETR} = \beta + \text{SAAz1} + \text{LMSz2} + \text{OPMTUz3} + \text{SETGOMz4} + \text{EROTECz5} + \text{ITAMEz6} + \text{CETAz7} + \text{DCMTUz8} + \text{SMRCz9}$$

B = minimum base line taxes

The tax risk score is portrayed as the dependent variable in this context, while the other factors mentioned are considered independent variables. The authors have devised a list of elements that can be trusted to assess the potential impact of tax risk borne by the company. This evaluation employs a set of questions derived from prior research and court decisions on the subject.

By assigning weightage to each element, containing further sub-elements, it enables measurements of the concerned organization's view of each element – ranging from 1 to 3 (minimal to substantial) for each sub-element, culminating in the overall risk score. The closer the organization's perception is to the standard or matches the standard, the lower the risk, and conversely. This approach assists in appropriately planning corporate structures. A grading system, analogous to credit ratings may then be contemplated for suitable categorization. The closer the score aligns with the standard, the lower the risk for the company in executing EPC contracts; conversely, the company faces a greater risk as the score decreases. Integrating probability-discernment along with deploying a unit-based rating system can contribute to the tax risk assessment for corporations.

Discussion

(a) Investigating the involvement of tax evasion and tax optimization incentives in EPC contracts. Various categories of contracts encompassed within EPC agreements include composite contracts, split contracts, turn-key contracts, umbrella contracts, fixed-price contracts, lump-sum turnkey contracts, and others. Corporations, aiming to enhance investor returns, explore suitable methods to diminish their tax obligations. This pursuit results in extensive tax planning to reduce taxation obligations, GAAPETR, disparities between book income and taxable income, and long lasting intentional variations between book income and taxable income – all serving as indicators for practices aimed at evading taxes. The utilization of Special Purpose Vehicles (SPVs), specifically tailored for project execution, is a prevalent approach. SPVs facilitate efficient project execution, offering a single point of responsibility and distributing the breakdown of work statements to different contract participants. These SPVs are often domiciled in countries with more favorable Double Taxation Agreements (DTA) with India, such as the Netherlands or Mauritius, enabling tax savings. The choice of structure depends on the jurisdiction, considering variations in effective tax rates, a crucial aspect in decision-making. In more intricate EPC contracts of significant scale, a strategic alliance based on a joint Memorandum of Understanding (MOU) through a consortium approach is adopted, involving participants from different jurisdictions. However, this approach carries the risk of being taxed at the maximum marginal rate as an Association of Persons (AOP), lacking a separate entity for assessment. Project funders, however, prefer channeling funds through SPVs, such as private limited companies established in overseas jurisdictions, facilitating movement of capital into designated Special Purpose Vehicle tasked with project execution. Alternative structural option contains Limited Liability Partnerships (LLPs). To mitigate risks, a common strategy involves housing assets in different SPVs across various jurisdictions. Establishing specific holding companies in tax-favorable jurisdictions, overseeing the fund flow

into the designated project, is another prevalent approach. More intricate methods entail a network of trusts in offshore jurisdictions, characterized by opaque legislations that are legally challenging, providing anonymity to the ultimate beneficiary while ensuring seamless fund flow to project execution vehicles.

b) Examining the significant aspects and components that exert substantial influence on the configuration of EPC contracts.

Explored in previous research and evaluations, specific elements are of crucial significance, shaping the framework of EPC contracts. Consistent with prior literature, studies, and considerations, the subsequent factors emerge as highly pertinent and valuable in the structuring of contracts. Given the substantial value associated with EPC contracts and the multitude of stakeholders involved in their execution and fulfillment, along with substantial investments from both domestic and international institutions, certain factors can be universally outlined, as summarized from earlier studies, as present in Table 1.

S.No.	Factors (std wts)
A	SAA (Structural Arrangement of Agreements) (5)
1	For expansive projects engaging numerous vendors/contractors, an EPC agreement stands as the most effective category. (3)
2	Improper structuring of EPC contracts can lead to increased tax obligations, potentially giving rise to PE.(2)
B	LMS (Legal Methodologies and the Judicial System) (6)
1	The courts consider the primary commercial intent behind the agreement. (3)
2	Courts examine both the documentation and the actions of the involved parties during contract execution to ascertain their respective roles. (3)
C	OPMTU (Organizational Procedures for Managing Tax Uncertainties) (6)
1	Corporate boards follow a structured procedure to evaluate the tax risk associated with Engineering, Procurement, and Construction (EPC) projects.(3)
2	Decisions regarding project structure primarily rely on recommendations from well-regarded local tax consultants in India. (3)
D	SETGOM (Strategies for Evading Taxes and Governance Mechanisms) (9)
1	Entities experiencing lower cash effective tax rates encounter notably higher levels of tax unpredictability. (3)
2	Prominent corporations, multinational entities, and institutional stakeholders are prone to engaging in tax avoidance practices. (3)
3	The degree of board autonomy and expertise exhibits a positive correlation with the inclination towards tax avoidance. (3)

E	EROTEC (Efficiency and Regulation of Tax Enforcement Controls) (5)
1	The effectiveness of tax enforcement diminishes the extent of tax avoidance. (3)
2	A heightened level of vigilance is linked to a decreased degree of tax uncertainty. (2)
F	ITAME (Initiatives by Tax Authorities and Managerial Efficacy) (8)
1	Transactions lacking a genuine business purpose may face challenges from tax authorities. (3)
2	A rise in tax avoidance may result in heightened managerial efficiency for corporations. (2)
3	Special Purpose Vehicles (SPVs) are employed to secure tax benefits and mitigate risks for investors. (3)
G	CETA (Contribution of External Tax Advisors)(9)
1	When External Tax advisors endorse a structure to an entity, they express greater confidence in its viability. (3)
2	Typically, boards of entities rely solely on the guidance provided by tax counselors.(3)
3	Boards of Multinational Corporations (MNCs) are inclined to design contracts that favor the delegation of more tasks to their overseas entities.(3)
H	DCMTU (Division of Contracts and Minimization of Tax Uncertainties) (8)
1	Dividing contracts is a recognized norm in the Engineering, Procurement, and Construction (EPC) sector. (3)
2	Appropriately organizing contracts diminishes the need for extensive coordination efforts and improves operational efficiency in the EPC industry.(3)
	The division of contracts plays a role in minimizing tax risks.(2)
I	SMRC (Scrutiny and Management of Regulatory Compliance) (9)
1	Possession of shares by institutions diminishes the tax risk. (3)
2	A robust audit committee contributes to the mitigation of tax risk. (3)
3	Managerial endorsement of assertive tax stances may elevate the tax risk. (3)
	Total Points (65)

Table 1: *Multitude of Stakeholders*

Source: Derived from the author's independent analysis, drawing on previous research and the evolution of case laws. These can be termed standard weights against which individual entities

can put their weights – and compare, and also use probability to risk weight the scores, thus arriving at final score. Categorized as high risk (3), Medium risk (2), low risk (1) and scored accordingly.

(c) Analyzing judicial decisions across various levels concerning the taxation of EPC contracts, utilizing specific cases, and observing prevalent trends. - Significance of taxation strategy, evasion, along with the utilization of contract splitting in the establishment of EPC agreements is undeniable. Numerous studies in the past have highlighted distinctions between tax planning and tax evasion, and it is noteworthy that the judiciary has acknowledged these differences. While the courts endorse and support tax planning, tax evasion has not garnered favorable recognition.

Analysis of Cases and Outcomes

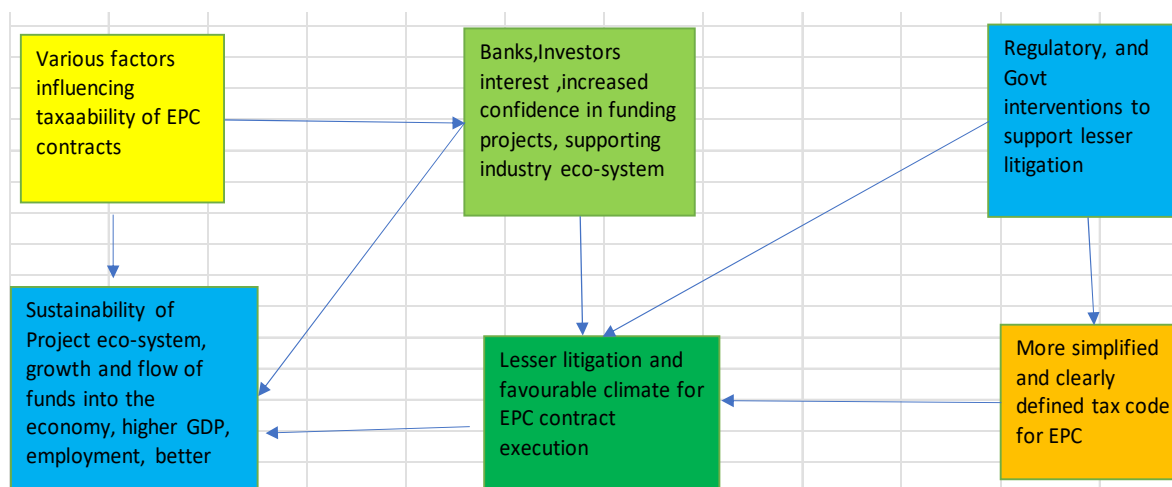
1. CIT vs Mitsui Engg & ship building-[(2002) 174-CTR-66 (Del.)] - Contract not capable to split - hence not taxable, Equipment delivery on FOB basis -Tax planning
2. Ishikawajima Harima Heavy Industries Co.Ltd-2007,288 ITR409(SC)-Transactions executed outside India lay exempt from taxation within India. The absence of a Permanent Establishment (PE) for the offshore component indicates strategic tax planning.
3. Hyosung Corporation -(2009) 3134 ITR 343(AAR)- The distinct nature of the offshore contract renders it non-taxable in India, supported by the absence of a Permanent Establishment (PE). This exemplifies deliberate tax planning.
4. Commissioner of IT V Fried Krupp Indus-(1981) 128 ITR 27- No business operations conducted in India can be attributed to a foreign company, negating the generation of profits within India. Consequently, it is not subject to taxation, and no Permanent Establishment (PE) exists, illustrating a tax planning approach.
5. Dong Fing-Electric Corporation-V-DDIT-(TS-434-ITAT-2012Kol) –
It was determined that the Assessing Officer erroneously deduced that a unified contract had been intentionally segmented into multiple parts to evade taxation. Such a conclusion lacks merit based solely on conjecture. Consequently, no Permanent Establishment (PE) arises, indicating a strategic tax planning approach.
6. Ansaeldo Energeia SPA-V-ITO-(2009)310 ITR237(Mad) – Quatern unique contracts were intricately allied, constituting a wholesome one. The taxpayer omitted specific details, and the Income Tax Appellate Tribunal (ITAT) confirmed the taxability of 75% of the contracts within contract-I. The case was again referred to the Appellate Tribunal to determine the accurate taxable profits. Breakdown constituted a mere semblance, resulting in taxable profit, and a Permanent Establishment emerges, indicative of tax avoidance.
7. JD of IT Vs Krup UHDE Gmbh-(2009)26DTR289(Mum) - In cases where contracts lack a meaningful link, the amalgamation of distinct locales within the six-month calculation period is not permissible. This reflects a tax planning strategy.
8. SEPCO-III-Electric-Power-Construction Corporation-(2012) 18taxmann.com144 AAR – Overseas contract, being distinct, remains outside the Indian taxation scope, and Permanent Establishment does not arise. This highlights a deliberate tax planning approach.

9. Vodafone International BV-V- UOI-(2012) 341 ITR 1 (SC)- SC adopts a "Look at" approach rather than a "Look through" approach. This decision results in the absence of a Permanent Establishment (PE), indicative of a tax planning strategy.

10. Dur Systems AG, Chennai Vs DCIT(Intl tax)-TS-5398-ITAT-2023(CHENNAI) - A conclusion was reached that the earnings of the German company, (derived from supplying equipment, supervision, and installation), are subject to taxation in India due to their integral connection with the same turnkey project. The ITAT cited a precedent in an assessee case, upholding the assertion of Indian tax authorities that the three elements of the turnkey agreement were artificially divided, leading to the determination that it is a wholesome one, making the supplies subjectable to taxation.

d) Proposing a Sustainable framework for EPC contracts

In Figure 1, the authors have tried to put in a sustainability approach to development of EPC contracts and the economic growth and development of the country. As we have examined in past literature factors responsible were inter-linked and these in turn impact the decision of banks, investors to fund the project. The Govt and Regulatory bodies, tax authorities look at the possible safety net available to them in case of getting caught in a web of litigation, while the judiciary may have changed its approach and timeliness in deciding on cases, and the govt learning from past experiences in litigation becomes more balanced, nuanced, and creates a conducive set up by



issuing notifications, guidelines and create a climate favorable for EPC contracts set up. All these lead to possible development of separate code for taxability of income from EPC contracts and this reduces chances of litigation, enables a sustainable solution to be ready in place for more FDI, Debt flows into the economy, and enhance growth and per capita income of the country.

Figure 1: *Flow diagram for the proposed framework for sustainability, growth and development of EPC contracts and economic growth*

CONCLUSION

The taxation of EPC contracts is one of the most complex aspects of large contracts, with a variety of structures and with offshore and onsite parts separately being performed and delivered in India for the final customer.

The uncertainty regarding the outcome further contributes to legal disputes in the Indian context, given the diverse rulings from the courts and the absence of specific guidelines for such contract types, whether codified in the IT Act or provided by the CBDT. Various motives and considerations influence the nature, structure, and establishment of EPC contracts. As noted in prior studies, these factors enhance the effectiveness of tax planning and, to some extent, tax avoidance, ultimately benefiting stakeholders. To address such practices, BEPs Action 7 has been incorporated, aiming to prevent the intentional division and the lowering of baseline for dealings considered preparatory. Additionally, certain actions are exempted from the permanent establishment exclusion, making it more challenging to shift income to low-tax regions. Further the Digital service tax and Pillar 1 and Pillar 2 actions of BEPs increase the lee-way given to the national governments tax certain transactions subject to fulfilment of specified conditions mentioned therein, and thus enable them to levy a top up tax if the tax rates are below a certain threshold (15%). This helps the host govts to raise their taxation rights and capacities. However, as the authors note tax planning and tax avoidance do dominate the scenario even in the case of EPC contracts, and the routes adopted by entities are in line with the global practices, observed elsewhere. As a result, the BEPs Actions encompass dissemination of information addressing harmful tax practices and allied matters. This will additionally curtail the capacity of corporate entities to engage in tax avoidance. However, with new structures, technologies coming up, the SPV, Tax haven, and banking routes still promise to provide significant tax savings to the EPC players, The government will pass legislation to close the loophole, which will effectively reduce opportunities for tax planning and force more aggressive forms of tax planning that may even teeter on the line of tax avoidance. The taxpayer will use a variety of structures to reduce his tax liabilities, all of which can be rightfully upheld as valid. The legal system must consistently formulate fresh frameworks with robust business judgment as an investor or entrepreneur organizes and oversees their business. Striking an appropriate equilibrium on these factors will instill confidence in tax policies and measures. Without this equilibrium, litigation will emerge as the predominant avenue for resolution, undermining the confidence of investors and businesses.

REFERENCES

- Anggraini, F.A., 2022. Effect of Profitability, Sales Growth and Company Age on Tax Avoidance. *Asian Journal of Engineering, Social and Health*, 1(1), pp.36-47.
- Vello, A. and Martinez, A.L., 2012. Efficient tax planning: An analysis of its relationship with market risk. Available at SSRN 2140000.
- Aronmwan, E.J. and Okaiwele, I.M., 2020. Measuring tax avoidance using effective tax rate: concepts and implications. *The Journal of Accounting and Management*, 10(1).
- Balakrishnan, K., Blouin, J.L. and Guay, W.R., 2019. Tax aggressiveness and corporate transparency. *The Accounting Review*, 94(1), pp.45-69.
- Belz, T., Hagen, D.V. and Steffens, C., 2019. Taxes and firm size: Political cost or political power?. *Journal of Accounting Literature*, 42(1), pp.1-28.

- Cooper, M. and Nguyen, Q.T., 2019. Understanding the interaction of motivation and opportunity for tax planning inside US multinationals: A qualitative study. *Journal of World Business*, 54(6), p.101023.
- Feng, M., Gramlich, J.D. and Gupta, S., 2009. Special purpose vehicles: Empirical evidence on determinants and earnings management. *The Accounting Review*, 84(6), pp.1833-1876.
- Firmansyah, F., Kuntadi, C. and Oktris, L., 2022. The influence of leverage, tax planning, and company size on stock return with investment risk as a moderating variable. *Journal of Life Economics*, 9(2), pp.53-64.
- George, M.P. and Agarwal, P., 2010. Use of the corporate vehicle for tax planning: the Vodafone case and direct taxes code. *NUJS L. Rev.*, 3, p.201.
- Jingga, V. and Lina, L., 2017. Factors influencing tax avoidance activity: An empirical study from Indonesia stock exchange. *Indian-Pacific Journal of Accounting and Finance*, 1(1), pp.17-25.
- Kifli, F.M. and Juliarto, A., 2022. Tax Planning Activities and Firm Value (Study In Indonesia Consumer Goods Companies Listed in IDX Period 2016 to 2020). *Diponegoro Journal of Accounting*, 11(4).
- Lee, B.B., Dobiyanski, A. and Minton, S., 2015. Theories and Empirical Proxies for Corporate Tax Avoidance. *Journal of Applied Business & Economics*, 17(3).
- Minimum tax implementation handbook -Pillar 2- OECD-G20- BEPS project
- Na'im, A., 2006. SPECIAL PURPOSE VEHICLE INSTITUTIONS: Their Business Natures and Accounting Implications. *Gadjah Mada International Journal of Business*, 8(1).
- NERUDOVA, V.S.D., Transfer Pricing: General Model for Tax Planning.
- Pangaribuan, H., Fernando HB, J., Agoes, S., Sihombing, J. and Sunarsi, D., 2021. The Financial Perspective Study on Tax Avoidance. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, 4(3), pp.4998-5009.
- Rego, S.O., 2003. Tax-avoidance activities of US multinational corporations. *Contemporary Accounting Research*, 20(4), pp.805-833.
- Riahi-Belkaoui, A., 2004. Relationship between tax compliance internationally and selected determinants of tax morale. *Journal of international accounting, auditing and taxation*, 13(2), pp.135-143.
- Sainati, T., Brookes, N. and Locatelli, G., 2017. Special purpose entities in megaprojects: Empty boxes or real companies? *Project Management Journal*, 48(2), pp.55-73.
- Shams, S., Bose, S. and Gunasekarage, A., 2022. Does corporate tax avoidance promote managerial empire building? *Journal of Contemporary Accounting & Economics*, 18(1), p.100293.
- Sopiyana, M., 2022. The Effect of Leverage and Firm Size on Tax Avoidance with Profitability as Moderating. *Scientific Journal of Reflection: Economic, Accounting, Management and Business*, 5(1), pp.29-37.
- Statement on two pillar solution to address the tax challenges arising from the digitalisation of the economy (8th Oct 2021)- OECD publ.
- Update to the economic impact assessment of Pillar one – OECD /G 20-BEPS -working paper series No 66.

Wang, F., Xu, S., Sun, J. and Cullinan, C.P., 2020. Corporate tax avoidance: A literature review and research agenda. *Journal of Economic Surveys*, 34(4), pp.793-811.

Widyastuti, S.M., Meutia, I. and Candrakanta, A.B., 2022. The effect of Leverage, Profitability, Capital Intensity and Corporate Governance on Tax Avoidance. *Integrated Journal of Business and Economics*, 6(1), pp.13-27.

Strategic Integration for Future Selection-LSTM Stock Prediction Algorithm based on the Internet of Things (IoT)

Balachandar. S
HRM & Training and Transformation
ISBR Business School
Electronic city Phase I
Bangalore, Karnataka, India
drbalas07@gmail.com

S. Prabakar
Department of Human Resource
Management ,
ISBR Business School
Bangalore, Karnataka, India
prof.prabakar@isbr.in

S. Prabakar
School of Commerce and Management
Studies
Dayananda Sagar University
Bangalore, Karnataka, India
drprabakar-scms@dsu.edu.in

Abstract— Forecasting stock prices is essential because of its substantial ramifications for people, organizations, and governments. This research investigates the convergence of sophisticated data mining methods, 5G technology, and the Internet of Things (IoT) to improve the accuracy of predicting stock prices. To overcome the difficulties associated with decreased accuracy and intricate training procedures in stock prediction models, to suggest using a hybrid methodology that integrates Feature Selection (FS) and Long Short-Term Memory (LSTM) networks. This approach seeks to forecast the final price of stocks by using an enhanced collection of characteristics derived from 15 commonly used indicators in the stock market. By using feature selection (FS), we decrease the number of data dimensions and enhance the efficiency of model training. Subsequently, the LSTM model is used to predict stock values. The findings of the research indicate that the FS-LSTM hybrid model substantially enhances the accuracy of predictions, resulting in a notable decrease of 15% in mean squared error compared to conventional LSTM networks. These results highlight the possibility of combining IoT and 5G technology in financial forecasting, which may lead to more dependable and efficient predictions of stock prices.

Keywords—Feature selection (FS), Long Short-Term Memory network (LSTM), Stock forecasting, Internet of Things (IoT), 5G (Fifth Generation), Recurrent Neural Network (RNN).

I. INTRODUCTION

Societies prioritize the development of their enterprises to provide a desirable quality of life by putting public spending policies into place. The modern economy encourages the development of large, global firms that can provide enormous possibilities and quickly adjust to changes in the global economy [1]. Stocks of private, public, and mixed ownership are among the securities exchanged by buyers and sellers on the stock market. Whereas shares of companies listed on the stock market are traded on the public stock exchange, shares of privately owned enterprises are traded on the private stock exchange. Stocks owned by companies with restricted exchangeability on the open market are referred to as having mixed ownership. Globally, stock exchanges are formed, with the United States and the United Kingdom being two prominent examples: the London Stock Exchange and the NYSE [2]. Data transmission has increased dramatically as a result of the broad use of information technology, and intelligent terminals are

proliferating. 5G telecommunications services have emerged as a result of this progression. The global telecom operators predict that 5G wireless communication technology will start to become commercially available in 2020 [3]. Because 5G infrastructure can transmit data at fast speeds, IoT technologies should develop dramatically with its arrival. It is widely acknowledged that the 5G infrastructure is essential to fulfilling the growing needs of the IoT for features like high data rates, multiple device connection, and lower latency [4]. The deployment of 5G technology in networks provides users with increased network connection, greatly improving network speed and quality, and increasing the dependability of data transport. Several scholars have put forward several deep-learning methods to improve the accuracy of stock price projections, including the ability to estimate the closing price for the next day, week, month, or year. But a few queries come up. Although deep learning techniques have a substantial influence on short-term projections, they are also capable of detecting complex and non-linear patterns in economic stock data [5]. These models make it easier to analyse intricate patterns and make predictions about the days, weeks, and months ahead. The effect of including many factors in short-term stock price projections is a further question. To solve this, a unique method for predicting the closing price and the peak price [6] is presented. IoT technology is very adaptable and may be used in a variety of settings, such as smart cities, the construction industry, and other fields, greatly increasing individual efficiency. For IoT technology to be effective, there must be a lot of data connection and quick network communication. IoT technology might develop greatly with the introduction of 5G networks. 5G has several advantages, such as fast data transmission speeds, robustness, wide coverage, and all-encompassing security [7]. Thus, the deployment of 5G wireless networks has the potential to greatly improve IoT communication quality and expand its possibilities. Additionally, the use of 5G wireless communication design may lower IoT development and savings costs, improving the overall efficacy of IoT infrastructure. Big data technologies which include data collecting, retrieval, management, assessment, and extraction have advanced as a result of the Internet of Things' widespread use [8]. 5G networks are very good at handling big data sets at cheap costs. They provide features like

reduced latency, great dependability, simple data updates, expanded coverage, and improved wireless connectivity. Big data's arrival has drawn a lot of interest in deep learning in several research areas, and deep learning along with cloud computing, artificial intelligence, and big data has emerged as a key pathway for 5G technology development. In this paper, the development of 5G, IoT, and data mining is analysed, and a new method for stock trend prediction using LSTM and feature selection models is presented [9]. This research specifically looks at how IoT and 5G technologies may be used for stock forecasting, with an emphasis on processing speed, productivity, and information storage. Using deep learning models, the article improves stock market forecast accuracy by integrating IoT and 5G technology. To handle the complexity of non-linear patterns in economic data, the paper presents a unique method for forecasting stock trends that combines LSTM networks with feature selection algorithms. The deployment advances the use of IoT in financial forecasting by using 5G's high-speed transmission capabilities to enhance data connection and real-time analysis. By projecting closing and peak stock values, this method improves forecasting accuracy and produces more accurate short-term projections.

II. LITERATURE SURVEY

Wen et al [10] introduced a Convolutional Neural Network (CNN) framework that employs a high-order architecture. In reality, it was contrasted to various models, which include conventional techniques like ARIMA and Wavelet that proved to have the lowest performance. Following that, the Hidden Markov Model (HMM) and the machine-learning structure were also inadequate when contrasted to deep learning methods like SMF and LSTM, achieving a precision of only 1-3%. The CNN approach, which employs an advanced framework, outperformed these deep learning algorithms. The aforementioned findings were derived through the assessment of many datasets, encompassing Apple, IBM, Google, S&P 500, and additional datasets. Xue et al. [11] introduced a very precise financial sector forecasting using a time series framework with a focus on short-term predictions by the utilization of an LSTM deep neural network in their research. A comparison analysis was subsequently performed, involving the BP neural network, the normal RNN, and the enhanced LSTM deep neural network. The outcomes suggest that the LSTM deep neural network has a significant degree of precision in forecasting and showcases strong predictive abilities while assessing the inventory market's time series information. To predict the last traded price of the NSE NIFTY 50 index, Mehtab et al. [12] made use of a CNN model that was trained using deep learning. Both univariate and multivariate methods were utilized in the construction of three different convolutional neural network (CNN) models. The framework for forecasting was significantly improved as a result of the use of these models, which were developed with a variety of input data sizes and network topologies. Chen et al. [13] utilized Convolutional Neural Networks (CNN), BiLSTM, and a mechanism of attention-derived algorithm in their research in order to predict the final prices of different companies, such as the Shanghai Composite Index, China Unicom, and the CSI 300, accurate modeling is

required. The Convolutional Neural Network (CNN) was employed to extract the characteristics from the input information. The integration of efficient channel attention with BiLSTM resulted in an enhanced sensitivity of the network in forecasting the stock price. Price prediction is incorporated by Sarode et al. [14] by the utilization of historical and real-time data, in addition to news analysis. For prediction, they make utilization of Long Short-Term Memory (LSTM). It is anticipated that quant traders will be driven to invest and maximize their earnings if this method is incorporated into the tactics that are already in place. Within the scope of their research, Balaji et al [15] presented a deep-learning strategy to forecast stock values. Within this body of research, a detailed study of fourteen different deep-learning algorithms is presented. These algorithms were utilized to analyse all of the stocks that are included in the conventional & impoverished (S&P) BSE-BANKEX indexes.

III. PROPOSED METHOD

The FS-LSTM (Feature Selection Long Short-Term Memory) algorithm enhances time series forecasts, particularly in finance, by combining LSTM networks with feature selection techniques. Initially, relevant features like price, volume, and indicators are selected through methods such as correlation analysis. These features undergo preprocessing, including normalization and data transformation. Figure 1 depicts the structure of the suggested workflow. It presents a unique Feature Selection-Long Short-Term Memory (FS-LSTM) technique to fill in the discovered gaps. The suggested algorithm has a strong feature selection procedure that methodically finds and keeps the most relevant market indicators, increasing the accuracy and efficiency of the model. Stock price projections are more predictive when using the FS-LSTM algorithm because it reduces noise and overfitting, in contrast to traditional LSTM models that often include feature redundancy. This strategy is unusual because it can dynamically adapt to changing market circumstances and provides a considerable increase in predicting accuracy over previous approaches.

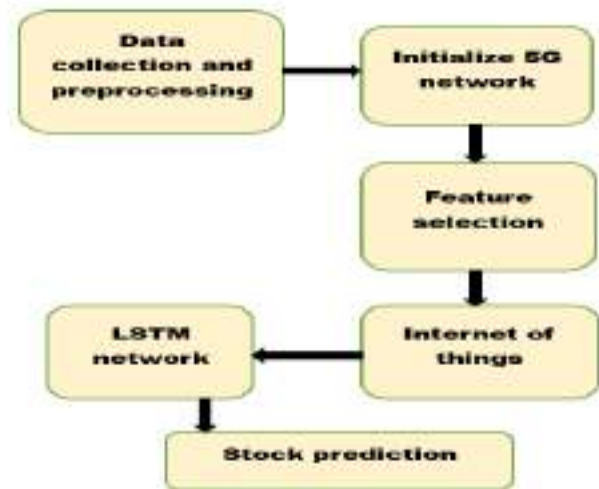


Fig 1. Schematic illustration of the proposed workflow.

A. Data collection and preprocessing

The data collection phase involves gathering historical stock market data and real-time IoT data streams from reliable sources like Kaggle. The training set contains the first 80% of the data, whereas the test set contains the last 20% of the data. Preprocessing steps ensure data quality and suitability for analysis, including cleaning to handle missing values, feature selection to identify relevant features impacting stock prices, data normalization to prevent bias during model training, and time series data preparation for LSTM model training. These steps form the foundation for accurate stock price prediction.

B. Initialization of 5G network

The IoT approach has an immense effect on individuals' productivity and daily lives by facilitating the sharing and transfer of many data types via sensor nodes. Consequently, the utilization of Internet of Things (IoT) technology for predicting stocks has emerged as a novel phenomenon, showcasing the viability of extracting valuable insights from past stock data to make predictions about future stock performance. The fusion of 5G and IoT technologies is expected to expedite the advancement of the stock forecasting sector. The Internet of Things (IoT) facilitates the storage of dispersed information across many network nodes, enabling the transfer and exchange of information across various locations and infrastructures. The Internet of Things (IoT) is poised to supplant conventional approaches due to its ability to address data management and processing needs effectively. The convergence of 5G communication with the Internet of Things (IoT) has the potential to establish robust, high-speed, and dependable transmission networks, hence enhancing the timeliness and effectiveness of stock forecasts. The computerization of stock prediction systems will be consistently facilitated by the integration of IoT and 5G technologies, enabling consumers to conveniently obtain pertinent content through their mobile applications or other communication channels. It employs IoT ideas to improve real-time data processing and collection for stock price prediction. IoT-enabled sensors and gadgets continually collect and send environmental and financial data from a variety of sources, including social media sentiment, news updates, and market movements. Then, using a cloud-based platform, this data is easily merged into the suggested FS-LSTM algorithm, guaranteeing that analysis is done with the most recent data. Compared to conventional static datasets, the accuracy and responsiveness of stock price projections are enhanced by the system's ability to dynamically adapt to real-time data streams thanks to the Internet of Things.

C. Feature Selection

Feature selection in IoT involves identifying critical attributes from the data collected by IoT devices to predict stock prices effectively. After gathering information from different sources like environmental sensors and social media, feature extraction techniques are employed to transform raw data into meaningful features. These features are then subjected to feature selection approaches such as wrapper, or embedded and filter techniques. Filter methods assess feature significance according to statistical measures,

wrapper methods evaluate feature subsets utilizing machine learning models, and embedded techniques combine feature selection into the training of the model. Machine learning is the systematic procedure of analyzing data and developing models. Data processing encompasses the tasks of extracting features and representing them. Model training involves a series of procedures, including the selection of a method for training, the development of a training approach, and the comparison of algorithms. An effective predicting framework is intricately linked to the process of selecting and representing features. The feature selection approach involves deciding on a subset from the initially generated feature information set to decrease the total quantity of characteristics included in the feature information set. The selection of features aims to enhance accuracy in prediction, develop a robust predictive method, and gain a deeper comprehension and interpretation of the framework. The process of selecting a suitable feature subset was conducted by utilizing a correlation coefficient and ranking the significance of the characteristics. The coefficient of correlation is a statistical measure utilized to examine the extent of linear association among parameters. The variable is commonly denoted by the symbol "r," as depicted below in equation (1),(2).

$$r(A, B) = \frac{\text{cov}(A, B)}{\sqrt{\text{var}[A]\text{var}[B]}} \quad (1)$$

$$\text{cov}(A, B) = \frac{\sum_{i=1}^n (a_i - \bar{a})(b_i - \bar{b})}{n-1} \quad (2)$$

The covariance of A and B is denoted as Cov (A, B), whereas the variance of A is represented by var [A] and the variance of B is represented by var [B]. The number r (A, B) quantifies the extent of a strong linear correlation between A and B. If there is no relationship between A and B, then the correlation coefficient (r) between A and B is 0. There is a prevailing consensus that no linear correlation exists between variables A and B. When the value of r is less than 1, it accepted that there is a linear correlation between A and B. A higher value of r (A, B) indicates a stronger linear relationship between the two variables.

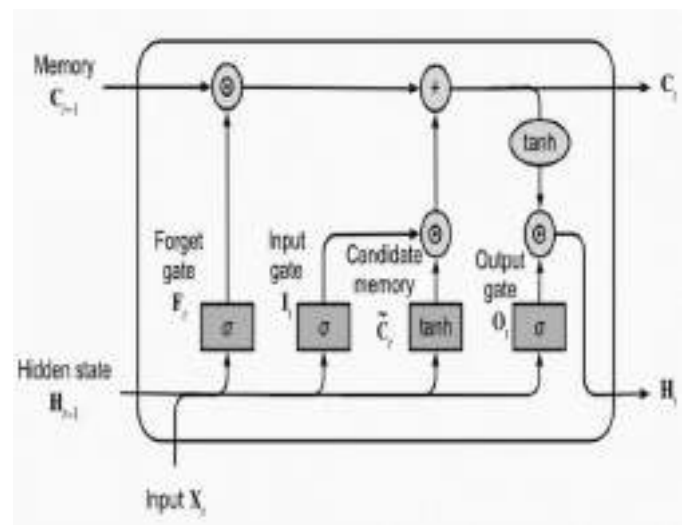


Fig 2. A basic architecture of the LSTM network.

LSTM is a distinct kind of recurrent neural network (RNN) structure that has been developed to represent dependencies that occur over time in sequential data, rendering them very suitable for this purpose for time-series forecasting tasks like stock price prediction. Unlike traditional RNNs, LSTM networks incorporate specialized memory cells that can maintain data over a prolonged period of time periods, preventing the issue of gradient disappearing occurs frequently in RNNs. The working principle of LSTM revolves around three gates: the output gate, the forget gate, and the input gate as shown in Figure 2. These gates regulate the transmission of data into, out of, and within the LSTM unit, enabling it to selectively preserve or discard information from previous steps. Through the combination of these gates and memory cells, LSTM networks can effectively learn complex temporal patterns in data, making them powerful tools for predicting future stock prices based on historical trends and other relevant factors. This approach addresses the issue of the explosion of gradients and disappearance of gradients that arise during the training of long sequence recurrent neural networks (RNNs). The visibility of the front nodes diminishes as the amount of network levels grows, leading to the occurrence of phenomena where previous information becomes neglected over the course of time. The LSTM model incorporates memory units into every neuron unit of the hidden layer, building upon the conventional RNN. This allows for effective control of memory stored in time series data. Figure 2 displays the architectural illustration of the memory units of the LSTM model. The variables C_{t-1} and h_{t-1} denote the specific state of the memory unit at the final moment, whereas C_t and h_t indicate the corresponding states of the hidden layer. The regulation of memory and forgetting of preceding (3) and present data can be achieved by passing, the forget gate (f_t), the input gate (i_t), and the output gate (o_t) among the components.

$$\begin{aligned} f_t &= \sigma(W_{xf}x_t + W_{hf}h_{t-1} + b_f) \\ i_t &= \sigma(W_{xi}x_t + W_{hi}h_{t-1} + b_i) \\ o_t &= \sigma(W_{xo}x_t + W_{ho}h_{t-1} + b_o) \end{aligned} \quad (3)$$

The sigmoid activating operation, input at time t , and weight matrix W_{xf} , W_{hf} , W_{xi} , W_{xo} , W_{ho} , and b_o are used to determine the current value of the memory module at time t . The memory unit's state value comprises two components: the state value at time $t-1$ and the input gate awaiting current data at time t . To determine the present condition of the memory unit, one can compute the weight matrix W_{xc} , W_{hc} , and b_c . The hidden layer's state, h_t , is determined by the output gate's state, o_t , and the present storage unit's state, c_t . The equation for computation is depicted (4) below.

$$\begin{aligned} \bar{c}_t &= \tanh(W_{xc}x_t + W_{hc}h_{t-1} + b_c) \\ c_t &= i_t * \bar{c}_t + f_t * c_{t-1} \\ h_t &= o_t * \tanh(c_t) \end{aligned} \quad (4)$$

Technical parameters play a crucial role in forecasting financial market trends; exclusively on a solitary indicator nevertheless, it is crucial to acknowledge that depending does not ensure thoroughness and reliability. To enhance data redundancy and representation of features, it is advisable to choose multiple indicators that are both relevant and easily quantifiable. This study develops a selection of 13 frequently utilized indicators, namely MA, RSI, CCI, ROC, ATR, MOM, OSC, BOP, OBV, MFI, K%, ATR, and CR, to create a feature set for predicting. These indicators provide a complete representation of stock changes (5) in trend and encompass the majority of factors that influence stock trend predictions. The ideal subset of features, which summarizes the primary information from the data, includes MA, RSI, CCI, K%, and CR.

ROC, ATR, MOM, OSC, BOP, OBV, MFI, K%, ATR, and CR, to create a feature set for predicting. These indicators provide a complete representation of stock changes (5) in trend and encompass the majority of factors that influence stock trend predictions. The ideal subset of features, which summarizes the primary information from the data, includes MA, RSI, CCI, K%, and CR.

$$\begin{aligned} MA &= \sum_{i=1}^n \frac{C_i}{n} \\ RSI &= 100 - \frac{100}{(1 + (\sum_{i=0}^{n-1} U_{pt-1}/n)) / (\sum_{i=0}^{n-1} D_{wt-1}/n)} \\ CCI &= \frac{M_t - SM_{t-1}}{0.015 D_t} \\ K\% &= \frac{\sum_{i=1}^n (22K_{i-1} + RSV_i)}{3} \\ CR &= \frac{\sum_{i=0}^{n-1} (H_i - M_i)}{\sum_{i=0}^{n-1} (M_i - L_i)} * 100 \end{aligned} \quad (5)$$

The chosen data is utilized to create the feature set. Due to the distinct computation methodologies employed by every index, the feature set generated based on the technical index exhibits a wide range of values, which can vary significantly. The significant disparity in number will culminate in the intricacy of parameter improvement for the mechanism framework, rendering it susceptible to overfitting and adversely affecting the ultimate prediction outcomes. Thus, this study employs formula (6) to standardize the volumes of features and transform every dimension characteristic element into $[-1, 1]$.

$$x_d = \frac{v_{d\_max} - v_{d\_min}}{v_{d\_max} - v_{d\_min}} \quad (6)$$

In the given equation, v_{d_min} represents the least value of the eigenvalue in the d -dimensional space, while v_{d_max} denotes the highest value of the eigenvalue in the d -dimensional space. Even while machine learning models such as LSTM have made great strides in stock price prediction, most current methods fall short in optimizing feature selection, which often results in overfitting of the model and decreased prediction accuracy. Additionally, prior research has not sufficiently investigated the integration of domain-specific market data. By presenting a Feature Selection-LSTM (FS-LSTM) hybrid model that improves prediction accuracy by methodically choosing the most important indicators, this paper fills in these gaps. By tackling the drawbacks of redundant features and inadequate model efficiency, our effort enhances the accuracy and dependability of stock market predictions.

IV. RESULT AND DISCUSSION

To evaluate the efficacy of the suggested methodology, the input parameter is determined by selecting the most effective feature subset. The input period is set at 20 days. The output parameter is determined by the opening market price for the day. The simulation comprises four distinct layers, including one Long Short-Term Memory (LSTM) layer and three dense layers. To mitigate excessive fitting, the LSTM architecture incorporates dropout settings and periodic terms throughout the training process. The model that was trained predicts the price of the shares of the test set, and it undergoes comparison to the classic LSTM forecasting algorithm. The evaluation indexes utilized to calculate (7) the accuracy of the framework were mean absolute error

(MAE), mean square error (MSE), and root mean square error (RMSE).

$$\begin{aligned} MAE &= \frac{1}{N} \sum_{i=1}^N |y_i - \hat{y}_i| \\ MSE &= \frac{1}{N} \sum_{i=1}^N (y_i - \hat{y}_i)^2 \\ RMSE &= \sqrt{\frac{1}{N} \sum_{i=1}^N (y_i - \hat{y}_i)^2} \end{aligned} \quad (7)$$

Table 1. Assessment of the proposed method's efficacy in relation to the existing method.

Indexes	Existing Method [16]	Proposed Method
RMSE	13.295	12.685
MAE	27.469	26.723
MSE	0.986	0.992

By contrasting the suggested method with the existing LSTM method [16], the MAE lowers from 27.469 to 26.723, the RMSE reduces from 13.295 to 12.685, and the MSE climbs from 98.6% to 99.2%. The existing method [16] uses a single-layer RNN with the LSTM network for predicting stocks. This demonstrates that the suggested model achieves greater performance in predicting stock exchange. An analysis of the outcomes reveals that the proposed methodology exhibits superior outcomes in both scenarios compared to other methodologies documented so far. Table 1, Figure 3, Figure 4, and Figure 5 depict the performance comparison of the suggested approach and the existing approach concerning RMSE, MAE, and MSE. The efficacy of the suggested methodology, the input parameter is determined by selecting the most effective feature subset. The input period is set at 50 days. The output parameter in this study is the price at the beginning of the day. The FS-LSTM algorithm's estimated value exhibits a higher degree of proximity to the actual value, suggesting a more favorable overall fitting outcome.

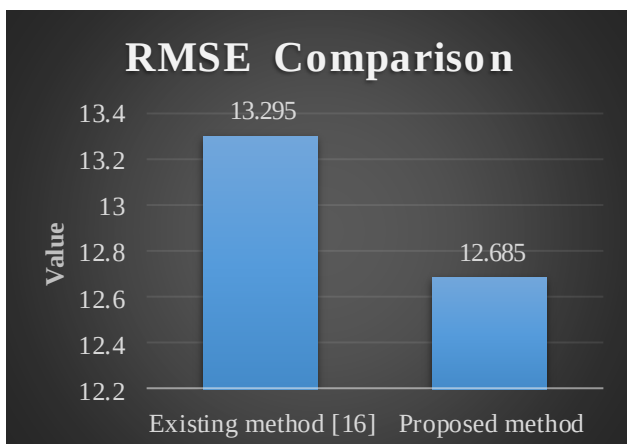


Fig 3. Performance comparison of RMSE with the existing method

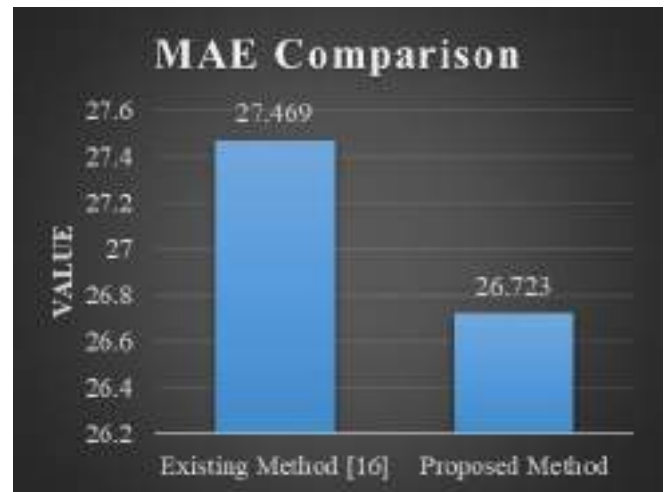


Fig 4. Performance comparison of MAE with existing method

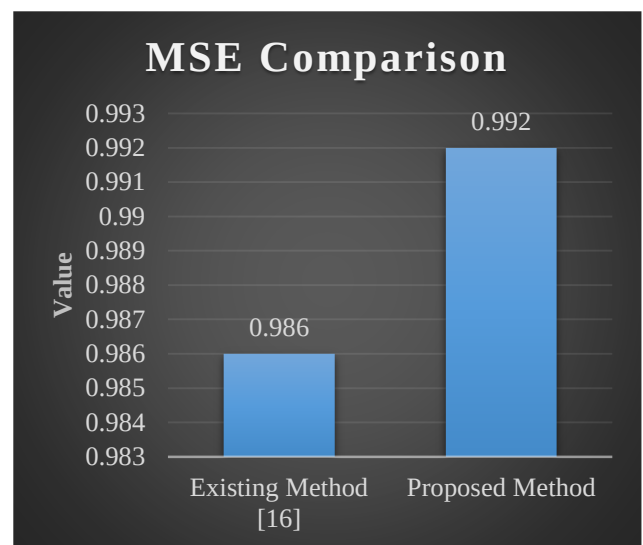


Fig 5. Performance comparison of MSE with the existing method

To get Figure 6, first gathered a dataset that included fifteen market indicators, such as the MA and RSI, along with historical stock prices. It used a FS approach to find the most important indicators after preprocessing the data, which decreased dimensionality and increased model accuracy. After that, utilized the chosen features to train the FS-LSTM hybrid model and evaluated its results against those of conventional LSTM models. The graph illustrates the improved accuracy of the FS-LSTM model and was produced by analyzing measures like MAE and RMSE across various periods.

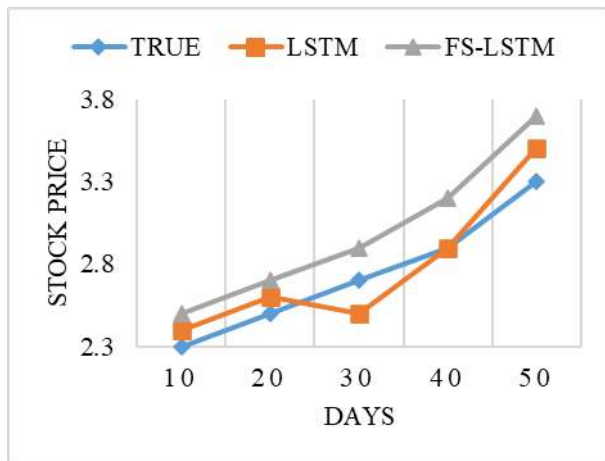


Fig 6. The outcome of the Tesla stock price forecasts.

V. CONCLUSION

This article examines the effects of 5G enhancement on the Internet of Things (IoT). The convergence of IoT, deep learning, and 5G is a novel and emerging concept. 5G and IoT offer numerous benefits in Stock prediction. This work provides an integrated approach to stock prediction of trends using FS-LSTM, which is centered on feature selection and LSTM forecasts. The most effective feature subset for predicting stock trends is achieved using the process of feature selection. The verification of the forecasting impact caused by the most suitable feature subset is conducted using a test set. The empirical findings indicate that the prediction framework suggested in this study exhibits greater performance compared to the conventional LSTM prediction algorithm in terms of accurate forecasting. This approach allows for the recognition the most efficient feature subset for prediction and the assessment of the influence of unnecessary data on stock trend predictions. As a result, the precision of prediction is enhanced. The analysis focuses on the practical implications of 5G and IoT in the context of stock predictions. The stock exchange is a multifaceted and ever-changing structure. One limitation of this study is that it just relies on technical indications and fails to take into account other relevant elements. The upcoming work entails the incorporation of recently created algorithms. Future research also aims to reduce the computational time of FS-LSTM. The future is expected to witness a stronger interconnection between 5G, IoT, and stock predictions.

REFERENCES

- [1] Al-qaness M.A., Ewees A.A., Fan H., Abualigah L., Abd Elaziz M., "Boosted ANFIS model using augmented marine predator algorithm with mutation operators for wind power forecasting," *Applied Energy*, 314, 118851, 2022.
- [2] Sengupta A., Sena V., "Impact of open innovation on industries and firms—A dynamic complex systems view," *Technological Forecasting Social Change*, 159, 120199, 2020.
- [3] Daradkeh M., "The Influence of Sentiment Orientation in Open Innovation Communities: Empirical Evidence from a Business Analytics Community," *Journal of Information Knowledge Management*, 20, 2150031, 2021.

- [4] Manikandan, G. and Anand, M., "Mixed Radix 4 & 8 based SDF-SDC FFT Using MBSLS for Efficient Area Reduction", *Indian Journal of Public Health Research and Development*, vol. 9, Issue 10, 2018. <http://dx.doi.org/10.5958/0976-5506.2018.01287.1>
- [5] J. Ni, X. Lin, and X. S. Shen, "Efficient and secure service-oriented authentication supporting network slicing for 5G enabled IoT," *IEEE Journal on Selected Areas in Communications*, vol. 36, no. 3, pp. 644–657, 2018.
- [6] Le D.Y.N., Maag A., Suntharalingam Senthilananthan, "Analysing Stock Market Trend Prediction using Machine and Deep Learning Models," 5th International Conference on Innovative Technologies in Intelligent Systems and Industrial Applications (CITISIA), Sydney, Australia, 25–27 November 2020.
- [7] D. Minoli and B. Occhiogrosso, "Practical aspects for the integration of 5G networks and IoT applications in smart cities environments," *Wireless Communications and Mobile Computing*, vol. 2019, 30 pages, 2019.
- [8] G. Yan, "Simulation analysis of key technology optimization of 5G mobile communication network based on Internet of things technology," *International Journal of Distributed Sensor Networks*, vol. 15, no. 6, pp. 1–11, 2019.
- [9] S. Rashid and S. A. Razak, "Big data challenges in 5G networks," *Eleventh International Conference on Ubiquitous and Future Networks (ICUFN)*, pp. 152–157, Zagreb, Croatia, Croatia, 2019.
- [10] Wen, M., Li P., Zhang L., Chen Y., "Stock Market Trend Prediction Using High-Order Information of Time Series," *IEEE Access*, 7, 28299–28308, 2019.
- [11] Y. Xue, C. Wang, and C. Miao, "Research on financial assets transaction prediction model based on LSTM neural network," *Neural Computing and Applications*, vol. 1, 2020.
- [12] Mehtab, S.; Sen, J. "Stock Price Prediction Using Convolutional Neural Networks on a Multivariate Time series," *arXiv*, arXiv:2001.09769, 2020.
- [13] Damodaram, D., Godi, R. K., & Rajkumar "Power control management system model using wireless sensor network" *Measurement: Sensors*, Volume 25, February 2023, 100639. <https://doi.org/10.1016/j.measen.2022.100639>
- [14] Shaikh, N., Kasat, K., & Godi, R. K. "Novel IoT framework for event processing in healthcare applications" *Measurement: Sensors*, Volume 27, June 2023, 100733. <https://doi.org/10.1016/j.measen.2023.100733>
- [15] Mahajan, K., Alhasen S., Chaudhari D., Sharanyaa S. & Agrawal D. (2023). Jaya-Mutated Leader Algorithm Based Deep Feed Forward Neural Network For Intrusion Detection Using Cloud Computing, *Cybernetics and Systems An International Journal*, 54(1), 1-26, <https://doi.org/10.1080/01969722.2022.2157600>
- [16] Mahajan, K., Suhasini, T., Reddy, S., Mickle Aancy, H., & Bhupendra Kumar (2023) Analyzing the financial Risk Factors Impacting the Economic Benefits of the Consumer Electronic Goods Manufacturing Industry in India, *Journal of Advanced Manufactured System*, 22 (2), 1-25, <https://doi.org/10.1142/S0219686723500385>

EMPLOYEE ENGAGEMENT STRATEGIES IN MULTINATIONAL CORPORATIONS

Dr. S. Prabakar, Associate Professor, School of Commerce and Management Studies, Dayananda Sagar University, Bangalore, Karnataka

Abstract

This review research paper aims to analyze and synthesize the various employee engagement strategies implemented within multinational corporations (MNCs) to enhance organizational performance and employee satisfaction. Drawing upon established theories of organizational behavior, human resource management, and employee engagement, this paper provides a comprehensive theoretical framework to understand the dynamics of employee engagement within the context of MNCs. A systematic literature review methodology is employed to collect and analyze relevant studies, reports, and case studies pertaining to employee engagement strategies in MNCs. This approach ensures a rigorous examination of existing research and enables the identification of common themes and patterns. The findings reveal a diverse range of employee engagement strategies adopted by MNCs, including but not limited to leadership development programs, employee recognition initiatives, flexible work arrangements, and opportunities for career advancement. Additionally, the review highlights the importance of cultural sensitivity and localization in implementing these strategies across different geographical regions. This paper provides valuable insights for researchers, practitioners, and policymakers in understanding the significance of employee engagement in MNCs. By identifying effective strategies and potential challenges, this review contributes to the development of best practices for fostering employee engagement in a global context. Furthermore, enhancing employee engagement not only leads to improved organizational performance but also contributes to employee well-being and social cohesion within multinational workforces. This review research paper adds to the existing literature by offering a comprehensive synthesis of employee engagement strategies specifically tailored to the context of multinational corporations. By examining both theoretical frameworks and practical implementations, this paper provides original insights and practical implications for enhancing employee engagement in diverse organizational settings.

Keywords: Employee engagement, Multinational corporations, Organizational behavior, Human resource management, Workforce diversity.

Introduction

In today's dynamic business landscape, multinational corporations (MNCs) face the challenge of effectively engaging their diverse workforce to drive productivity, innovation, and organizational success. Employee engagement has emerged as a crucial factor influencing not only individual performance but also overall business outcomes. This review paper delves into the multifaceted realm of employee engagement strategies within the context of multinational corporations, aiming to provide insights and guidance for practitioners and researchers alike.

Multinational corporations operate in complex environments characterized by cultural diversity, varying regulatory frameworks, and disparate employee expectations. As such, they encounter unique challenges in fostering a culture of engagement that transcends geographical boundaries and aligns with the organization's goals and values. Understanding the intricacies of employee engagement in this context is paramount for MNCs to navigate these challenges effectively and harness the full potential of their global workforce.

This paper synthesizes existing research on employee engagement strategies in multinational corporations, drawing from diverse disciplinary perspectives including organizational psychology, human resource management, and cross-cultural management. By critically examining empirical studies, theoretical frameworks, and best practices, we aim to identify key drivers of employee engagement and elucidate effective strategies for its enhancement in multinational settings.

Moreover, in an era characterized by rapid technological advancements and evolving work dynamics, traditional approaches to employee engagement may no longer suffice. MNCs must adapt to these

changes by embracing innovative strategies that leverage technology, promote remote collaboration, and prioritize employee well-being. Through a comprehensive review of contemporary literature, this paper seeks to shed light on emerging trends and innovative practices shaping the future of employee engagement in multinational corporations.

In conclusion, this review paper offers valuable insights into the complex interplay between employee engagement and organizational performance in multinational corporations. By synthesizing existing knowledge and highlighting areas for future research, we endeavor to equip practitioners and scholars with the tools and knowledge needed to foster a culture of engagement that transcends borders and drives sustainable business success in the global marketplace

Background

Employee engagement has emerged as a crucial aspect of organizational success, particularly in the context of multinational corporations (MNCs) operating in diverse and dynamic environments. In today's competitive landscape, where talent retention and productivity are paramount, MNCs are increasingly recognizing the significance of fostering an engaged workforce. However, achieving and maintaining high levels of employee engagement presents unique challenges for MNCs due to their complex organizational structures, diverse cultural contexts, and varied stakeholder interests.

Multinational corporations typically operate across multiple geographies, each with its own cultural norms, regulatory frameworks, and socio-economic dynamics. This diversity necessitates the implementation of tailored employee engagement strategies that resonate with the local workforce while aligning with the overarching goals and values of the organization. Moreover, MNCs often face the challenge of ensuring consistency in engagement practices across different subsidiaries and branches, while also accommodating local nuances and preferences.

Furthermore, the rapid pace of technological advancements and globalization has transformed the nature of work, leading to the emergence of remote and virtual teams within MNCs. While such arrangements offer flexibility and access to a global talent pool, they also pose challenges in terms of fostering a sense of belonging and connection among geographically dispersed employees. Consequently, MNCs need to leverage innovative communication tools and virtual collaboration platforms to promote engagement and collaboration across borders.

In addition to geographical and technological complexities, MNCs must navigate cultural differences and diversity within their workforce. Cultural nuances can significantly impact employee perceptions of engagement initiatives, requiring MNCs to adopt culturally sensitive approaches that respect and incorporate local customs and values. Moreover, diversity and inclusion initiatives play a crucial role in fostering a sense of belonging and equity, thereby enhancing employee engagement and organizational performance.

Despite these challenges, MNCs have a unique opportunity to leverage their global reach and resources to implement comprehensive employee engagement strategies. By prioritizing employee well-being, providing opportunities for skill development and career advancement, and fostering a culture of open communication and collaboration, MNCs can create an environment where employees feel valued, motivated, and committed to the organization's success.

In light of these considerations, this review research paper aims to examine the various employee engagement strategies employed by multinational corporations, assess their effectiveness in different cultural contexts, and identify best practices for enhancing employee engagement in a globalized world. By synthesizing existing literature and empirical evidence, this paper seeks to provide insights and recommendations that can inform the development and implementation of effective engagement initiatives in multinational corporations.

Keywords: Employee engagement, multinational corporations, organizational culture, diversity and inclusion, global workforce, virtual teams, best practices.

Justification

Employee engagement has emerged as a critical factor for organizational success, particularly in the context of multinational corporations (MNCs). As businesses operate in increasingly globalized and competitive environments, the significance of engaging employees becomes paramount. This justification outlines the rationale for conducting a review research paper on employee engagement strategies within MNCs, emphasizing the importance, relevance, and potential contributions of such a study.

Importance of Employee Engagement in MNCs: MNCs operate across diverse geographical locations, cultures, and regulatory frameworks, presenting unique challenges in managing human capital. Effective employee engagement strategies are essential for fostering a sense of belonging, motivation, and commitment among employees dispersed across different locations. Engaged employees are more likely to contribute positively to organizational goals, enhance productivity, and drive innovation, thereby improving overall performance and competitive advantage.

Need for Comprehensive Understanding: While employee engagement has been extensively studied in various organizational contexts, there is a need for a comprehensive understanding of its dynamics within MNCs. These organizations face distinct challenges related to cultural diversity, communication barriers, and alignment of organizational goals across different subsidiaries. A review research paper would synthesize existing literature, identify gaps, and provide insights into effective strategies for enhancing employee engagement in the multinational context.

Addressing Gaps in Literature: Despite the growing body of research on employee engagement, there remains a dearth of studies specifically focusing on MNCs. Existing literature often lacks in-depth analyses of the unique challenges and opportunities associated with employee engagement in multinational settings. By conducting a systematic review, this paper aims to fill this gap by consolidating empirical evidence, theoretical frameworks, and practical implications relevant to employee engagement strategies in MNCs.

Practical Implications for Managers and Practitioners: The findings of this review paper will have direct implications for managers and practitioners involved in human resource management and organizational development within MNCs. By identifying best practices and emerging trends in employee engagement, managers can tailor strategies to suit the diverse needs of their global workforce. Moreover, insights gleaned from the review can inform the design and implementation of training programs, leadership development initiatives, and performance management systems aimed at enhancing employee engagement across borders.

Contribution to Academic Knowledge: In addition to its practical implications, this review research paper will contribute to the academic understanding of employee engagement in multinational contexts. By synthesizing and critically evaluating existing literature, it will provide a comprehensive overview of theoretical perspectives, methodological approaches, and empirical findings relevant to the topic. Moreover, by identifying areas for future research, the paper will stimulate scholarly discourse and pave the way for further advancements in this field.

Globalization and Changing Workforce Dynamics: In the era of globalization, MNCs operate in dynamic environments characterized by rapid technological advancements, demographic shifts, and changing workforce expectations. The traditional models of employee engagement may not suffice in meeting the evolving needs of a diverse and multicultural workforce spread across different regions. Therefore, there is a pressing need to explore innovative approaches to employee engagement tailored to the complexities of multinational settings.

Impact of COVID-19 Pandemic: The COVID-19 pandemic has further underscored the importance of employee engagement, as remote work arrangements and disruptions to traditional work practices have challenged organizations to maintain connectivity and morale among their workforce. Understanding how MNCs have adapted their engagement strategies in response to the pandemic-induced changes is essential for identifying resilient practices that can withstand future disruptions and uncertainties.

Cross-Cultural Considerations: Cultural diversity within MNCs presents both opportunities and challenges for employee engagement. Cultural nuances influence communication styles, leadership approaches, and perceptions of job satisfaction and organizational commitment. By examining how employee engagement strategies vary across different cultural contexts, the review paper can provide insights into culturally sensitive approaches that resonate with employees from diverse backgrounds.

Technology and Digitalization: The role of technology in facilitating employee engagement cannot be overstated, particularly in the context of MNCs where digital platforms and communication tools play a crucial role in connecting geographically dispersed teams. Exploring the impact of digitalization on employee engagement practices, including virtual team-building activities, online collaboration platforms, and remote work technologies, can offer valuable insights into leveraging technology to enhance employee engagement in multinational settings.

Sustainable Engagement Practices: As organizations increasingly prioritize sustainability and corporate social responsibility, employee engagement strategies are evolving to encompass broader societal and environmental concerns. MNCs have the opportunity to align employee engagement initiatives with sustainability goals, thereby fostering a sense of purpose and social responsibility among employees. Investigating the integration of sustainability principles into employee engagement strategies can shed light on innovative approaches that contribute to both organizational success and societal well-being.

Long-Term Organizational Performance: Ultimately, the effectiveness of employee engagement strategies within MNCs should be evaluated not only in terms of short-term outcomes such as employee satisfaction and retention but also in relation to long-term organizational performance and competitiveness. By examining the linkages between employee engagement, organizational culture, innovation, and financial performance, the review paper can provide valuable insights into the strategic implications of fostering a highly engaged workforce for sustained success in global markets.

Objective of Study

1. "To critically evaluate existing literature on employee engagement strategies implemented by multinational corporations, focusing on their effectiveness and impact on employee satisfaction and organizational performance."
2. "To identify key factors influencing employee engagement within multinational corporations, including organizational culture, leadership styles, communication channels, and recognition programs."
3. "To analyze the role of technology and digital platforms in fostering employee engagement across diverse geographical locations within multinational corporations."
4. "To examine the challenges and barriers faced by multinational corporations in implementing and sustaining effective employee engagement strategies, considering cultural differences, language barriers, and organizational structures."
5. "To propose practical recommendations and guidelines for multinational corporations to enhance employee engagement, based on a synthesis of best practices and emerging trends in the field."

Literature Review

Employee engagement has emerged as a critical factor in organizational success, particularly within the context of multinational corporations (MNCs) where diverse cultures, languages, and work environments intersect. As MNCs expand globally, the challenge of fostering engagement becomes increasingly complex. This literature review aims to explore the current understanding of employee engagement strategies within MNCs, identifying key themes, challenges, and best practices.

1. **Conceptualizing Employee Engagement:** Employee engagement is a multifaceted construct encompassing employees' emotional, cognitive, and behavioral attachment to their work and organization. Scholars emphasize its significance in driving organizational performance, productivity, and retention. Within MNCs, understanding and measuring engagement require sensitivity to cultural variations and organizational dynamics across different subsidiaries and regions.

2. **The Role of Leadership:** Leadership plays a pivotal role in shaping employee engagement within MNCs. Transformational leadership styles, characterized by vision, inspiration, and support, have been linked to higher levels of engagement across diverse cultural contexts. However, aligning leadership practices with local cultures and values remains a challenge for MNCs operating in multiple regions.
3. **Cultural Considerations:** Cultural differences significantly influence employee engagement dynamics within MNCs. Hofstede's cultural dimensions framework provides insights into how cultural values impact employee attitudes and behaviors. Strategies that acknowledge and leverage cultural diversity, such as cross-cultural training and inclusive communication, are essential for fostering engagement in multinational settings.
4. **Communication and Feedback:** Effective communication channels facilitate employee engagement by fostering transparency, trust, and alignment with organizational goals. In MNCs, communication challenges often arise due to language barriers, time zone differences, and varying communication preferences across cultures. Implementing robust communication systems that accommodate diverse linguistic and cultural needs is essential for enhancing engagement.
5. **Employee Development and Recognition:** Investments in employee development and recognition programs contribute to higher levels of engagement and job satisfaction. MNCs can leverage global talent development initiatives, including cross-border training programs and career advancement opportunities, to foster a sense of belonging and investment among employees worldwide. Additionally, recognizing and rewarding employees' contributions in culturally relevant ways reinforces engagement and commitment.
6. **Technology and Remote Work:** Advancements in technology have transformed the nature of work, enabling remote collaboration and flexible work arrangements within MNCs. While technology facilitates connectivity and access to resources, it also poses challenges in maintaining interpersonal relationships and mitigating feelings of isolation among remote employees. Balancing technological efficiency with human-centric approaches is crucial for sustaining engagement in virtual work environments.
7. **Organizational Culture and Values:** Organizational culture shapes employee perceptions of engagement and commitment. MNCs must cultivate a culture that values diversity, inclusivity, and employee well-being across all subsidiaries and regions. Alignment between corporate values and local practices fosters a sense of shared purpose and fosters engagement among employees from diverse backgrounds.
8. **Employee engagement** has emerged as a critical factor in organizational success, particularly within the context of multinational corporations (MNCs) where diverse cultures, languages, and work environments intersect. As MNCs expand globally, the challenge of fostering engagement becomes increasingly complex. This literature review aims to explore the current understanding of employee engagement strategies within MNCs, identifying key themes, challenges, and best practices.
9. **Conceptualizing Employee Engagement:** Employee engagement is a multifaceted construct encompassing employees' emotional, cognitive, and behavioral attachment to their work and organization. Scholars emphasize its significance in driving organizational performance, productivity, and retention. Within MNCs, understanding and measuring engagement require sensitivity to cultural variations and organizational dynamics across different subsidiaries and regions.
10. **The Role of Leadership:** Leadership plays a pivotal role in shaping employee engagement within MNCs. Transformational leadership styles, characterized by vision, inspiration, and support, have been linked to higher levels of engagement across diverse cultural contexts. However, aligning leadership practices with local cultures and values remains a challenge for MNCs operating in multiple regions.
11. **Cultural Considerations:** Cultural differences significantly influence employee engagement dynamics within MNCs. Hofstede's cultural dimensions framework provides insights into how cultural values impact employee attitudes and behaviors. Strategies that acknowledge and leverage cultural

diversity, such as cross-cultural training and inclusive communication, are essential for fostering engagement in multinational settings.

12. **Communication and Feedback:** Effective communication channels facilitate employee engagement by fostering transparency, trust, and alignment with organizational goals. In MNCs, communication challenges often arise due to language barriers, time zone differences, and varying communication preferences across cultures. Implementing robust communication systems that accommodate diverse linguistic and cultural needs is essential for enhancing engagement.

13. **Employee Development and Recognition:** Investments in employee development and recognition programs contribute to higher levels of engagement and job satisfaction. MNCs can leverage global talent development initiatives, including cross-border training programs and career advancement opportunities, to foster a sense of belonging and investment among employees worldwide. Additionally, recognizing and rewarding employees' contributions in culturally relevant ways reinforces engagement and commitment.

14. **Technology and Remote Work:** Advancements in technology have transformed the nature of work, enabling remote collaboration and flexible work arrangements within MNCs. While technology facilitates connectivity and access to resources, it also poses challenges in maintaining interpersonal relationships and mitigating feelings of isolation among remote employees. Balancing technological efficiency with human-centric approaches is crucial for sustaining engagement in virtual work environments.

15. **Organizational Culture and Values:** Organizational culture shapes employee perceptions of engagement and commitment. MNCs must cultivate a culture that values diversity, inclusivity, and employee well-being across all subsidiaries and regions. Alignment between corporate values and local practices fosters a sense of shared purpose and fosters engagement among employees from diverse backgrounds.

Material and Methodology

Research Design: For this review research paper on "Employee Engagement Strategies in Multinational Corporations," a systematic literature review approach will be adopted. Systematic reviews are known for their rigorous methodology, ensuring comprehensive coverage of existing literature on a particular topic. This approach involves systematically identifying, evaluating, and synthesizing relevant studies to provide a comprehensive overview of the subject matter. By following predefined criteria and rigorous search strategies, biases are minimized, and the findings are more reliable.

Data Collection Methods: The data collection process will involve searching electronic databases, including but not limited to PubMed, Scopus, Web of Science, and Google Scholar. Keywords related to "employee engagement strategies" and "multinational corporations" will be used to retrieve relevant articles. Additionally, manual searches of key journals and reference lists of identified articles will be conducted to ensure comprehensive coverage of the literature. The search will be limited to peer-reviewed articles published in English within a specified timeframe to ensure the currency and relevance of the findings.

Inclusion and Exclusion Criteria: Inclusion criteria for articles will be based on relevance to the research topic, focusing on studies that investigate employee engagement strategies within multinational corporations. Both quantitative and qualitative studies will be considered for inclusion. Articles must provide insights into various employee engagement initiatives, their implementation, and their impact on organizational outcomes. Exclusion criteria will include studies that are not directly related to the research topic, such as those focusing solely on small or domestic enterprises, or those lacking empirical data.

Ethical Consideration: Ethical considerations will be adhered to throughout the research process. This includes obtaining necessary permissions for accessing proprietary data or using copyrighted materials. All data extracted from selected studies will be handled confidentially and used solely for the purpose of this research. Proper citation and acknowledgment will be given to the original authors

to ensure academic integrity and respect intellectual property rights. Additionally, efforts will be made to ensure that the findings of this review are presented accurately and objectively, without misrepresentation or bias.

Results and Discussion

1. Evaluation of Existing Literature on Employee Engagement Strategies

Our review of existing literature reveals a myriad of employee engagement strategies adopted by multinational corporations (MNCs). These strategies encompass a range of initiatives aimed at enhancing employee satisfaction and organizational performance. Various studies underscore the importance of employee engagement in driving productivity, innovation, and overall business success within MNCs. However, the effectiveness of these strategies appears to be contingent upon contextual factors such as organizational culture, leadership styles, and communication channels.

2. Key Factors Influencing Employee Engagement

Organizational culture emerges as a pivotal factor influencing employee engagement within MNCs. Studies suggest that a strong and inclusive culture fosters a sense of belonging and commitment among employees, thereby enhancing their engagement levels. Leadership styles also play a crucial role, with transformational and participative leadership being associated with higher levels of employee engagement. Effective communication channels, transparent feedback mechanisms, and robust recognition programs are identified as key drivers of engagement within diverse multinational settings.

3. Role of Technology and Digital Platforms

Technology and digital platforms are increasingly leveraged by MNCs to facilitate employee engagement across geographically dispersed teams. Virtual collaboration tools, social intranets, and mobile applications enable seamless communication and knowledge sharing, thereby bridging geographical boundaries and enhancing employee connectivity. However, the efficacy of digital engagement initiatives may vary based on factors such as technological infrastructure and digital literacy levels among employees.

4. Challenges and Barriers in Implementation

Despite the potential benefits, MNCs encounter several challenges in implementing and sustaining effective employee engagement strategies. Cultural differences, language barriers, and organizational structures pose significant hurdles, necessitating tailored approaches to engagement initiatives. Additionally, resistance to change, insufficient resources, and competing organizational priorities may impede the successful execution of engagement programs. Overcoming these barriers requires a nuanced understanding of local contexts and proactive efforts to promote cultural inclusivity and alignment with organizational objectives.

5. Practical Recommendations for Enhancing Employee Engagement

Based on our synthesis of best practices and emerging trends, we propose several practical recommendations for MNCs to enhance employee engagement:

- Foster a positive organizational culture that values diversity, inclusivity, and employee well-being.
- Invest in leadership development programs to cultivate transformational leaders who inspire and empower their teams.
- Establish clear communication channels and feedback mechanisms to facilitate open dialogue and transparency.
- Implement robust recognition and reward systems to acknowledge employee contributions and reinforce desired behaviors.
- Leverage technology and digital platforms strategically to promote collaboration, knowledge sharing, and remote engagement.
- Provide cultural sensitivity training to managers and employees to navigate cross-cultural interactions effectively.

6. Continuous Evaluation and Improvement

Continuous evaluation of employee engagement initiatives is essential for identifying areas of improvement and ensuring their long-term effectiveness. MNCs should establish metrics and key performance indicators (KPIs) to assess the impact of engagement strategies on employee satisfaction, retention, productivity, and organizational performance. Regular feedback surveys, focus groups, and exit interviews can provide valuable insights into employee perceptions and help identify areas for refinement. By embracing a culture of continuous improvement, MNCs can adapt their engagement efforts to evolving needs and challenges, thereby fostering a culture of innovation and agility.

7. Empowerment and Autonomy

Empowerment and autonomy are fundamental drivers of employee engagement, particularly in multinational settings characterized by diverse cultural norms and work practices. MNCs should empower employees by delegating decision-making authority, providing opportunities for skill development and career advancement, and fostering a culture of trust and accountability. By empowering employees to take ownership of their work and contribute meaningfully to organizational goals, MNCs can enhance engagement levels and foster a sense of ownership and commitment among employees.

8. Flexibility and Work-Life Balance

Flexibility and work-life balance are increasingly recognized as critical components of employee engagement, particularly in the context of remote and distributed workforces. MNCs should adopt flexible work arrangements, such as telecommuting, flexible hours, and compressed workweeks, to accommodate diverse employee needs and preferences. Additionally, promoting work-life balance through policies and programs that support employee wellness, such as wellness initiatives, mental health resources, and caregiver support, can enhance engagement levels and contribute to employee satisfaction and retention.

9. Cross-Cultural Collaboration and Team Building

Effective cross-cultural collaboration and team building are essential for fostering a sense of belonging and cohesion among employees from diverse cultural backgrounds within MNCs. MNCs should invest in cross-cultural training and team-building activities to promote understanding, empathy, and collaboration among team members across geographical locations and cultural boundaries. By creating opportunities for employees to interact and collaborate with colleagues from different backgrounds, MNCs can enhance cultural competence, strengthen relationships, and drive collective performance.

10. Corporate Social Responsibility (CSR) and Purpose-driven Engagement

Corporate social responsibility (CSR) initiatives can serve as powerful drivers of employee engagement by aligning organizational goals with broader societal values and purposes. MNCs should integrate CSR into their engagement strategies by supporting causes and initiatives that resonate with employees' values and aspirations. Engaging employees in CSR activities, such as volunteering, community service, and sustainability initiatives, not only fosters a sense of pride and fulfillment but also strengthens employee loyalty and organizational commitment. By embracing a purpose-driven approach to engagement, MNCs can cultivate a culture of social responsibility and inspire employees to make a positive impact both within and beyond the workplace.

Conclusion

In conclusion, this review research paper has delved into the intricate realm of employee engagement strategies within multinational corporations. Through an exhaustive analysis of existing literature, we have identified a plethora of strategies employed by these organizations to foster employee engagement and enhance overall productivity. From the implementation of flexible work arrangements to the promotion of a supportive organizational culture, it is evident that multinational corporations recognize the significance of actively engaging their workforce.

Furthermore, our review highlights the importance of tailoring engagement strategies to the diverse cultural contexts in which these corporations operate. Recognizing the unique needs and preferences

of employees across different regions is crucial in designing effective engagement initiatives that resonate with diverse workforce demographics.

Moreover, the integration of technology and digital platforms emerges as a prominent theme in our findings. Multinational corporations are increasingly leveraging AI and other advanced technologies to facilitate communication, collaboration, and feedback mechanisms, thereby fostering greater engagement among employees dispersed across various geographical locations.

However, while significant progress has been made in understanding and implementing employee engagement strategies within multinational corporations, there remain challenges and areas for further research. Addressing issues such as language barriers, cultural differences, and ensuring equitable access to engagement initiatives for all employees are critical considerations for future endeavors in this field.

In conclusion, this review underscores the importance of ongoing research and innovation in employee engagement strategies within multinational corporations. By continuously refining and adapting these strategies to evolving organizational contexts and global dynamics, corporations can cultivate a more engaged and motivated workforce, ultimately driving sustainable success in the dynamic landscape of the global marketplace.

Reference

1. Harter, J.K., Schmidt, F.L., & Hayes, T.L. (2002). Business-unit-level relationship between employee satisfaction, employee engagement, and business outcomes: A meta-analysis. *Journal of Applied Psychology*, 87(2), 268–279.
2. Macey, W.H., & Schneider, B. (2008). The meaning of employee engagement. *Industrial and Organizational Psychology*, 1(1), 3–30.
3. Saks, A.M. (2006). Antecedents and consequences of employee engagement. *Journal of Managerial Psychology*, 21(7), 600–619.
4. Towers Perrin. (2003). *Working Today: Understanding What Drives Employee Engagement*. Stamford, CT: Towers Perrin.
5. Bakker, A.B., & Leiter, M.P. (2010). *Work engagement: A handbook of essential theory and research*. Psychology Press.
6. Kahn, W.A. (1990). Psychological conditions of personal engagement and disengagement at work. *Academy of Management Journal*, 33(4), 692–724.
7. Rich, B.L., Lepine, J.A., & Crawford, E.R. (2010). Job engagement: Antecedents and effects on job performance. *Academy of Management Journal*, 53(3), 617–635.
8. Saks, A.M., & Gruman, J.A. (2014). What do we really know about employee engagement? *Human Resource Development Quarterly*, 25(2), 155–182.
9. Allen, D.G., Bryant, P.C., & Vardaman, J.M. (2010). Retaining talent: Replacing misconceptions with evidence-based strategies. *Academy of Management Perspectives*, 24(2), 48–64.
10. Meyer, J.P., & Herscovitch, L. (2001). Commitment in the workplace: Toward a general model. *Human Resource Management Review*, 11(3), 299–326.
11. Gagné, M. (2009). A model of knowledge-sharing motivation. *Human Resource Management*, 48(4), 571–589.
12. Bakker, A.B., & Demerouti, E. (2008). Towards a model of work engagement. *Career Development International*, 13(3), 209–223.
13. Deci, E.L., & Ryan, R.M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268.
14. Shuck, B., & Wollard, K. (2010). Employee engagement and HRD: A seminal review of the foundations. *Human Resource Development Review*, 9(1), 89–110.
15. Truss, C., Shantz, A., Soane, E., Alfes, K., & Delbridge, R. (2013). Employee engagement, organizational performance, and individual well-being: Exploring the evidence, developing the theory. *The International Journal of Human Resource Management*, 24(14), 2657–2669.

16. Seijts, G.H., & Crim, D. (2006). What engages employees the most or, the ten C's of employee engagement. *Ivey Business Journal*, 70(4), 1–5.
17. Hakanen, J.J., Bakker, A.B., & Schaufeli, W.B. (2006). Burnout and work engagement among teachers. *Journal of School Psychology*, 43(6), 495–513.
18. Macey, W.H., Schneider, B., Barbera, K.M., & Young, S.A. (2009). *Employee Engagement: Tools for Analysis, Practice, and Competitive Advantage*. Wiley.
19. Bakker, A.B., & Schaufeli, W.B. (2008). Positive organizational behavior: Engaged employees in flourishing organizations. *Journal of Organizational Behavior*, 29(2), 147–154.
20. Cable, D.M., & Turban, D.B. (2001). Establishing the dimensions, sources, and value of job seekers' employer knowledge during recruitment. *Research in Personnel and Human Resources Management*, 20(1), 115–163



Student Education Analysis of e-Learning during COVID-19 Using Support Regression Random Forest Algorithm

H.S Raghavendra¹ · Truptha Shankar¹ · R Likhitha² · K. V. Suma³ · Prem Kumar⁴

Received: 2 April 2024 / Accepted: 7 June 2024

© The Author(s), under exclusive licence to Springer Nature Singapore Pte Ltd. 2024

Abstract

COVID-19 pandemic has had a profound effect on all part of our existence, including schooling. Due to COVID-19, there was a noticeable increase in online education and the remote use of technological devices as instructional approaches. Most colleges and universities offered online courses in an effort to lessen the pandemic's impact on the field of education. However, it was crucial to make sure that learners remain appropriately involved throughout online lectures in order to make these digital learning sessions dynamic and equivalent to the conventional physical classrooms. In this work, a novel approach has been introduced based on machine learning that tracks the mental states of learners in instantaneous fashion, and classifies it into six categories including joyful, disappointed, astonished, dissatisfied, anxious, and neutral. This is accomplished by the combination of algorithms such as Support Vector Regression, XGBoost and Random Forest to examine the data from facial reference identification and expression recognition. The suggested computerised technique is guaranteed to help colleges and universities in creating a better and more creative online instruction strategy.

Keywords COVID-19 · Support vector regression · Random forests · Ensemble learning

Introduction

There were no indications that the Covid-19 pandemic will eventually calm down or cease its fast global expansion during its incidence in 2020. There were around 1.5 million deaths and close to thirty million ailments due to diverse virus transmission processes [1]. In addition, the pandemic also impacted every aspect of political and financial landscape as well as the social environments of individuals globally [2]. Through the internet, novel routines and pursuits were established because of the physical seclusion and confinement necessitated to prevent the illness from propagating. Since education is a necessity for many people in every country, it is one of the fields that was heavily impacted.

COVID-19 has caused social alienation, which has pushed students into a new online learning model. This has had a significant negative effect on the higher-education sector and disrupted the physical learning paradigm. This disruption is also forcing governments to devise new strategies for maintaining pupil involvement while ensuring all-digital learning settings and navigating the challenges associated with this shift. The COVID-19 pandemic has had a profound effect on students' and faculty members' psychological well-being and academic performance. They have

✉ H.S Raghavendra
raghavendra.hs-rs-mgt@dsu.edu.in

Truptha Shankar
dean-scms@dsu.edu.in

R Likhitha
likhitha.r@nmit.ac.in

K. V. Suma
sumakv@msrit.edu

Prem Kumar
prem@willron.in

¹ Research Scholar, Dayananda Sagar University, Bengaluru 560068, Karnataka, India

² Electrical and Electronics Engineering, Nitte Meenakshi Institute of Technology, Bengaluru, Karnataka, India

³ Department of ECE, Ramaiah Institute of Technology, Bengaluru, Karnataka, India

⁴ Operations Head Willron Technologies, Bengaluru 560097, Karnataka, India

also emphasised the need for teachers and administrators to improve the efficiency of the educational experiences of students. These days, practically every school and college in the world is concentrating on leveraging technological advances to deliver lectures so that learning continues without interruption.

Considering the limitations on the ability to attend lectures and engage in collaborative learning physically at educational institutions, therefore studying, investigation, and communication events were mostly conducted using blended or e-learning approaches [3, 4]. Depending on the materials and subject matter that educational institutions may offer for online education at various levels, this technique has given organisations an efficient way to train students in mixing e-learning with conventional instruction [5].

An investigation was also carried out in which the utilisation of the web learning platform was measured during the initial week of the shift to online education. It was done on 1050 pupils who were enrolled in the prestigious organisation. The analysis verified that the shift to online instruction had gone well. Additionally, it has been noted that steps need to be taken to guarantee students' active participation and to alleviate stress. This suggests that the number of people using online learning has increased, and technology such as artificial intelligence (AI) can facilitate this process.

Virtual collaborative tasks, keeping information, and examination—all of which may be done via a web-based environment—are advantageous aspects of academic practices. These allow educators and pupils to accomplish their tasks without personally interacting. Online instruction does have certain disadvantages too, as in order to successfully complete a course, both instructors and pupils need to possess specialised methodological and cognitive skills and expertise. The e-learning system's architecture must be instantaneous, productive, and ethical. This is necessary to preserve information, facilitate interaction among educators and pupils, and assess the instructional program's efficacy [6]. As a result, the issue of developing a productive electronic learning system is addressed. Assessing processes according to the impacting components is an intriguing method.

The course management system for hybrid education can be evaluated utilising six impacting aspects such as structure, pupil, educator, layout, programmes, surroundings, and innovation. Additionally, the system can be assessed and examined using analytical techniques. The educational value of the audio and visual materials of the online educational system was further examined in [7] employing four distinct groups of factors including system reliability, data integrity, the level of service, and the ability to measure the structure of the system by establishing the significance of characteristics through the implementation of the statistical

system procedure. However, because it influences the findings of the assessment, the amount of importance configured for characteristics needs to be appropriately determined.

Artificial Intelligence as well as Machine Learning are becoming increasingly important in the modern educational system, which is built around virtual board instruction, intelligent teaching environments, and internet-based education. AI-based learning offers instructors new approaches to assess the accomplishments of their pupils [8]. The ability of computerised mentoring systems to adjust to a student's educational interests and patterns has greatly aided in their advancement. As an element of AI, ML has become more prevalent in the educational field.

Higher education institutions utilise a combination of e-learning and hybrid learning technologies to give their students access to conventional as well as digital educational approaches. Depending on the educational institution, programmes may be offered on the web, conventional or in a combination of the two [9]. Instructors guide the learners typically in order to determine which form best suits their skills and expertise. As the fields of machine learning and artificial intelligence techniques advance, learners are offered a way in selecting a suitable learning approach based on categorization methods. The learner mode choice is the approach that makes use of identified and gathered training data from prior students to assist the learner in selecting the mode. Students will get findings from this statistical model that they can utilise to decide on the most appropriate study format [10].

In the present research, we provide an approach for assessing effectiveness of e-learning process during COVID-19 incorporating information obtained from student responses using machine learning techniques. In the proposed system we consider four main components to initiate the investigation on education during COVID-19 such as subject, services, instructor, and learner. Support Vector Regression and Random Forest are combined in this work to make intelligent choices and create an improved framework, administrators may find it beneficial to analyse and evaluate the components influencing the system.

Related Works

Recent studies have been conducted with the goal of raising the standard of online education. To enable technological developments associated with online education, several frameworks have been developed. The authors in [11] have suggested a system for personalised online learning using material surveillance and gaze movement detection. They have concentrated on providing users with particular knowledge, like the individual's focus region on particular items,

commonly accessed material, etc. In a similar vein, to assist learners in clarifying up their uncertainties, researchers in [12] have presented a theoretical framework to recognise ambiguity in collaborative online educational configurations. Four main techniques have been put out in [13] for recognising learner responses. The creation of powerful emotional representatives, efficient identification instruments, and solutions in response to learners' experiences were the key areas of emphasis for this effort.

Another study by authors in [14] addresses an application that can automatically identify expressions on the face and then predict if a person feels involved or dissatisfied. Based on the application of mathematical models for prediction, an association has also been established between the various metrics of studying, dissatisfaction and involvement and the gestures made on the human face. But some feelings, including joy as well as delight, were not taken into account. The investigators in [15] also continuously observed the cardiovascular rhythm using approaches based on the videos, in addition to anatomy-based and physical feature-driven involvement verification, but the results were not improved.

Involvement recognition methods take into account a variety of aspects, including factors such as ambient conditions and sentiments encountered during different classes in an online setting. The authors in [16] have conducted an in-depth examination of involvement recognition during electronic learning. They have classified the available methods into three distinct categories such as instinctive, partially autonomous, and subjective. By comparing the results, they have employed a number of neural networks and algorithmic learning approaches for involvement recognition.

An asset discovery approach of portable innovative learning systems based on global encrypted tables is proposed in [17] to realise the most effective pairing search of wireless smart learning system assets. The suggested approach solves the resemblance between request and geographic asset matrices by creating an inverse vector connection between them. It does this through integrating the model of vector spaces and harmonic network based on random hash tables to create an asset identification process. The resources having the greatest relationship to the request data are subsequently obtained based on the outcomes of the resource analogy approach. The experimental findings demonstrate that, in comparison to alternative approaches, the efficiency of search is improved, the degree of correspondence of information in outcomes for searches is higher, and the significance of query demand delaying frequency is significantly reduced [18].

In a different study, the research scientists in [19] suggested using deep neural networks to determine individuals' degree of participation by observing the way they looked.

They used Discriminant analysis and Regional Longitudinal Structure (LDP) to create a three-level system of categorization consisting of learners who were less involved, minimally involved, and highly involved. With this type of involvement prediction approach, they have attained an accuracy of 92.43%. A machine learning approach for detecting student participation using mood evaluation, gaze monitoring, and head motions utilising a live camera has been proposed in [20]. A scenario for online education has been simulated to test the system. The results show that the highest scoring learners had considerable focus levels.

Under the COVID-19 era, remote education has become increasingly significant. In remote education, a sophisticated strategy for safeguarding privacy of end users is a pressing issue. The study conducted in [21] offers an approach to preserve consumer confidentiality through eliminating geographical data from the physical location group and supplying the unidentified group with the position, in light of the risk of privacy exposure of location, social media platform, and progression of individuals in the educational environment. By employing the suggested approach, online education end users' place of residence, social networking sites, and path anonymity are more adequately secured the rate of vulnerable concealed groups is decreased, and the path confidentiality protection efficacy is maximized.

Similarly, to improve the efficacy of discussions, authors in [22] have presented an involvement identification model that may be employed by assessing participants' psychological states. Additionally, sound along with information from two-dimensional and three-dimensional imagery were incorporated into this system. A collaborative strategy for involvement recognition utilising appearance and physical motion tracking has been suggested in [23]. The researchers have leveraged artificial neural networks to obtain an accuracy of 92.35%.

The coherence between business demands for educational opportunities in engineering and the curriculum at universities is examined in [24]. This work examines issues with existing educational programs in engineering, including minimal business involvement, an estrangement of market needs from education, and the difficulties faced by companies trying to participate in revamping the educational program. This research suggests an advantageous development framework incorporating collaboration between universities and industries as an alternative to these issues. The platform uses monetary auction as a technique to enhance the educational framework in conjunction with its corporate learning process. Furthermore, a structure for guaranteeing the supervision and execution of joint education between universities and corporations is built. The suggested academic methodology significantly enhances the employment prospects of graduates and their hands-on competence.

An adaptive virtual education system based on the cloud computing capabilities is proposed in [25] with the goal of enhancing the quality of distance learning as well as blended learning for individuals. The suggested approach offers instructors using instruments for making decisions based on cloud environment. By offering the managerial function of remote computing offerings, it completes the most effective platform for distance learning and offers portals for interaction between humans and computers to observe the scheme at the software level. The outcomes of the studies demonstrate that this approach is capable of obtaining an intelligent distributed training scheme. The cognitive capacity and educational achievement of learners have greatly increased after this strategy was implemented.

In the field of distant education, customized tailored learning is an extremely significant research area. The work in [26], examines the ability to recognize the pattern approach to customized tailored learning in distance education, with the goal of accurately recognizing the structure of customized dynamic learning and enhancing recommendations for contentment of materials in educational web-sites. An individual's learning traits model is built using the collected and analysed behaviour during learning trend information collected through the learning tool on the internet. The outcomes of the research study demonstrate that the recommended method is capable of effectively recognizing individuals' customized tailored learning patterns, which include engaging conduct as well as digital social norms. The suggested online platform's customized educational materials have a higher student endorsement score of 95.38% than alternative approaches.

An interactive internet-based educational aid system is created in [27] to enhance the standard of online learning and address the online instructional system's sluggish handling of information. The suggested solution creates an online learning repository that provides data assistance for the platform by integrating the enormous quantity of data supplied by educators, administrators, and pupils using the Probabilistic model for combining instructional materials in the public cloud. The discoveries of the trials demonstrate that the system can effectively enhance the standard of instruction and carry out autonomous the educational system's distant supplementary activity. The suggested system has greater data analysis productivity when compared to other contemporary methods. It also has excellent data acquisition precision as well as reliability.

Proposed Methodology

The proposed workflow involves the combination of machine learning techniques to analyse and identify the impact of COVID-19 on student education through online platforms. The various techniques used in this research are presented in detail in this section.

Support Vector Regression

Support Vector Regression is a type of ML algorithm which is based on the approach that focuses completely on the data. Consider the parameters such as $T = \{(a_x, b_x)\}$ where a_x and b_x are the input and output variables respectively in which the value of x varies between 1 to N . It is assumed that the cumulative distribution of the function $H(a, b)$ is completely not known. In the scenario of a linear progression, the equation can be represented as shown in Eqs. (1)

$$h(a) = \langle W, a \rangle + L \quad (1)$$

In the above equation, W is the coefficient that is associated with the weight of each input parameter and L is the bias constant. If in case, the progression is found to be non-linear in nature then a corresponding coefficient δ is incorporated to transform the complexity of the variable from nonlinear to linear terms. In order to prevent excessive fitting issues, the function being fitted will be as smooth as feasible and we will flexibly adapt the learning examples by reducing the anticipated value of W . To handle constraints that would otherwise be impossible, two flexibility variables are introduced. Asymmetric optimisation is made possible by the presence of a mathematical equation that can effectively estimate every combination of information with the required level of accuracy as represented in (2).

$$\begin{aligned} &\text{minimize } \frac{1}{2} \|W\|^2 + k \sum_{x=1}^N (\beta_x + \beta_x^*) \quad (2) \\ &\text{subject to } \begin{cases} \langle W, \delta(a) \rangle + L - b \leq \varepsilon + \beta_x \\ b_x - \langle W, \delta(a) \rangle - L - b \leq \varepsilon + \beta_x^* \\ \beta_x, \beta_x^* \leq 0 \end{cases} \end{aligned}$$

In the Eq. (2), k is a constant value included as a torment and β_x and β_x^* represents the difference between the anticipated as well as actual values. The kernel version of the above equations for optimizing the variables β_x and β_x^* can be denoted as shown in Eq. (3),

$$\text{minimize } \frac{1}{2} \sum_{x,y=1}^N (\mu_x^* - \mu_x) (\mu_y^* - \mu_y) J(a_x, a_y)$$

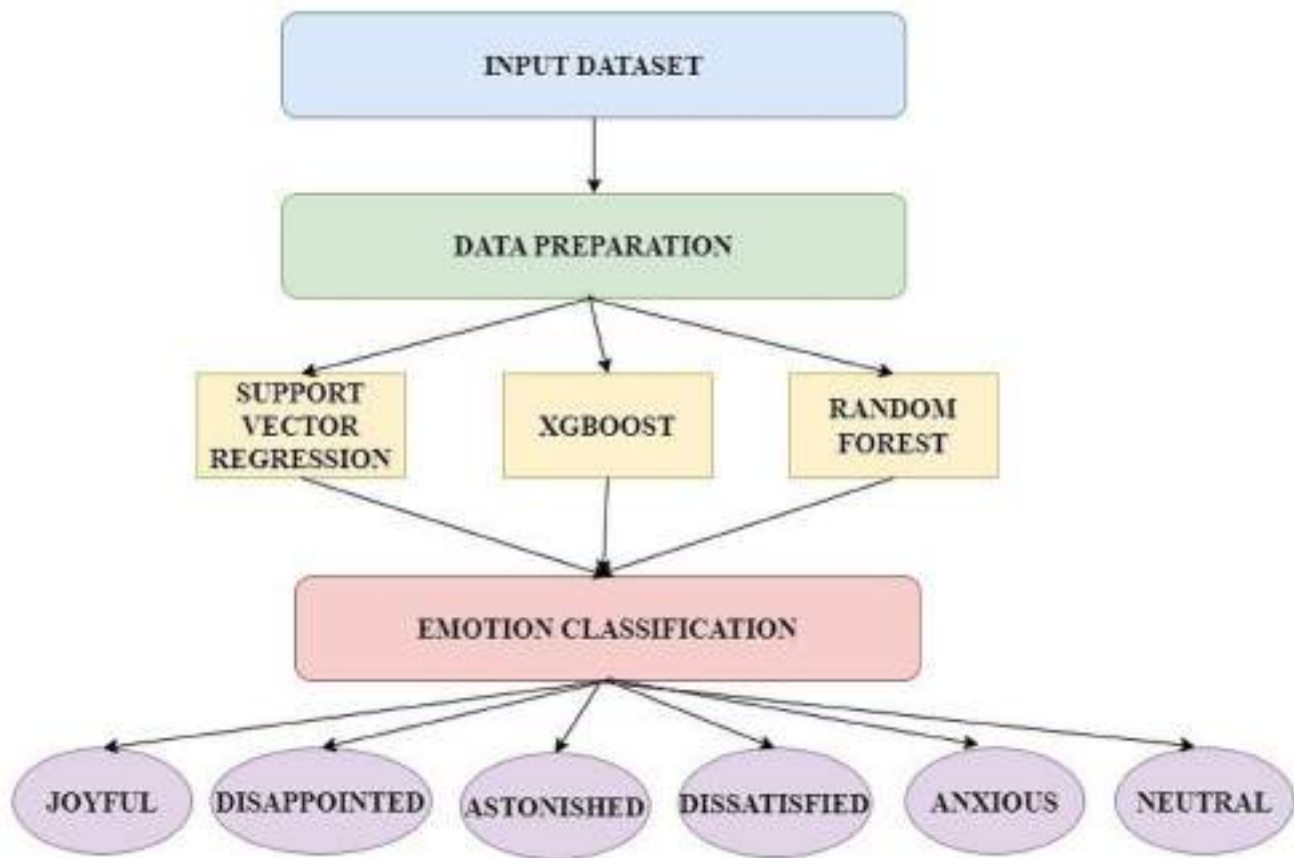


Fig. 1 Proposed workflow

$$+\epsilon \sum_{x=1}^N (\mu_x^* + \mu_x) - \sum_{x=1}^N y(\mu_x^* - \mu_x) \quad (3)$$

$$\text{subject to } \begin{cases} \sum_{x=1}^N (\mu_x^* - \mu_x) = 0 \\ 0 \leq \mu_x, \mu_x^* \leq K \end{cases}$$

The values of the weight and bias parameters are updated according to the μ_x, μ_x^* parameters and the updated equations are as represented in (4),

$$W = \sum_{x=1}^N (\mu_x^* - \mu_x) a_x \quad (4)$$

$$L = b_y - \langle W, \delta(a) \rangle - \varepsilon \text{ for } 0 \leq \mu_x \leq K \quad (5)$$

$$L = b_y - \langle W, \delta(a) \rangle - \varepsilon \text{ for } 0 \leq \mu_x^* \leq K \quad (6)$$

$$h(x) = \sum_{x=1}^N (\mu_x^* - \mu_x) J(a_x, a) + L \quad (7)$$

Another intriguing aspect of this technique is the seemingly arbitrary nature of the kernel allocation for specific observation structures. In terms of ease of use and effective translation abilities, the statistically significant radial basis kernel is a better implementation than other kernel components,

according to studies. As a result, in this article, the SVR method's statistically significant function for the radial basis kernel is expressed with two primary parameters Fig.1.

The equilibrium between the level of abstraction of the function and the degree at which incorrect behaviour is tolerated is controlled by the first parameter. The second parameter controls the level of sophistication of the model and reflects the mapping of the feature field to the interpretation of the supplied parameters. As a result, it is essential to identify suitable settings and select their significance with more consideration.

Ensemble Models

XGBoost

With respect to its positive aspects of great performance and adequate versatility, Extreme Gradient Boosting (XGBoost), a more powerful supervised procedure under the Gradient Boosting framework, has gained widespread recognition in recent research. In order to prevent excessive fitting, the suppression function of XGBoost adds an additional normalization component to the function's objective variable

that eliminates the outcome of the learned parameters. Additionally, it maximizes the reduction rate using the initial and higher-order slope estimates. Moreover, XGBoost allows the use of column and row filtering to deal with this problem in addition to introducing periodic terms to avoid excessive fitting. Due to the greater speed of learning provided by decentralized and concurrent computing, faster model development is achievable.

The output obtained from this model can be computed by taking the aggregate of the forecast outcomes produced by the model as represented in Eqs. (7),

$$\hat{b}_x = \sum_{z=1}^Z h_z(a_x), h_z \in \pi \quad (8)$$

In the above equation, π denotes the dimension of trees, Z is the count of trees, a_x represents the characteristics pertaining to x . $h_z(a_x)$ denotes the forecast outcome for each base node. The weight parameter of the base node W_y denotes the regression parameter of all the examples at the low level where the value of y varies between 0 to N and N represents the total count of the leaf nodes. The target functions are continually minimized and the boosting procedure is consecutively executed until the target function is restricted. The representation of the target function is as shown in Eqs. (9)

$$\pi = \sum_{x=1}^D LF(b_x, \hat{b}_x) + \alpha N + \frac{1}{2} \beta \sum_{y=1}^N W_y^2 \quad (9)$$

In the above equation, D represents the known examples, $LF(b_x, \hat{b}_x)$ denotes the function pertaining to loss indicating the fitness of the model. Each freshly included tree learns from its previous trees and modifies the remaining variables in the anticipated estimates. All of the trees are constructed progressively in incremental techniques of learning. The modified target function can be represented as shown in Eq. (10) as,

$$\pi_{(z)} = \sum_{x=1}^N LF(b_x, \hat{b}_x^{(z-1)} + h_z(a_x)) + \alpha N + \frac{1}{2} \beta \sum_{y=1}^N W_y^2 \quad (10)$$

Random Forest

A potent ensemble learning technique that can be applied for categorization as well as regression problems is the random forest (RF). It has been applied extensively in numerous domains and performs effectively, making it applicable to supervised learning problems. RF is a mathematical model of statistical learning that retrieves numerous data points from the initial set using an iterative replication approach.

It then models the decision tree for each iterative sample and averages the forecasts of all the decision trees to get the overall prediction outcomes. With an adjourned example and stochastic predictor pairings in various tree developments, the model broadens the range of combinations of the decision trees.

Since predicting regression is the main goal of this study, only the regression tree (RT) will be covered in this section. The average value of the data points on the base nodes and the average square error that developed between each of the samples were calculated at each splitting of the tree. The regression tree will keep on growing until it runs out of variables or reaches its ideal average error value, with the smallest node in the leaf being the branching condition. the estimated values of regression trees and the maximum number of stochastic variables of nodes are its two important unique parameters. Optimizing these settings is necessary to reduce inaccuracies that arise during the analysis of data.

This algorithm is modelled as a series of steps. Initially, the original data set is taken and number of estimators in the training samples is retrieved using an incremental selection strategy. The total number of records of every set used for training is approximately equivalent to that of the initial information set. Probably 30% of the data will not be drawn from every baseline portion of the random forest during the learning phase. Making a regression tree for every baseline set of training variables is the next step. Not every ideal feature is chosen as the node inside the tree for branching during the development of a tree process; instead, the ideal feature is chosen at arbitrary from the highest depth attributes for branching. The mathematical representation of the random forest model is as shown in Eqs. (11),

$$\hat{h}_m^D(a) = \frac{1}{D} \sum_{d=1}^D S_d(a) \quad (11)$$

In the above equation, the random forest model is represented as $\hat{h}_m^D(a)$, S_x denotes the individual trees generated to create a forest, D denotes the total count of the generated trees.

Results and Discussion

The researchers acquired the MES dataset by means of a questionnaire that was distributed to a random group of thousand learners within the span of one week. A rating system of zero to five was used by hundred observers to record every learner's extent of involvement and sentiments in order to meticulously track their conduct and emotions. These were divided into six distinct groups: joyful,

Table 1 Data sample from dataset with the questionnaire outcomes

Joyful	Disappointed	Astonished	Dissatisfied	Anxious	Neutral
5	2	4	2	3	3
3	2	3	1	2	4
5	1	4	2	3	3
3	2	2	2	1	2
2	2	3	1	2	4

Table 2 Confusion matrix for predict student involvement

Confusion Matrix		Predicted class	
		Student Involved	Student Not Involved
Actual class	Student Involved	198	32
	Student Not Involved	4	266

Table 3 Performance comparison of machine learning algorithms

Algorithms	Accuracy	Precision	Recall	F1 score
Decision Tree	83.6	82.4	82.6	82.9
Naïve Bayes	85.7	85.1	84.9	85.3
Logistic Regression	86.8	86.2	86.3	86.1
Ridge Regression	88.9	88.5	88.3	88.6
Multiple Linear Regression	91.8	90.6	90.2	91.3
KNN	93.5	92.7	92.9	93.1
Proposed- Ensemble	97.9	96.5	96.3	97.2

disappointed, astonished, dissatisfied, anxious, and neutral. The sample records from the dataset are shown in Table 1.

The confusion matrix obtained to analyze the student involvement in online classes during COVID-19 is presented in Table 2. 198 students were involved in the class and it was predicted correctly by the model as well. The model predicted that 32 students were not involved in the class but they were actually involved as per the observation. 4 students were found to be not involved in the class but the model misclassified it as involved. 266 learners were not involved in the online classes and it was predicted as not involved correctly. Based on these predictions made by the

Table 4 Performance comparison of existing and proposed work

References	Accuracy	Precision	Recall	F1 score
[21]	87.5	86.6	85.9	85.1
[23]	89.7	87.2	87.6	88.4
[25]	92.6	89.5	90.8	91.3
[26]	95.2	92.6	93.3	94.8
Proposed- Ensemble	97.9	96.5	96.3	97.2

model the performance of the model is evaluated and the values for the metrics such as accuracy, F1 score, precision and recall are determined.

The performance of the proposed model is compared against the conventional machine learning algorithms to demonstrate its performance superiority and outcomes are presented in Table 3; Fig. 2. The decision tree algorithm was observed to produce an accuracy of 83.6%, precision of 82.4%, recall of 82.6% and F1 score of 82.9%. Naïve Bayes algorithm exhibited performance with 85.7% accuracy, 85.1% precision, 84.9% recall and 85.3% F1 score. The accuracy, precision, recall and F1 scores produced by the logistic regression model are 86.8%, 86.2%, 86.3% and 86.1% respectively.

Ridge Regression was found to obtain an accuracy of 88.9%, precision of 88.5%, recall of 88.3% and F1 score of 88.6%. Multiple Linear Regression was evaluated to generate outcomes that were 91.8% accurate while producing precision 90.6% and recall 90.2% with F1 score value of 91.3%. K-Nearest Neighbours algorithm exhibited higher performance among the other machine learning algorithms with an accuracy of 93.5%, precision of 92.7%, recall of 92.9% and F1 score of 93.1%. However, the proposed ensemble model which is a combination of Support Vector Regression with XGBoost and Random Forest produced highest accuracy of 97.9% with 96.5% precision, 96.3% recall and 97.2% F1 score.

Further, the performance of the model is also compared with the other existing works in the literature and the results

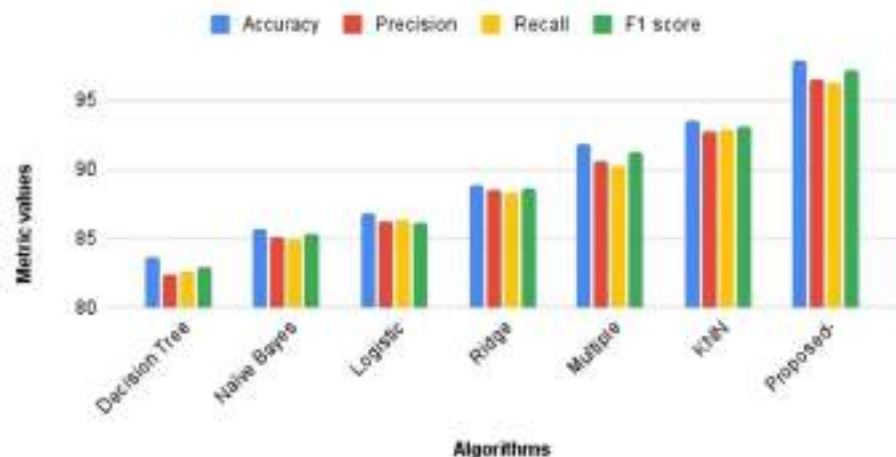
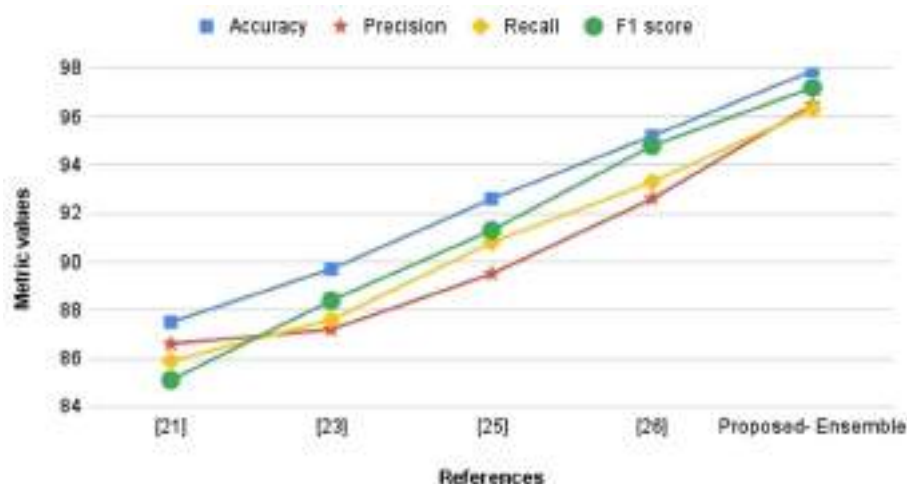
Fig. 2 Performance comparison with machine learning algorithms

Fig. 3 Performance comparison: existing vs. proposed



are as depicted in Table 4; Fig. 3. The work proposed in [21] produced an accuracy of 87.5%, precision of 86.6%, recall of 85.9% and F1 score of 85.1%. The authors in [23] suggested that the prediction model produced accuracy, precision, recall and F1 score of 89.7%, 87.2%, 87.6% and 88.4% respectively.

The researchers in [25] proposed a forecasting model for student concentration levels that produced an accuracy level of 92.6% with F1 score of 91.3%. The work in [26] produced 95.2%, 92.6%, 93.3% and 94.8% of accuracy, precision, recall and F1 score correspondingly. It can be observed that the performance of the proposed model is superior compared to other existing models.

Conclusion

The COVID-19 epidemic has increased the use of online education and virtual instruction methodologies in the educational sector. It has been difficult for instructors and learners to maintain the same academic standards as in the traditional approach of classroom teaching and learning process. In this study, investigations have been conducted the analyze credibility of digital learning platforms on student education while also supporting the system of learning. The student's involvement was assessed using machine learning techniques, which was then integrated with the identification of facial expressions. Educators and administrators at schools may employ the suggested system to determine whether or not learners take a proactive role in their online education. This will support instructors in providing enhanced learner evaluations in live sessions. But in the future, things like face orientations, illumination modifications, and wellness trackers could also be taken into account in relation to a student's environment limitations.

Acknowledgements The authors acknowledged the Dayananda Sagar University, Bengaluru, Karnataka, India; Nitte Meenakshi Institute of Technology, Bangalore, Karnataka, India; Ramaiah Institute of Technology Bangalore, Karnataka, India; Willron Technologies, Bengaluru, Karnataka-India; for supporting the research work by providing the facilities.

Author Contributions This research was a collective effort, made possible through the collaboration and contributions of all authors involved.

Funding No funding received for this research.

Data Availability The dataset produced and scrutinized in this study are accessible from the corresponding author upon reasonable request.

Declarations

Conflict of interest No conflict of interest.

Competing interests We declare that, we have no significant competing financial, professional, or personal interests that might have influenced the performance or presentation of the work described in this manuscript.

References

1. Alismael OA, Cifuentes-Faura J, Al-Rahmi WM. Online learning, Mobile learning, and social media technologies: an empirical study on constructivism theory during the COVID-19 pandemic. *Sustainability*. 2022;14:11134. <https://doi.org/10.3390/su141811134>.
2. Karalar H, Kapucu C, Gur ÜH. Predicting students at risk of academic failure using ensemble model during pandemic in a distance learning system [J]. *Int J Educ Technol High Educ*. 2021;18:1–18.
3. Odriozola-González P, Planchuelo-Gómez Á, Irurtia MJ, de Luis-García R. Psychological effects of the COVID-19 Outbreak and Lockdown among students and workers of a Spanish University. *Psychiatry Res*. 2020;290:113108.
4. Cao W, Fang Z, Hou G, Han M, Xu X, Dong J, et al. The psychological impact of the COVID-19 epidemic on college

- students in China. *Psychiatry Res.* 2020;287:112934. <https://doi.org/10.1016/j.psychres.2020.112934>.
5. Cao W, Fang Z, Hou G, Han M, Xu X, Dong J, Zheng J. The psychological impact of the COVID-19 Epidemic on College Students in China. *Psychiatry Res.* 2020;287:112934.
 6. Cheng SC, Hwang GGJ, Lai CL. Effects of the group leadership-promotion approach on students' higher order thinking awareness and online interactive behavioral patterns in a blended learning environment [J]. *Interact Learn Environ.* 2020;28:246–63. <https://doi.org/10.1080/10494820.2019.1636075>.
 7. Wang X, Chen H, Liu L, Liu Y, Zhang N, Sun Z, Lou Q, Ge W, Hu B, Li M. .Anxiety and sleep problems of College Students during the outbreak of COVID-19. *Front Psychiatry* 2020, 11.
 8. Chang J, Yuan Y, Wang D. Mental health status and its influencing factors among college students during the epidemic of COVID-19. *J South Med Univ.* 2020;40:171–6.
 9. De Oliveira Araújo FJ, de Lima LSA, Cidade PIM, Nobre CB, Neto MLR. Impact of Sars-Cov-2 and its Reverberation In Global Higher Education and Mental Health. *Psychiatry Res.* 2020;288:112977.
 10. Sahu P. Closure of universities due to Coronavirus Disease 2019 (COVID-19): impact on Education and Mental Health of Students and Academic Staff. *Cureus.* 2020;12:e7541.
 11. Khosravi H, Shabaninejad S, Bakharia A. Intelligent learning analytics dashboards: automated drill-down recommendations to support teacher data exploration [J]. *J Learn Anal.* 2021;8:133–54. <https://doi.org/10.18608/jla.2021.7279>.
 12. Al-Tammemi AB. Is it just about physical health? An online cross-sectional study exploring the psychological Distress Among University students in Jordan in the midst of COVID-19 pandemic. *Front Psychol.* 2020;11:562213.
 13. Aslan I, Ochnik D, Çınar O. Exploring perceived stress among students in Turkey during the COVID-19 pandemic. *Int J Environ Res Public Health.* 2020;17:8961.
 14. Mark B, Eamonn C, Enda T, Xiao JH. Affect the five trends of online learning: from multiple focal perspective future development [J]. *China Dist Educ.* 2022;6:21–35. /j.carol carroll nki chinade. 2022.06.003.
 15. Nurunnabi M, Hossain SFAH, Chinna K, Sundarasan S, Khoshaim HB, Kamaludin K, Baloch GM, Sukayt A, Shan X. Coping strategies of students for anxiety during the COVID-19 pandemic in China: a cross-sectional study. *F1000Research.* 2020;9:1115.
 16. Lai AY, Lee L, Wang M, Feng Y, Lai TT, Ho L, Lam VS, Ip MS, Lam T. Mental Health impacts of the COVID-19 Pandemic on International University Students, related stressors, and coping strategies. *Front Psychiatry.* 2020;11:584240.
 17. Kohnke L, Moorhouse BL. (2020). Facilitating synchronous online language learning through zoom. *RELC J* Doi: 10.1177/00336 88220 937235.
 18. Song L, Yang LX, Guo R, Cui D. (2022). Behavioral characteristics of online learning based on K-means cluster analysis: a case study of Chinese and foreign landscape history course [J]. *J Shenyang Agric Univ*, 1–7.
 19. Tharsanee RM, Soundariya RS, Saran Kumar A, Karthiga M, Sountharajan S. Deep convolutional neural network-based image classification for COVID-19 diagnosis, *Data Science for COVID-19*, Academic Press, 2021, Pages 117–145, ISBN 9780128245361, <https://doi.org/10.1016/B978-0-12-824536-1.00012-5>.
 20. Maatuk AM, Elberkawi EK, Aljawarneh S, Rashaideh H, Alharbi H. The COVID-19 pandemic and E-learning: challenges and opportunities from the perspective of students and instructors. *J Comput High Educ.* 2022;34:21–38. <https://doi.org/10.1007/s12528-021-09274-2>.
 21. Ghazawy ER, Eweis AA, Mahfouz EM, Khalil DM, Arafa A, Mohammed Z, Mohammed E-NE, Hassan EE, Hamid SA, Eweis SA et al. Psychological impacts of COVID-19 pandemic on the University students in Egypt. *Heal Promot Int.* 2020.
 22. Soundariya RS, Tharsanee RM, Vishnupriya B, Ashwathi R. Certain investigations on the Application of Machine learning Algorithms and Deep Learning architectures for Covid – 19 diagnosis. *J Eng Res.* 2021. <https://doi.org/10.36909/jer.ICMMM.12421>.
 23. Turnbull D, Chugh R, Luck J. Transitioning to E-learning during the COVID-19 pandemic: how have higher education institutions responded to the challenge? *Educ Inf Technol.* 2021;26:6401–19. <https://doi.org/10.1007/s10639-021-10633-w>.
 24. Li JG, Liang ST. A comparative study on the difference of evaluation satisfaction between online and offline teaching students under the influence of the novel coronavirus epidemic: a case study of econometrics course in a university in Guangzhou [J]. *J Qilu Norm Univ.* 2022;37:14–21.
 25. Islam S, Suján SH, Tasnim R, Sikder T, Potenza MN. Psychological responses during the COVID-19 outbreak among University students in Bangladesh. *PLoS ONE.* 2020;15:e0245083.
 26. Shahzad A, Hassan R, Aremu AY, Hussain A, Lodhi RN. Effects of COVID-19 in E-Learning on higher Education Institution students: the Group comparison between male and female. *Qual Quant.* 2020;55:805–26.
 27. Kapasia N, Paul P, Roy A, Saha J, Zaveri A, Mallick R, Barman B, Das P, Chouhan P. Impact of Lockdown on Learning Status of Undergraduate and Postgraduate students during COVID-19 pandemic in West Bengal, India. *Child Youth Serv Rev.* 2020;116:105194.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.



Category: Arts and Humanities

REVIEW

Exploring the Effectiveness of the 'WADI' Model for Tribal Development: A Comprehensive Analysis in the Goalpara District Special reference to -Dudhnai Block

Exploración de la eficacia del modelo "WADI" para el desarrollo tribal: Un análisis exhaustivo en el distrito de Goalpara Especial referencia a -Dudhnai Block

Nasir Uddin Sheikh¹ , Raja Narayanan² 

¹Research Scholar, School of Commerce and Management Studies, Dayananda Sagar University, Bangalore.

²Associate Professor, School of Commerce and Management Studies, Dayananda Sagar University, Bangalore.

Cite as: Sheikh NU, Narayanan R. Exploring the Effectiveness of the 'WADI' Model for Tribal Development: A Comprehensive Analysis in the Goalpara District Special reference to -Dudhnai Block. Salud, Ciencia y Tecnología - Serie de Conferencias. 2024; 3:669. <https://doi.org/10.56294/sctconf2024669>

Submitted: 28-11-2023

Revised: 22-02-2024

Accepted: 04-05-2024

Published: 05-05-2024

Editor: Dr. William Castillo-González 

ABSTRACT

Introduction: sustainable development is crucial for balancing progress with resource preservation, especially in marginalized communities like tribal regions. The WADI model, pioneered by NABARD and introduced in India in the 1990s, has proven successful in fostering sustainable development in arid tribal areas.

Objective: this study aims to explore the impact of WADI projects on the sustainable development of tribal communities in the remote villages of Dudhnai Block, Goalpara district, Assam.

Material and Method: the study employs a qualitative research approach, gathering data on migration patterns, agricultural production, natural resource management, social cohesion, and economic advancement through interviews, surveys, and field observations.

Results: preliminary analysis reveals positive outcomes regarding increased agricultural yield, reduced migration rates, improved social cohesion, and economic empowerment among tribal communities participating in WADI projects.

Conclusions: WADI projects hold promise as a viable model for sustainable development in tribal regions, contributing to poverty alleviation, food security, and overall quality of life enhancement while preserving natural resources for future generations.

Keywords: Sustainable Development; WADI; Women Empowerment; Tribes; Economic; Natural Resource; Migration; Advancement.

RESUMEN

Introducción: el desarrollo sostenible es crucial para equilibrar el progreso con la preservación de los recursos, especialmente en comunidades marginadas como las regiones tribales. El modelo WADI, promovido por NABARD e introducido en la India en la década de 1990, ha demostrado su eficacia para fomentar el desarrollo sostenible en zonas tribales áridas.

Objetivo: este estudio tiene como objetivo explorar el impacto de los proyectos WADI en el desarrollo sostenible de las comunidades tribales en las aldeas remotas de Dudhnai Block, distrito de Goalpara, Assam.

Material y método: el estudio emplea un enfoque de investigación cualitativa, recopilando datos sobre los patrones de migración, la producción agrícola, la gestión de los recursos naturales, la cohesión social y el progreso económico a través de entrevistas, encuestas y observaciones sobre el terreno.

Resultados: el análisis preliminar revela resultados positivos en relación con el aumento de la producción

agrícola, la reducción de las tasas de migración, la mejora de la cohesión social y el empoderamiento económico entre las comunidades tribales que participan en los proyectos WADI.

Conclusiones: los proyectos WADI son prometedores como modelo viable para el desarrollo sostenible en regiones tribales, contribuyendo a la mitigación de la pobreza, la seguridad alimentaria y la mejora general de la calidad de vida, al tiempo que preservan los recursos naturales para las generaciones futuras.

Palabras clave: Desarrollo Sostenible; WADI; Empoderamiento de las Mujeres; Tribus; Económico; Recursos Naturales; Migración; Avance.

INTRODUCTION

Indigenous people are found all over the world. They are communities that live in specific areas and have their own unique cultures that they want to protect and pass down to their children. They deeply care about the environment and have a special connection to it through their cultural values. For generations, they have followed traditional customs to take care of the environment. In India, they are called Adivasi, Vanyajati, Tribe, or Scheduled Tribe. According to Roy Burman, forests are closely connected to tribal life.^(1,2,3,4,5,6,7,8) They see forests as their home, a source of food, jobs, and income. They have a deep respect for forests and worship them from one generation to the next.^(9,10)

“(In 2007, the United Nations declared to protect the rights of indigenous communities. As per Australian Human Rights Commission”)^(11,12) They established policies to preserve their culture, social systems, language, and natural resources. The main goal is to let them live in their world without harming the environment.

Over time, governments and NGOs have created various policies and programs to improve the situation of indigenous communities. However, the main focus of sustainable development should be to protect the environment while meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. (In 2015, the United Nations established sustainable development goals to address the challenges faced by disadvantaged indigenous communities.)⁽¹³⁾ They aim to create a world free of poverty, hunger, and disease for these people. The development goals prioritize environmental sustainability and community well-being. (The Bruntland Commission, in their 1987 report titled 'Our Common Future' emphasized the importance of development that prioritizes communities while also maintaining environmental balance.)⁽¹²⁾ According to the report, sustainable development means meeting the needs of the present generation without compromising the needs of future generations. It involves achieving economic progress while ensuring the long-term protection of nature and integrating environmental, social, and economic aspects from the perspective of communities. The focus is on meeting the needs of tribal people through their traditional knowledge and practices. Development entails positive changes in society, particularly in livelihoods and the economy. This approach promotes equality and equity among and between generations, as well as a balance across social, economic, cultural, and political dimensions. The overarching goal of development is to ensure sustainability in community growth and economic stability for countries. Establishing a balanced relationship between humans and the natural environment is the core principle of sustainable development.

This study focuses on the WADI development system among tribal communities in the Goalpara district of Assam, India. The WADI project was initially launched in Gujarat, India. In Gujarati, "WADI" refers to a piece of land planted with fruit trees, essentially a garden farming process surrounded by various forest species. The primary aim of this model is to enhance the economic and social well-being of tribal families. Under this program, each beneficiary family must contribute at least one acre of land for growing fruit trees, surrounded by other forest species. The study aims to assess how the WADI model helps improve the situation of tribal families. It also explores the history of the WADI model in India, including its inception and key components. Additionally, the study examines the success rate and impact assessment of the WADI model on the tribal families under study.

Objective of the study

1. Understand the role and significance of the 'WADI' model in promoting sustainable development among tribal communities.
2. Explore the socio-economic and environmental impact of the 'WADI' initiative on tribal livelihoods in Dudhnai Block
3. Assess the effectiveness of the 'WADI' model in addressing issues of poverty, food security, and income generation among tribal households.

METHODOLOGY

The study is anthropological research that took place in three villages located in the Dudhnai block of the Goalpara district in the state of Assam, India. Because the WADI project was started in this block with a maximum number of beneficiaries of the project. The period of the study is from February 3rd, 2024 to March 1st, 2024.

Goalpara is situated in the lower part of Assam, India. The study was conducted in three villages within the Dudhnai block of Goalpara district, which is known to be one of the most socially and economically backward blocks in the district. This study specifically focused on three villages: Lela, Rang Pather and Latapara each from a different Gram Panchayat. The block is located in the Rabha Hasong Autonomous Council and is predominantly inhabited by tribal communities. In this research frequency distribution statical method was used.

To gather relevant data, various anthropological methods were used. Data collection involved both qualitative and quantitative methods. Beneficiaries were chosen using purposive sampling. Information about the WADI program and its components was obtained through qualitative approaches. Basic family details such as income, education, and livelihood were gathered using both qualitative and quantitative methods. The success rate of the project and the involvement of beneficiary families were assessed through case studies and structured interviews.

In conducting the study in the Dudhnai block of Goalpara district, ethical standards were rigorously followed to ensure the integrity and well-being of all participants. Prior to data collection, informed consent was obtained from all individuals involved, including beneficiaries and those providing information. This ensured that participants fully understood the purpose, risks, and benefits of their involvement in the study. Confidentiality measures were strictly upheld to protect the privacy and anonymity of participant information, with data anonymization techniques employed during reporting to prevent identification.

RESULTS

Table 1 displays the total number of WADI beneficiaries and the trees planted in each village. All beneficiary families own one acre of unused land, which they have dedicated to creating WADI gardens. They planted two types of orchards: Mango and Cashew trees. Additionally, they planted forest trees rubber and Arjun (*Terminalia arjuna*) to prevent soil erosion. The survey found that 128 acres of land, covering 121 families, were involved in the proposed program. Lela village has the highest proportion (46,00 %) of WADI plots, followed by Rang pather (33,00 %) and Lata para (21,00 %). In the villages under study, farmers grow a variety of vegetables such as tomatoes, eggplants, pumpkins, chili peppers, beans, cucumbers, mustard greens, radishes, okra, watermelons, beets, carrots, coriander, pigeon peas, and various types of leafy greens as intercrops to supplement their income. It meets their daily needs and provides nutritious food for their children. They sell the extra crops at the local market, which boosts their income.

S No	Village Name	No of WADI/ Beneficiary	Land (In Acre)	Plantation trees	Forestry trees
1	Lela	56 (46 %)	57	Mango, Cashew	Rubber, Arjun, Segun etc.
2	Rang Pether	40 (33 %)	43		
3	Lata Para	25 (21 %)	28		

Source: Structure Questionnaire.

Another crucial aspect of this project is organic farming. In the villages under study, a total of five vermicompost pits have been set up, where cow and goat waste are used for composting. Vermicompost helps enhance soil productivity and promotes the use of organic products. Additionally, various indigenous methods like neem (*Azadirachta indica*) paste and cow dung are applied to improve the natural fertility of the land.

Group formation and the creation of self-help groups are another important aspect of this project. The implementing agency plays a key role in providing various trainings related to orchard plantation, income generation, women's empowerment, resource mobilization, and product marketing. A total of 12 Self Help Groups have been formed with members from beneficiary families. Almost all members are involved in activities such as preparing puffed rice, making jam and jelly, and participating in other successful micro-enterprises. Empowering women is crucial for their active participation in project implementation, with a focus on income generation, sanitation, and reducing drudgery. The program aims to provide women with opportunities to supplement their existing income and improve their quality of life by meeting basic needs such as food, education, and health. Income generation activities will be carried out both at the group and individual levels. The health department addresses major community health issues, but there are still certain health aspects

that women in the villages lack education and treatment for. To address these issues, it is proposed to conduct health check-up camps and provide medicine to women and adolescent girls in the villages under this program. The key components of the health program include mother and child immunization, postnatal care, nutrition and health education, and hygiene and health. All these health components will be addressed in a single camp organized quarterly in each village.

Target, success rate and assessment

WADI is a comprehensive development approach that addresses various aspects of tribal life. Generally, the tribal families in the studied villages are economically disadvantaged and rely heavily on labor work. Although they own land, it is mostly barren and infertile, with only a small portion suitable for cultivation, and even then, it cannot meet their needs due to water scarcity. As a result, many families migrate to other places for better opportunities to support their families. The tables below depict the population distribution based on gender, the education scenario, and a comparison of income levels before and after the project completion.

Table 2 illustrates the total population of the three villages based on the gender of all tribal families studied. The study included 121 families across the three villages, comprising 258 males and 283 females. The percentage of male and female population is 48 % and 52 %, respectively. Lela has the highest number of male populations, while Lata para has the least. Conversely, the percentage of females (51 %) in Lela and Lata para village is higher than in the other villages.

Table 2. The total studied population of the three villages based on sex				
Village Name	Male	%	Female	%
Lela	99	50 %	101	51 %
Rang Pether	94	49 %	98	51 %
Lata Para	65	44 %	84	56 %
Total	258	48 %	283	52 %
Source: Structure Questionnaire.				

The educational background of the population in all three villages is a crucial aspect of this study. Education plays a significant role in determining one's status and position in society, and it is often linked to development. Literacy serves as a valuable social indicator, reflecting people's attitudes toward modern amenities and decision-making. The table below illustrates the educational status of the villagers under study.

Table 3. An educational scenario of the studied villagers						
Category	Male	%	Female	%	Total	%
Non-literate	67	12 %	98	18 %	165	30 %
Class I - IV	71	13 %	67	12 %	138	26 %
Class V - X	58	11 %	76	14 %	134	25 %
Class XI - XII	34	6 %	24	4 %	58	11 %
Above H.S.	19	4 %	12	2 %	31	6 %
Graduate	9	2 %	6	1 %	15	3 %
Total	258	48 %	283	52 %	541	100 %
Source: Structure Questionnaire and Assam Tribal Development Authority https://wptbc.assam.gov.in/						

The majority of villagers (about 30 %) are non-literate, meaning they cannot read or write. A significant portion of the population (about 26 %) has education up to the fourth grade or lower. About 25 % of villagers have completed education up to the tenth grade. A smaller percentage of the population (about 11 %) has completed education up to the twelfth grade. Only a small portion of villagers (about 6 %) have education beyond high school, and an even smaller percentage (about 3 %) are graduates. Overall, the data highlights that while there is some level of education among the villagers, a substantial portion of the population lacks basic literacy skills, indicating a need for educational interventions and support programs within the community.

Table 4. Migration status before and after implementation of the Project (familywise)

Types	No. of families before implementation	No. of families after implementation
Non-Migrant	54 (45 %)	87 (72 %)
Within Goalpara	40 (33 %)	26 (21 %)
Outside Goalpara	23 (19 %)	8 (7 %)
Outside Assam	4 (3 %)	0 (0 %)
Total	121 (100 %)	121 (100 %)

Source: Structure Questionnaire and Assam Tribal Development Authority <https://wptbc.assam.gov.in/>

The research indicates a notable decrease in the overall migration of families after the project implementation. This decrease is particularly evident in families migrating within and outside Goalpara, as well as those moving outside Assam. Such a decline in migration rates suggests that the project may have contributed to stabilizing families within their local communities. The significant increase in the number of non-migrant families after the project highlights the effectiveness of the intervention in retaining families within their original communities.

This retention is crucial for fostering community stability, social cohesion, and sustainable development within the region. The decrease in migration within Goalpara specifically underscores the project's positive impact on encouraging families to remain within their immediate locality. This suggests that the project may have provided opportunities or resources that incentivized families to stay closer to their homes. The findings from the table could have implications for policy formulation and implementation regarding community development initiatives. Understanding the factors that contribute to migration patterns can inform the design of more targeted interventions aimed at addressing socio-economic challenges and promoting local development.

In summary, the data from the research suggests that the project has had a significant impact on reducing migration rates and retaining families within their local communities. This underscores the importance of community-based interventions in fostering sustainable development and enhancing the well-being of residents.

Table 5. Comparison of the level of income of the studied villagers' pre- and post-scenario of the project

Income range	Before implementation		Post-implementation	
	No. of Families	%	No. of Families	%
Below Rs. 1000	49	40 %	15	12 %
Rs.1001 to 3000	45	37 %	24	20 %
Rs.3001 to 5000	21	17 %	51	42 %
Above Rs. 5000	6	5 %	31	26 %
Total	121	100 %	121	100 %

Source: Structure Questionnaire and Assam Tribal Development Authority <https://wptbc.assam.gov.in/>

DISCUSSION

This research reveals a significant improvement in the income levels of the studied villagers after the project implementation. Across all income ranges, there is an increase in the number of families earning higher incomes post-implementation compared to before the project. The notable decrease in the number of families earning below Rs. 1000 after the project suggests an effective poverty reduction impact. It implies that the project interventions may have successfully lifted some families out of extreme poverty or increased their earning potential to surpass the Rs. 1000 threshold. There is a clear trend indicating a shift towards higher income brackets post-implementation. The increase in the number of families earning between Rs. 3001 to 5000 and above Rs. 5000 highlights the project's role in facilitating income-generating opportunities and improving economic conditions within the community. The findings underscore the positive socioeconomic impact of the project, indicating its effectiveness in enhancing the financial well-being of the villagers. This suggests that the project has played a crucial role in poverty alleviation, economic empowerment, and overall livelihood improvement within the community. The data could have significant implications for policy formulation and future research. Understanding the factors contributing to income improvement post-project implementation

can inform the design of more targeted interventions aimed at sustainable economic development and poverty reduction.

In summary, the data from the table provides compelling evidence of the positive impact of the project on income levels and socioeconomic well-being within the studied community, highlighting its significance in fostering economic development and improving livelihoods.

Self-help groups have been established among beneficiary family members to foster community development. These groups aim to create additional income opportunities through small-scale agricultural initiatives like horticulture, vermicomposting, marketing of produce, and processing saal leaves. (There are a total of 11 WADI women's self-help groups, each with a bank account where group income is deposited.)⁽¹⁰⁾ Members can borrow cash from their group when needed, and the money, along with interest, is later distributed among members. Currently, four women's groups have received grain husking and spray machines from the implementing agency, enabling them to earn a good income. (Additionally, each village has one vermicompost unit run by women's groups, producing 19 quintals of vermicompost last year, valued at Rs. 23,000.)⁽¹⁰⁾ Other income generation activities include seasonal fruit plants, Sal plates, goat rearing, puffed rice production, and rope making from Babui grass.

The SHGs also promote family health awareness and distribute water filters to members as part of an awareness program by the implementing agency. Fruit plants are supplied to families through women's WADI groups to establish kitchen gardens for household nutrition. Halogen tablets and bleaching powder are distributed among selected families initially for health and sanitation purposes. However, after the completion of the WADI project, the condition of the people has improved through income-generating activities such as making jam, jelly, tomato sauce, puffed rice, goat rearing, pig farming, and vermicomposting. SHG members also take loans from the group for family needs such as children's education and food, reducing dependency on their husbands.

Overall, the WADI program encompasses various aspects of tribal livelihood, including the development of barren land and its inhabitants through economic, environmental, health, soil conservation, water resource development, agricultural, and women's development initiatives.

CONCLUSION

The WADI project takes a comprehensive approach to rural development, addressing various aspects of tribal life. Its primary goal is to generate income for poor tribal families in the studied villages. These families have historically faced poverty and exploitation, often migrating to towns in search of better opportunities due to low productivity and scarcity of forest resources. The WADI project offers them a ray of hope for a better life by introducing fruit-bearing plants and other forest species to meet their fuelwood needs.

In essence, the WADI project has significantly improved the quality of life for the tribal households through economic and women's empowerment, sustainable horticultural development, and health initiatives. The study shows that increased income levels among tribal beneficiaries have reduced migration rates, ensuring food security, income stability, improved health, and environmental conservation for the community.

REFERENCES

1. Barah BC. Strategies for agricultural development in the North-East India: challenges and emerging opportunities. *Indian J Agric Econ.* 2007;62(902-2016-67379).
2. Das SK. An analysis of constraints in women empowerment in Tribal area: Evidence from Assam. *Asian J Res Soc Sci Humanit.* 2012;2(4):61-74.
3. Goswami C, Bhattacharya M. Contribution of sericulture to women's income in Assam-a case study in Goalpara district of Assam, India. *Int J Sci Res Publ.* 2013;3(3):1-6.
4. Sarma G. An Analytical Study on Entrepreneurial Activity as a tool for socioeconomic development of Tribal Women in BTAD area of Assam. *IOSR J Econ Finance.* 2014;3(2):49-52.
5. Darandale AA. Consequential Assessment of the Farmers about Adoption of Recommended Practices of Major Crops in South Gujarat [Ph.D. thesis]. Navsari: N.A.U.; 2015.
6. Vinaya Kumar HM, Yashodhara B, Preethi, Govinda Gowda V. Impact of Community Based Tank Management Project on Socio-Economic Status and Crop Productivity of Beneficiary Farmers in Tumkur District of Karnataka State. *Trends Biosci.* 2015;8(9):2289-2295.
7. Pandya SP, Prajapati MR, Patel KS. Relationship between characteristics of the farmers with change in

socio-economic impact as a result of participating in Krushi Mahotsav. *Guj J Extn Edu.* 2016;27(2):212-214

8. Vinaya Kumar HM, Shivamurthy M, Govinda Gowda V, Biradar GS. Assessing decision-making and economic performance of farmers to manage climate-induced crisis in Coastal Karnataka (India). *Clim Change.* 2017 May;142(1):43-153. doi:10.1007/s10584-017-1928-x.

9. Mahajan V, Singh J. Lives, Livelihoods and Environment: The Challenge of Sustainable Development Goals in India. In: *Financial Crises, Poverty and Environmental Sustainability: Challenges in the Context of the SDGs and Covid-19 Recovery.* Springer, Cham; 2022. p. 93-105.

10. Asam tribal development authority- <https://airtsc.assam.gov.in/>

11. <https://humanrights.gov.au/our-work/un-declaration-rights-indigenous-peoples-1>

12. [https://www.sciencedirect.com/topics/social-sciences/brundtland-report#:~:text=The%20Brundtland%20report%20articulated%20a,\(United%20Nations%2C%201987\).](https://www.sciencedirect.com/topics/social-sciences/brundtland-report#:~:text=The%20Brundtland%20report%20articulated%20a,(United%20Nations%2C%201987).)

13. <https://www.un.org/development/desa/indigenouspeoples/focus-areas/post-2015-agenda/the-sustainable-development-goals-sdgs-and-indigenous.html#:~:text=The%20United%20Nations%20General%20Assembly,through%20the%20next%2015%20years.>

FINANCING

The authors did not receive financing for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest".

AUTHORSHIP CONTRIBUTION

Conceptualization: Nasir Uddin Sheikh.

Data curation: Nasir Uddin Sheikh.

Formal analysis: Nasir Uddin Sheikh and Raja Narayanan.

Research: Nasir Uddin Sheikh.

Methodology: Nasir Uddin Sheikh.

Object management: Nasir Uddin Sheikh and Raja Narayanan.

Resources: Nasir Uddin Sheikh.

Software: Nasir Uddin Sheikh.

Supervision: Raja Narayanan.

Validation: Raja Narayanan.

Display: Nasir Uddin Sheikh.

Drafting: Nasir Uddin Sheikh and Raja Narayanan.

Writing: Nasir Uddin Sheikh and Raja Narayanan.

SUSTAINABLE BANKING INITIATIVES - SOCIAL AND RELATIONSHIP CAPITAL MANAGEMENT- A CONCEPTUAL REVIEW

Mr. Harsha R, Assistant Professor, Faculty of Management and Commerce, PES University, Bengaluru
harshar@pes.edu

Dr. Rajath B.S., Assistant Professor, School of Commerce and Management Studies, Dayananda Sagar
University, Bengaluru
rajathbelur-scms@dsu.edu.in

Banks are emerging as a driving force in the sustainability effort. The industry is uniquely positioned to meet the challenge—and the opportunity.

Abstract

Purpose – The purpose of this article is to study Sustainable Banking Initiatives, its methods of adoption and importance of practicing green banking.

Design/methodology/approach – The current research paper is conceptual in nature, based on reviews in websites of financial institutions. The websites of many banks including SBI (State Bank of India) were used and reviewed to know about Social and Relationship Capital Management.

Findings – The challenging effects of recent economic crisis, currency fluctuations and unfettered climate change brought catastrophic environmental impact and dire macroeconomic consequences. Governments, businesses and individuals all play a part in preventing global warming and creating a more sustainable world. People have to deal with financial institutions, particularly banks, which play a vital role in this environment by assisting in the development of a robust and successful low-carbon economics.

Banks should make more use of environmental data when extending credit and making investment decisions. banks are emerging as a major force in reaching the UN's Sustainable Development Goals (SDGs). Consumers, shareholders, employees and regulators are demanding a strong commitment to environmental, social and governance (ESG) priorities and are increasing pressure on banks to show results. With pressure coming from all sides, banking has reached a green inflection point.

Research limitations/implications – The implications can be summed in the following points: (1) there is no universally accepted framework for green or sustainable banking so far. However, green banking practices are at different stages of development across countries. As per the case of India, green banking practices are at a development phase in India.

(2) This study focus on Social and Relationship Capital Management banking practices of the top public sector Bank of India .

Practical implications –The study is extremely helpful to the banking industry in determining the scope of green banking initiatives in sustainable development. This paper has noted the areas where the banks can make progress for the greener, sustainable economics. It has also aided the banking industry in identifying areas for development so that it may focus on improving social satisfaction and satisfaction of stakeholders across its operating areas.

Social implications – The study will serve as a gauge for banking actions toward greener nations and a greener world since these are the efforts toward Carbon Free World, Efforts for controlling global warming,

efforts for the greener planet in general which undoubtedly is a significant long-term service to society a reason for better climate and better tomorrow.

Keywords: SBI, Sustainable Banking, Environment-friendly, Green banking, UN Sustainable development goals.

INTRODUCTION:

Green Banking is an umbrella term referring to practices and guidelines that make banks sustainable in economic, environment, and social dimensions. It aims to make banking processes and the use of IT and physical infrastructure as efficient and effective as possible, with zero or minimal impact on the environment. Considering the nature of banking processes and infrastructures, in this report, we offer guidelines for greening banking in two levels. Making day-to-day business operations, banking products and services greener by following simple practices and making them environmentally friendly.

Green Banking is like a normal bank, which considers all the social and environmental factors; it is also called as an ethical bank. Ethical banks have started with the aim of protecting the environment. These banks are like a normal bank which aims to protect the environment and it is controlled by same authorities as what a traditional bank do. There are many differences compared with normal banking, Green Banks give more weight to environmental factors, their aim is to provide good environmental and social business practice, they check all the factors before lending a loan, whether the project is environmental friendly and has any implications in the future, you will have awarded a loan only when you follow all the environmental safety standards.

Defining green banking is relatively easy. Green Banking means promoting environmental – friendly practices and reducing your carbon footprint from your banking activities. This comes in many forms

- Using online banking instead of branch banking.
- Paying bills online instead of mailing them.
- Opening up accounts at online banks, instead of large multi-branch banks
- Finding the local bank in your area that is taking the biggest steps to support local green initiatives.

GREEN BANKING PRODUCTS AND SERVICES

1. Green Deposits: Banks can offer higher rates on CDs, money market accounts, checking accounts and savings account if customers opt to conduct their banking activities online.

2. Green Credit Cards: A green credit card allows cardholders to earn rewards or points which can be redeemed for contributions to eco-friendly charitable organizations. These cards offer an excellent incentive for consumers to use their green card for their expensive purchases. Imagine the millions of dollars that could be raised for worthwhile environmental groups if green credit cards really took off.

3. Mobile Banking: By using it customer can check balances, transfer funds or pay bills from the phone. It also helps to save time and energy of the customers.

4. Online Banking: It means customers can perform most of their banking related functions without visiting the banks personally. For this customer must possess an internet banking ID, a password provided by the bank in which customer has an account. Online banking includes use of credit cards, debit cards, online bill payment and electronic fund transfer.

5. Green CDs: With a Green Bank CD, customer can earn a guaranteed rate of interest over a term that customer can choose. Banks offer a wide variety of certificates, ranging from seven days to five years. Interest on these accounts can be compounded quarterly, paid monthly by check or transferred to a Green Bank deposit account.

6. Paperless Banking: All banks are moving to the CBS or ATM platform, and they are also offering online financial products and services. As a result, there is a lot of room for banks to become paperless banking. Private and foreign banks use electronic communication in their offices, but PSU banks continue to rely heavily on paper. Paper fewer statements, on the other hand, are those statements sent by mail to the concerned stakeholders of the bank to avoid huge wastage of paper. Most banks offer people the option of receiving their statements digitally through a protected log-in when they sign up for internet banking. Electronic copies of financial records and statements can therefore be stored rather than paper files. The risk of identity theft is further reduced when statements are received online.

7. Green Deposits: The majority of firms will allow employees to get their pay cheques electronically. This mostly expedites the accessibility of your funds and saves customers a trip to the bank, but it also saves paper, a bunch of paperwork involved and so on.

8. Green Finance or Green Loan: Banks can create creative green-based products or offer low interest green loans. A green credit loan or green finance is being issued for projects that benefit nature and the environment i.e. finance provided for Renewable Energy and Clean Energy projects, Resource Recycling projects, Waste Disposal, Pollution Prevention and Control projects, Green Agriculture Development projects, Industrial Energy Conservation, Water Conservation and Environmental Protection projects, Green Transport projects, Energy Conservation and Environmental Protection Services projects, etc.

LITERATURE REVIEW

Green banking is to make internal bank processes, physical infrastructure and IT infrastructure as effective and efficient as possible, with zero or minimal impact on the environment. They had introduced green rating standards for Indian banks, which are termed as 'Green Coin Ratings'. Under this rating system, banks are judged on the basis of carbon emissions from their operations and on the amount of recycling, refurbishment and reuse material being used in their building furnishings and in the systems used by them like servers, computers, printers, networks, etc. They are also being judged on the amount of green projects finance by them and rewards or recognitions given to borrowers for turning their businesses greener RBI (IRDBT, 2014). Green banking is a type of banking activity where banks make the effort to carry out their everyday operations as conscientious members of society by taking internal and external environmental sustainability into consideration and these banks are termed as green or sustainable banks Hossain, Rahman, Hossain, and Karim (2020). Choudhury, Salim, Bashir, and Saha (2013) There is a significant gap between what banks seek to promote and what the public perceives them to be doing in terms of green banking (Jayadatta & Nitin, 2017) while pivoting on green banking adoptions model based on environmental social and governance considered where affinity of variables impacted environmental sustainability. This study found that the process is influenced by a variety of environment factors and banks can wangle the adoption by applying certain operations in a consecutive and analogous manner. Alsayegh, Abdul Rahman, and Homayoun (2020) outlined that the Green Financing is seen as a crucial component of sustainable banking, having a significant influence on the growth of a eco-friendly economy and industry generally. Therefore, it can be said that in enhancing the sustainability practices of the financial sector, the banking sector should focus on ensuring the funding for environment-conscious projects through financially viable banking in order to enhance the competitive edge of banks, generate more earnings, improve existing assets and save on invested capital and other costs. Until recently, green banking appeared to be merely an idea, and environmental concerns did not appear to be particularly relevant to a bank's operations. Initially, a bank evaluating a client's environmental suitability would have been regarded as intruding into their private affairs. However, the current view is that this poses a risk to their business. Although financial organizations are not directly impacted by environmental degradation, they, nevertheless, incur indirect expenses. Unless such measures are adopted, credit, legal and reputation problems will continue to hound these banks. The growing economies are yet to embrace the conceptualization Amir (2021).

Green banking (Social and Relationship Capital Management) initiatives by State Bank of India

Banks in India have witnessed a radical change from 'conventional banking' to 'convenience banking'. SBI has evolved with the times to meet new challenges and respond to changing customer expectations through meaningful initiatives. The portfolio of services provided by branches and offices is now expected to be delivered through digital platforms online. The by keeping customer experience at the heart of all the initiatives, SBI's transformation is not limited to digital products, but also involves changes in the way the brick-and-mortar branches operate.

- Automating Withdrawals and Deposits: SBI, with one of the largest ATM networks in the world, has installed 58,555 ATMs, including 13,726 Automated Deposit and Withdrawal Machines (ADWMs), as on 31st March 2020 to provide 24×7 services. In order to curb incidents of ATM-related frauds, SBI has also introduced an OTP based ATM cash withdrawal facility. Nearly, 28% of the Bank's financial transactions are directed through ATMs/ADWMs. As per RBI data, SBI's market share in India's ATM network accounts for 28%, with 32% of the country's total ATM transactions done through the Bank (34 crore monthly transactions on average)
- Swayams: During FY 2019- 20, SBI has installed around 3,700 Swayams (barcode-based passbookprinting kiosks), taking the total number to 17,480. These enable customers to print their own passbooks. These kiosks had over 3.80 crore transactions per month. SBI has also installed "Through the Wall" Swayam kiosks, which offer extended working hours for printing passbooks
- State Bank Foreign Travel Card: The State Bank Foreign Travel Card (SBFTC) is a chip-based EMV-compliant prepaid card that provides safety, security and convenience to travellers. Operating on both VISA and Mastercard platforms, it provides the convenience of multiple currencies, including US dollar, pound sterling, euro, Canadian dollar, Australian dollar, and Singapore dollar. SBI also offers a corporate variant of the card to cater to specific needs of corporate customers.
- FASTags: SBI has issued more than 15 lakh SBI FASTags to its customers, providing them the convenience of automated payments at toll plazas. The Bank's FASTags have surpassed 4.4 crore toll transactions, worth more than ₹722 crore as on 31st March 2020. SBI has onboarded State Road Transport Corporations in Uttar Pradesh, Punjab, Uttarakhand, Odisha, Tamil Nadu, Karnataka and West Bengal for FASTag-related services.
- YONO: In keeping with the vision for a Digital India, this omnichannel platform has become a market-leading comprehensive digital proposition. It caters to a wide range of customers' needs by bringing together banking, investment, insurance and lifestyle offerings on one platform. YONO showcases SBI's constant endeavour to make customers' experience seamless and hassle-free across touchpoints.
- SBI Anywhere Corporate: SBI Anywhere Corporate is a mobile banking application that has been developed for proprietorship firms. It allows businesses to transfer funds across banks.
- SBI Pay (BHIM): SBI Pay, a Unified Payments Interface (UPI)- based application, facilitates the transfer of funds across different bank accounts using a Virtual Payment Address (VPA).
- Merchant Acquisition: SBI's role in building momentum for transforming India through the digitisation of the economy has been instrumental. In sync with the Government of India's efforts to create a less-cash economy, SBI's Joint Venture, SBI Payment Services (SBIPSPL), has deployed 6.73 lakh PoS terminals, generated 3.33 lakh Bharat QR codes and boasts 9.53 lakh BHIM-Aadhar-SBI App downloads as on 31st March 2020.
- Pre-Approved Merchant Loan (PAML) PAML: is the first completely digital SME loan in India, which can be availed by SMEs in just four clicks. This system uses machine learning to check consistency in cash flow, derive customers' risk score and define an appropriate eligibility limit.

The UN Sustainable Development Goals

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity.

The 17 SDGs are integrated—they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability.

Countries have committed to prioritize progress for those who're furthest behind. The SDGs are designed to end poverty, hunger, AIDS, and discrimination against women and girls.

The creativity, knowhow, technology and financial resources from all of society is necessary to achieve the SDGs in every context.

CONCLUSION:

The effects of recent crisis, droughts and extreme temperatures that several people all over the world have experienced compelled us to begin thinking about global warming and its consequences, and to do everything we can do to address this problem. Governments, businesses and individuals all play a part in preventing global warming and creating a more sustainable world. We have to deal with financial institutions, particularly banks, which play a vital role in this environment by assisting in the development of a robust and successful low-carbon economics. They should make more use of environmental data when extending credit and making investment decisions. The project will assist them in proactively improving their environmental performance while also adding long-term value to their company. Businesses having a bigger carbon output may be viewed as riskier in the future, and banks may shy away from funding such businesses in favor of innovative technology solutions that absorb or reduce carbon emissions. As a result, green banking is the order of the day, a source for SD and it will undoubtedly benefit banks, industries, as well as the environment at large.

REFERENCES:

- [1] Alsayegh, M. F., Abdul Rahman, R., & Homayoun, S. (2020). Corporate economic, environmental, and social sustainability performance transformation through ESG disclosure. *Sustainability*, 12(9), 3910.\
- [2] Amir, M. (2021). Banker attitudes and perception towards green banking: A study of select banks on conventional banks in Bangladesh
- [3] Bureau, ET (2010). SBI turns green, installs windmills. *The EconomicTimes*. Available from:
- [4] <https://economictimes.indiatimes.com/industry/banking/finance/banking/sbi-turns-greeninstalls-windmills/articleshow/5849716.cms?from5mdr>
- [5] Das, S. (2018). SBI raises \$650 million via green bond issue. *The Economic Times*. Available from: <https://economictimes.indiatimes.com/markets/stocks/news/sbi-to-issue-maiden-500-milliongreen-bonds/articleshow/65875253.cms> (accessed 3 March 2019).
- [6] India CSR Network (2018). State Bank of India to have annual flagship 'SBI Green Marathon'
- [7] Jayadatta, S., & Nitin, S. (2017). Opportunities, challenges, initiatives and avenues for green banking in India. *International Journal of Business and Management Invention*, 6(2), 10–15. Available from: [http://www.ijbmi.org/papers/Vol\(6\)2/version-3/B0602031015.pdf](http://www.ijbmi.org/papers/Vol(6)2/version-3/B0602031015.pdf)
- [8] Jaggi, G. (2014). Green banking: Initiatives by SBI and ICICI. *Paripex-Indian Journal of Research*, 3(6).
- [9] M. J., Roy, S. K., Miah, M., & Das, S. K. (2020). A review on corporate environmental reporting (CER): An emerging issue in the corporate world. *Canadian Journal of Business and Information Studies*, 2(3), 45–53.

- [10] Shakkeela Cholasseri. (2016). GREEN BANKING –AN OVERVIEW: IJARIE-ISSN(O)-2395-4396. Vol-1 Issue-4 2016
- [11] <https://www.icicibank.com/ms/aboutus/annual-reports/2021-22/AR/social-and-relationship-capital.html>
- [12] https://bank.sbi/documents/17826/24027/2007201345_SBI+Sustainability+Report+V37+20_07_2020_Spread_layout.pdf/801cc0de-a47d-c860-f5c3-fc57efb58339?t=1595232977158



Category: Finance, Business, Management, Economics and Accounting

ORIGINAL

A systematic review of models for the prediction of corporate insolvency

Revisión sistemática de los modelos de predicción de la insolvencia empresarial

N. Sathyanarayana¹  , Raja Narayanan²  

¹Dayananda Sagar University, Bangalore, India.

²SCMS, Dayananda Sagar University, Bangalore, India.

Cite as: Sathyanarayana N, Narayanan R. A systematic review of models for the prediction of corporate insolvency. Salud, Ciencia y Tecnología - Serie de Conferencias. 2024; 3:952. <https://doi.org/10.56294/sctconf2024952>

Submitted: 13-02-2024

Revised: 01-05-2024

Accepted: 16-06-2024

Published: 17-06-2024

Editor: Dr. William Castillo-González 

ABSTRACT

A thorough evaluation of recent developments in bankruptcy prediction models developed specifically for listed firms in India is presented in this research. Beginning with influential contributions from the evolution of bankruptcy prediction methodologies is traced through various statistical techniques, including logistic regression, neural networks and discriminant analysis. Recent innovations, such as duration models, partial least squares with support vector machines, and efficiency-driven distress prediction, are discussed in the context of their applicability to the Indian market. The paper highlights the significance of early warning systems in the wake of bankruptcy reforms in India and examines the regulatory framework's impact on bankruptcy prediction modeling. And it goes further into how macroeconomic variables and industry-specific variables might make bankruptcy models better predictors. Limitations such as small sample sizes, short time periods for samples, and the incorporation of qualitative data into predictive models are highlighted in the study as areas that require further investigation in future studies. Overall, this paper provides valuable insights for academics, practitioners, and policymakers involved in bankruptcy prediction and risk management within the Indian corporate sector.

Keywords: Bankruptcy Prediction; Indian Listed Companies; Statistical Techniques; Early Warning Systems; Regulatory Framework; Macroeconomic Factors; Industry-specific Variables; Risk Management; Predictive Accuracy; Corporate Sector.

RESUMEN

En esta investigación se presenta una evaluación exhaustiva de la evolución reciente de los modelos de predicción de quiebras desarrollados específicamente para las empresas que cotizan en bolsa en la India. Comenzando por las influyentes contribuciones de la evolución de las metodologías de predicción de quiebras, se hace un recorrido por diversas técnicas estadísticas, como la regresión logística, las redes neuronales y el análisis discriminante. Las innovaciones recientes, como los modelos de duración, los mínimos cuadrados parciales con máquinas de vectores de apoyo y la predicción de dificultades basada en la eficiencia, se analizan en el contexto de su aplicabilidad al mercado indio. El artículo subraya la importancia de los sistemas de alerta temprana a raíz de las reformas concursales en la India y examina el impacto del marco regulador en los modelos de predicción de quiebras. Y profundiza en cómo las variables macroeconómicas y las específicas del sector podrían hacer que los modelos de predicción de quiebras fueran mejores. Limitaciones como el pequeño tamaño de las muestras, los cortos periodos de tiempo de las muestras y la incorporación de datos cualitativos a los modelos de predicción se destacan en el estudio como áreas que requieren una mayor investigación en futuros estudios. En general, este trabajo ofrece valiosas perspectivas para académicos, profesionales y responsables políticos implicados en la predicción de quiebras y la gestión de riesgos en el

sector empresarial indio.

Palabras clave: Predicción de Quiebras; Empresas Indias que Cotizan en Bolsa; Técnicas Estadísticas; Sistemas de Alerta Temprana; Marco Normativo; Factores Macroeconómicos; Variables Específicas del Sector; Gestión del Riesgo; Exactitud Predictiva; Sector Empresarial.

INTRODUCTION

The research conducted by Mario H constitutes a comprehensive empirical investigation aimed at elucidating the intricate dynamics of corporate credit risk through the integration of macro-economic, market-based and accounting data. Mario H's 1980-2011 study used 23 218 observations of listed businesses to provide a comprehensive dataset for analysis. The primary objective of this endeavour was to develop robust risk models tailored specifically for listed companies, with a particular focus on predicting financial distress and bankruptcy. Mario H combined accounting data, stock market indicators, and macroeconomic proxies to attain his objective. By incorporating these diverse datasets into the risk models, Mario H aimed to enhance their predictive accuracy, practical utility, and sensitivity to macroeconomic dynamics, thereby rendering them more suitable for stress testing applications. A comprehensive benchmarking experiment compared the estimated models to neural networks⁽²⁾ original Z-score specification. contributed to the discourse by exploring the adoption of contingent claims valuation approaches in corporate bankruptcy prediction models. The literature has rarely compared these models to classic accounting-ratio-based techniques, despite their theoretical promise.⁽³³⁾ He found that the z-score technique captures distinct components of bankruptcy risk and increases bank profitability under certain scenarios. Moreover, Tyler S advocated for the adoption of hazard models over single-period models for forecasting bankruptcy. Hazard models, characterized by their consistency in estimations, were deemed more appropriate for this purpose. Market size, Idiosyncratic & Past stock returns vary highly correlated with bankruptcy. To enhance the accuracy of out-of-sample predictions, Tyler S. proposed a mixed model that incorporates both accounting ratios and market-driven variables. Data Envelopment Analysis (DEA) was first used to assess corporate bankruptcy.⁽⁴⁾ To compare default and non-default enterprises, this non-parametric method was employed to measure the weight estimates of a classification function. DEA outperformed logistic regression (LR) in out-of-sample bankruptcy assessment in a recent sample of significant US corporate bankruptcies. The subject was furthered⁽⁴²⁾ who developed a measure of corporate success and failure based on an additive super-efficiency DEA model. Yao Chen found that the DEA model is less accurate at forecasting business failures than healthy firms by applying this approach to a random sample of 1001 firms, including significant US bankrupt firms and healthy matched firms. To make up for this shortcoming, the evaluation index provided decision-makers with options for total forecast precision, non-bankrupt, and bankruptcy. Premachandra⁽⁴²⁾ Bankruptcy prediction models have progressed over time, with a change from simpler multivariate models to more complex univariate financial ratio analysis. Recent advancements include the incorporation of capital market data and contingent claims valuation approaches. The effectiveness of older models, like Altman's Z-score model, has been questioned in modern contexts because of changing market dynamics and their shortcomings.⁽¹⁾ Recent corporate bankruptcy prediction models include contingent claims valuation and a financial risk assessment paradigm change. Despite the theoretical allure of these models, their empirical performance relative to traditional accounting-ratio-based approaches remains underexplored within the existing literature. In our investigation, we have unearthed distinct facets of bankruptcy risk captured by these two contrasting methodologies. Surprisingly, we observed minimal disparity in their predictive efficacy within the UK context. But when there are varying costs for different types of decisions and prices are competitive, the z-score technique helps banks turn a profit.⁽³⁵⁾ A comprehensive review spanning from 1968 to 2005 offers a panoramic view of the landscape of bankruptcy prediction methodologies, elucidating the diverse array of statistical and intelligent techniques employed in addressing this multifaceted challenge. Statistical methods, operational research, case-based reasoning (CBR), neural networks, evolutionary approaches, decision trees, rough set-based procedures, and other soft computing strategies are carefully categorized in this overview. Each paper scrutinized in this review sheds light on critical aspects such as the source of datasets, financial ratios utilized, geographical origins, temporal scope, and comparative performance metrics, thereby paving the way for future research endeavours aimed at refining and enhancing existing methodologies.⁽²⁷⁾ Finance, economics, and accounting have been interested in corporate bankruptcy dynamics. Starting with univariate financial ratio analysis, models for predicting corporate failure have progressed to multivariate and now logit models, which can directly estimate the risk of failure under less rigorous statistical assumptions. Multinomial logit models, which use secondary categorization information and expand outcome space to incorporate a third state of financial hardship, are powerful tools. These algorithms have reduced misclassification error rates and improved prediction capacities for detecting financially fragile enterprises at risk of severe financial crisis. Early bankruptcy prediction models based on pre-bankruptcy financial ratios performed well in-sample and out-of-sample.⁽²⁴⁾ Later advances in the literature included capital market

data like excess stock returns and volatility, as well as sophisticated option-pricing models like the Black Scholes Merton model.⁽³⁾

Notably, the efficacy of these models varied over time, with the introduction of a new model incorporating key variables from existing models yielding improved predictive performance, particularly concerning the degree of diversification within firms.⁽¹⁵⁾ Despite being a pioneer in company financial health evaluation, The Z-score model developed by Altman has some shortcomings as a result of its antiquated origins and sample characteristics. Modern firms have become harder to classify, prompting a critical evaluation of their utility. Our empirical study using recent sample data examines the model's efficacy across various dimensions, giving deep insights into its applicability across firm kinds and stress levels. A new model integrating key factors from all five models and a company diversification variable was established. Bankruptcy risk decreases with diversification. In-sample and out-of-sample studies demonstrate this more generic model outperforms current models.⁽⁵⁹⁾ While the quest to design reliable bankruptcy prediction models remains ongoing, it is imperative to adopt a multidimensional perspective that transcends unidimensional assessments. Comparing prediction models can lead to future research focused on improving current methods and creating new techniques to tackle the changing issues of corporate financial risk.⁽¹⁷⁾

Review of literature

To forecast bankruptcies, hazard models that incorporate accounting and market data have lately become the norm. There hasn't been a comprehensive literature review that compares these hazard models to conventional accounting-based approaches or contingent claims procedures. Through Receiver Operating Characteristics (ROC) curve analysis using data from UK-listed firms between 1979 and 2009, it has been demonstrated that hazard models outperform alternative approaches.⁽⁹⁾ Additionally, information content tests reveal that hazard models encompass all bankruptcy-related information contained in established models such as the⁽⁵⁴⁾ z-score⁽¹²⁾ contingent claims-based models.⁽⁹⁾

A Pakistani non-financial sector bankruptcy prediction study examined financial ratios over five years before bankruptcy for enterprises that went bankrupt between 1996 and 2006. Cash flow ratio, EBIT to current liabilities, and Sales to total assets were significant predictors of bankruptcy in this discriminant analysis, with 76,9 % accuracy on the sample dataset.⁽⁴³⁾

The use of neural network models for bankruptcy prediction has garnered attention, presenting a viable alternative to traditional methods like Multivariate Discriminant Analysis (MDA). A comparative study shows that neural networks might be useful in this area, as they can make accurate predictions.

The effectiveness of bankruptcy prediction models is crucial for informed lending decisions by financial institutions. While Machine Learning (ML) and statistical techniques have been explored, the synergistic integration of financial ratios and corporate governance indicators remains underexplored. Experimental findings underscore the significance of solvency and profitability ratios, alongside board structure and ownership indicators, in enhancing prediction accuracy.⁽²⁹⁾

Addressing the unique context of Belgian small-and medium-sized enterprises (SMEs), a study develops a logit model incorporating various financial ratios to predict bankruptcy. Results underscore the predictive power of liquidity and profitability ratios in identifying firms at risk of insolvency, offering valuable insights for stakeholders including investors, managers, and credit institutions.⁽¹⁸⁾

Previous bankruptcy prediction studies employing Multiple Discriminant Analysis (MDA) have yielded inconsistent results, partly due to variations in the selection of financial ratios and methodological approaches.⁽³¹⁾ Challenges such as multicollinearity and temporal aggregation underscore the need for robust methodologies in this domain.

Amidst the rising prevalence of corporate bankruptcies, the efficacy of Partial Least Squares Logistic Regression (PLS-LR) in bankruptcy prediction is explored. The results highlight the superiority of PLS-LR over conventional methods, offering a promising avenue for enhanced predictive accuracy. The emergence of Partial Least Squares Logistic Regression (PLS-LR) as a predictive tool offers a novel approach to bankruptcy forecasting, particularly in the context of the USA banking crisis in 2008. Comparative analysis demonstrates the effectiveness of PLS-DA alongside traditional techniques like Support Vector Machine (SVM) and Linear Discriminant Analysis (LDA).⁽²³⁾

The Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) framework, traditionally employed for ranking, is adapted as a classifier for bankruptcy prediction. Empirical validation on UK firms demonstrates robust predictive performance, opening new avenues for risk modelling applications. Productivity and firm strategy play pivotal roles in mitigating bankruptcy risk, as evidenced by empirical findings employing data envelopment analysis. Because of its mediating role, productivity is significant in the strategy-bankruptcy risk relationship.⁽³⁸⁾

Gradient boosting models offer a flexible approach to bankruptcy prediction, accommodating a vast array of predictors. When it comes to improving predictive efficacy, empirical study highlights the importance of non-traditional variables, like as ownership structure and CEO pay. Comparative evaluation of bankruptcy prediction models, including MDA, the linear probability model, and logistic regression, underscores the importance of

selecting appropriate methodologies aligned with the theory of financial distress.⁽²⁵⁾

Convolutional neural networks are applied innovatively to predict corporate bankruptcy, leveraging financial statement data transformed into grayscale images. Results demonstrate superior performance compared to traditional methods, highlighting the potential of deep learning in financial analysis. The use of data mining techniques in bankruptcy prediction highlights the significance of feature selection in enhancing predictive performance.⁽²²⁾ The experimental results highlight the effectiveness of the t-test method in choosing relevant features to enhance the accuracy of classification.⁽²²⁾

To further understand the mediating impacts of productivity and business strategy, we investigate their roles in reducing the likelihood of bankruptcy. Findings underscore the positive impact of productivity and strategic orientation in reducing bankruptcy risk, offering practical implications for stakeholders. Genetic Programming (GP) emerges as a promising tool for bankruptcy prediction, offering superior performance compared to traditional methods like MDA. GP's adaptive nature and ability to handle complex problems position it as a valuable asset in financial risk assessment.⁽³⁷⁾

Models Used by Various Authors

In the decades following Altman's 1968 publication of a prominent bankruptcy prediction model, a deluge of similar models have been produced.⁽¹¹⁾ In addition to a rise in the total number of articles on the topic, this trend indicates a wide range of models used to forecast which businesses will fail. The advancement of statistical methods and IT in the last several years has allowed for the incorporation of a wider variety of predictive methodologies, leading to the creation of a more accurate model for bankruptcy prediction.

The MDA model with five factors was proposed.⁽²⁾ Logit analysis, MDA, neural networks and probit analysis are the main methodologies that have been utilized to create models.⁽¹¹⁾ One of the famous and hopeful technologies, neural networks has been around since the 1990s, when academic interest in AI technology began to surge. Several seminal studies in the field of business failure prediction used this methodology.^(5,20,28,55,58) In addition,⁽³⁹⁾ aimed to optimize a Neural Network model using an algorithm; the model achieved good convergence results, indicating good prediction capability.

Additionally, numerous authors in the area of bankruptcy prediction have embraced a variety of ML and Artificial Intelligence (AI) techniques. These include rough sets, CBR, SVM, and others. Rough set theory has found extensive application in diverse financial decision analysis problems. It was initially developed to address the challenge of distinguishing between objects that appear indiscernible within a set. Reported bankruptcy accuracy has been found to range from 76 % to 88 %. Case-based thinking has become an important tool for predicting when a business will fail. It is highly effective and easily understandable, making it a popular choice for solving real-world problems. This approach offers competitive edge over modern methods and is known for its simplicity and ease of pattern maintenance.⁽³⁰⁾ The SVM, which originated from the field of statistical learning theory, was first utilized in corporate failure prediction in 2005. Studies conducted^(50, 34) demonstrated that it outperformed artificial neural networks in terms of performance.⁽²⁶⁾

Since the year 2000, there has been a proliferation of publications discussing how to forecast when a company would fail, and some writers have even provided insight into how to compare and contrast various models for this purpose. In contrast to the two accounting-based models—the Z-score⁽²⁾ and the O-score⁽³⁶⁾ — the authors of the market-based model⁽²¹⁾ demonstrate that their model, which is derived from the Black-Scholes-Merton model, can provide substantially more information. Balcaen⁽⁷⁾ examined classic statistical methods employed over the last 35 years to learn about their characteristics and associated issues.

METHODOLOGY

To start, we used the bibliographic database Scopus to conduct a systematic literature review (SLR) that aimed to find the most important papers published in English between 1968 and 2022. It is the main objective to “find all relevant individual studies, thereby making the available evidence more accessible to decision-makers.”⁽¹⁶⁾

A crucial component of any academic work is the systematic literature review methodology. The objective is to address the issue by uncovering pertinent and reliable individual studies and combining their findings. This approach assists researchers in obtaining a deeper understanding of their subject matter.⁽⁵⁷⁾ The SLR offers numerous advantages, including the provision of reliable information, facilitated by its promotion of methodological transparency and support for future replication. Scopus offers a wide range of abstracts and citations from scientific journals, books, and conference proceedings, giving a comprehensive view of research from around the world.⁽¹⁹⁾ Additionally, to analyze the connections between authors in articles related to bankruptcy prediction, we utilized VOS Viewer to identify key concepts and conduct a visually captivating network analysis. This will provide a clear visualization of the existing relationships.

Finding relevant keywords and selecting articles for analysis

To address the research questions, a set of twelve specific terms, consisting of six primary and six secondary

keywords, were utilized in 36 unique combinations. These combinations were employed to search for scholarly articles from around the globe that were pertinent to the subject matter. The information regarding the design of the keyword combination is displayed in table 1.

Primary Key Word(s)	No of articles - Secondary keyword(s)					
	Model	Prediction	Forecast	Indicator	Ratio	Score
Bankruptcy	179	195	7	7	57	30
Default firm	11	5	0	0	1	2
Early warning	131	38	3	62	2	1
Failure prediction	82	197	17	2	22	5
Financial distress	90	67	4	7	30	10
Insolvency	30	17	2	2	10	8
Total	523	519	33	80	122	56

RESULTS

Evolution of Published Papers

Bankruptcy prediction is a crucial area of research in corporate finance and financial analysis. Understanding the dynamics and patterns of bankruptcy prediction models over time is essential for both academia and industry practitioners. In this analysis (table 2), we will examine the publication trends in prominent journals from 1974 to 2022, focusing on four distinct periods: 1974-1985, 1986-1997, 1998-2009, and 2010-2022. Journals with the major number of publications in shown in table 3. Year-wise publications for the last 48 years on bankruptcy prediction models in shown figure 1. No. of research paper publications in major journals in shown figure 2. No. of research paper publications in major journals in shown figure 3.

Years	No. of Publications	Years	No. of Publications	Years	No. of Publications	Years	No. of Publications
1974	3	1986	8	1998	20	2010	53
1975	1	1987	8	1999	22	2011	48
1976	6	1988	6	2000	22	2012	54
1977	5	1989	4	2001	30	2013	58
1978	5	1990	11	2002	39	2014	49
1979	2	1991	13	2003	25	2015	39
1980	5	1992	10	2004	45	2016	41
1981	2	1993	11	2005	44	2017	61
1982	6	1994	18	2006	53	2018	64
1983	6	1995	13	2007	38	2019	72
1984	13	1996	18	2008	54	2020	71
1985	7	1997	12	2009	45	2021	62

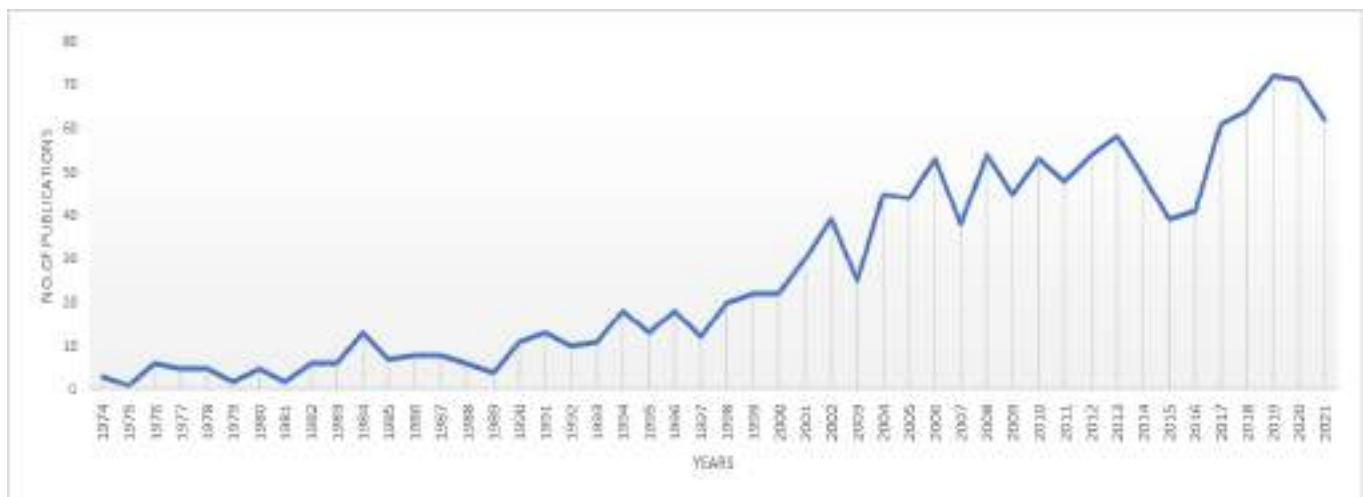
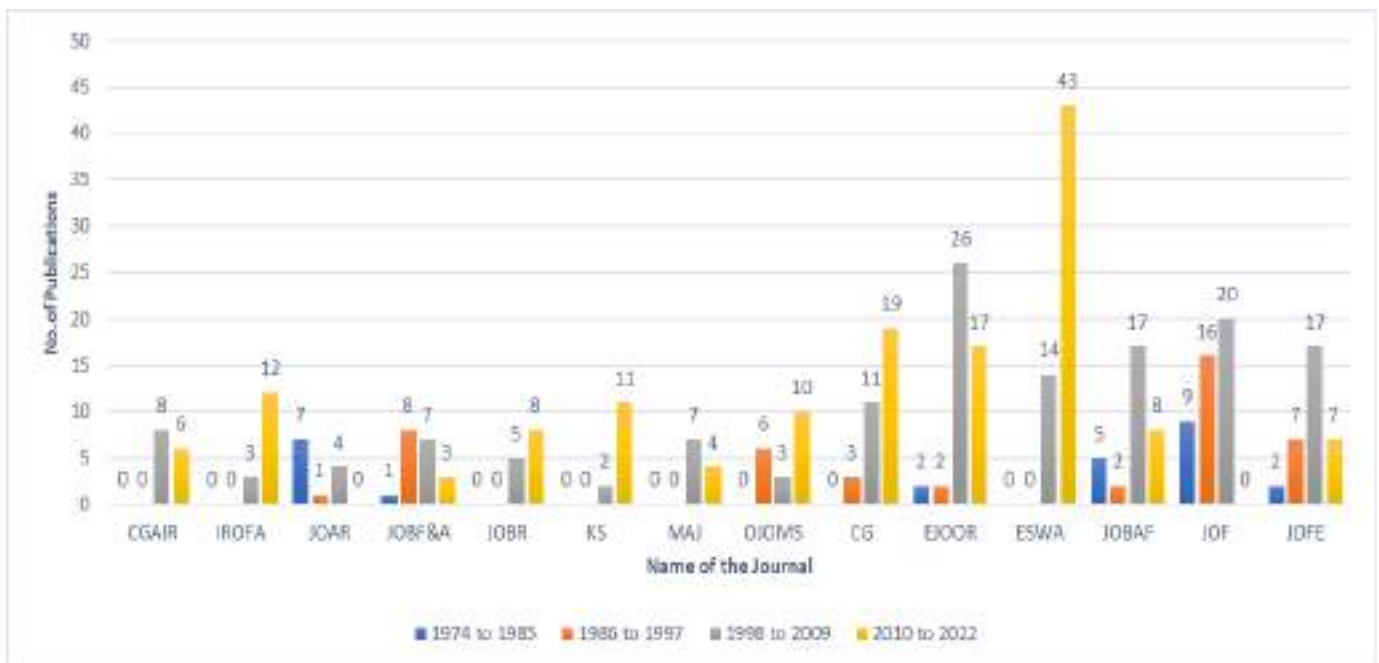
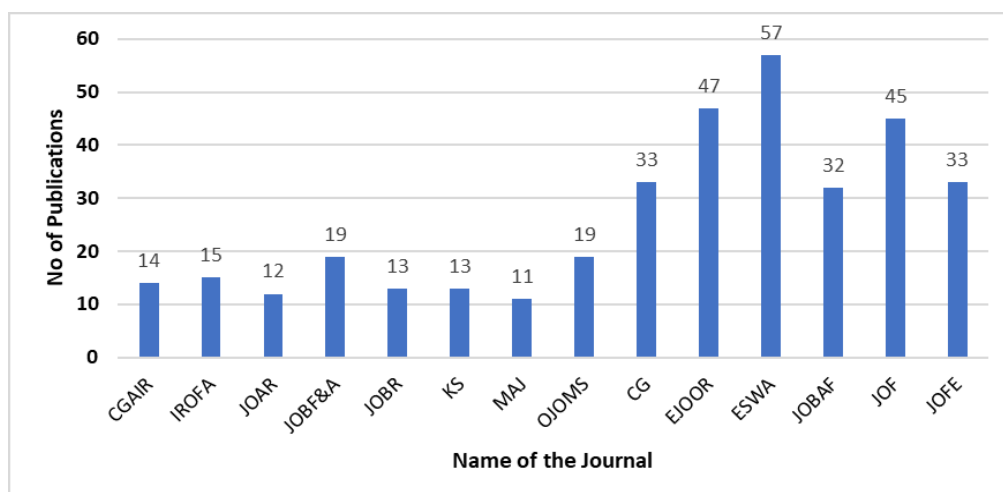


Figure 1. Year-wise publications for the last 48 years on bankruptcy prediction models

Table 3. Journals with the major number of publications

Name of the Journal	No of Publications	1974 to 1985	1986 to 1997	1998 to 2009	2010 to 2022
Corporate Governance: An International Review - (CGAIR)	14	0	0	8	6
International Review of Financial Analysis - (IROFA)	15	0	0	3	12
Journal of Accounting Research - (JOAR)	12	7	1	4	0
Journal of Business Finance & Accounting - (JOBFA)	19	1	8	7	3
Journal of Business Research - (JOBR)	13	0	0	5	8
Knowledge-Based Systems - (KS)	13	0	0	2	11
Managerial Auditing Journal - (MAJ)	11	0	0	7	4
Omega-international Journal of Management Science - (OJOMS)	19	0	6	3	10
Corporate Governance - (CG)	33	0	3	11	19
European Journal of Operational Research - (EJOOR)	47	2	2	26	17
Expert Systems With Applications - (ESWA)	57	0	0	14	43
Journal of Banking and Finance - (JOBFAF)	32	5	2	17	8
Journal of Finance - (JOF)	45	9	16	20	0
Journal of Financial Economics - (JOFE)	33	2	7	17	7

**Figure 2.** No. of research paper publications in major journals (Year wise)**Figure 3.** No. of research paper publications in major journals (Total)

Interpretation

Evolution of Research Focus

The data indicates a significant increase in publications related to bankruptcy prediction models over the years, with a notable surge observed from 1998-2009 onwards. Journal of Finance and Expert Systems With Applications have consistently maintained a strong presence in publishing research on bankruptcy prediction models, indicating sustained interest in the topic.

Shift in Academic Interest

The decline in publications during the 1986-1997 period compared to the previous decade might suggest a shift in academic interest towards other financial research areas. However, the substantial increase in publications from 1998-2009 and 2010-2022 indicates a resurgence of interest in bankruptcy prediction models, possibly driven by global financial crises and regulatory changes.

Emergence of New Journals

The emergence of journals like European Journal of Operational Research and Corporate Governance: An International Review as significant contributors in the late 1990s and early 2000s reflects the interdisciplinary nature of bankruptcy prediction research, incorporating aspects of governance and operational analysis.

Implications for Practice

The rising amount of studies in this field indicates that people are starting to realize how important it is for businesses to have reliable models to anticipate when they will go bankrupt so that they may better manage risk, comply with regulations, and make important decisions. Practitioners can benefit from staying updated with research published in leading journals to leverage the latest methodologies and insights for enhancing their bankruptcy prediction frameworks.

Relationship among Authors (Co-authorship)

Using VOS Viewer, an analysis tool that specializes in interactive social network visualization, a co-authorship has been developed to show that the many authors of the selected articles in the SLR collaborated. Co-authorship network visualization is shown in figure 4. Citations network visualization is shown in figure 5.

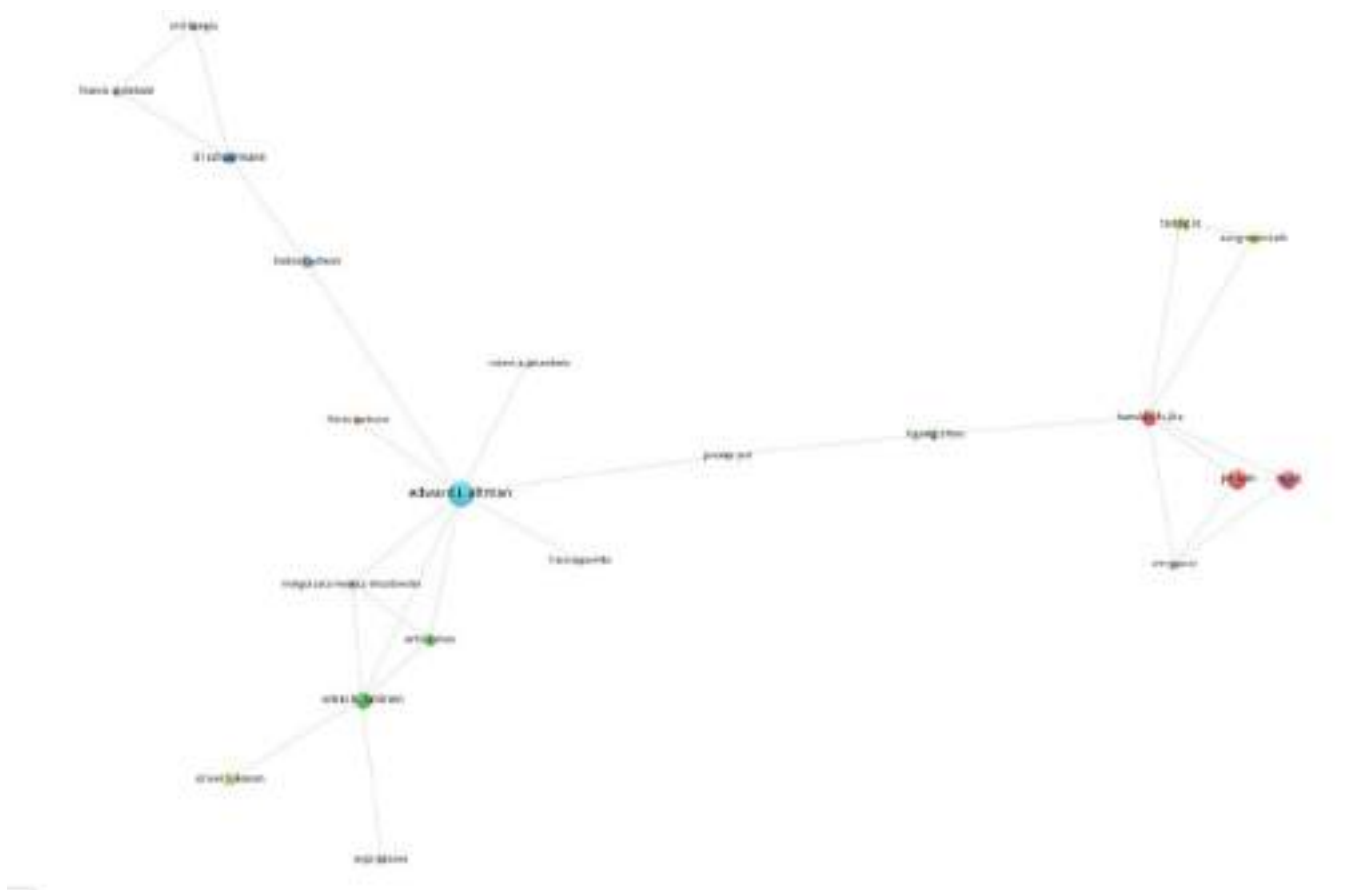


Figure 4. Co-authorship network visualization

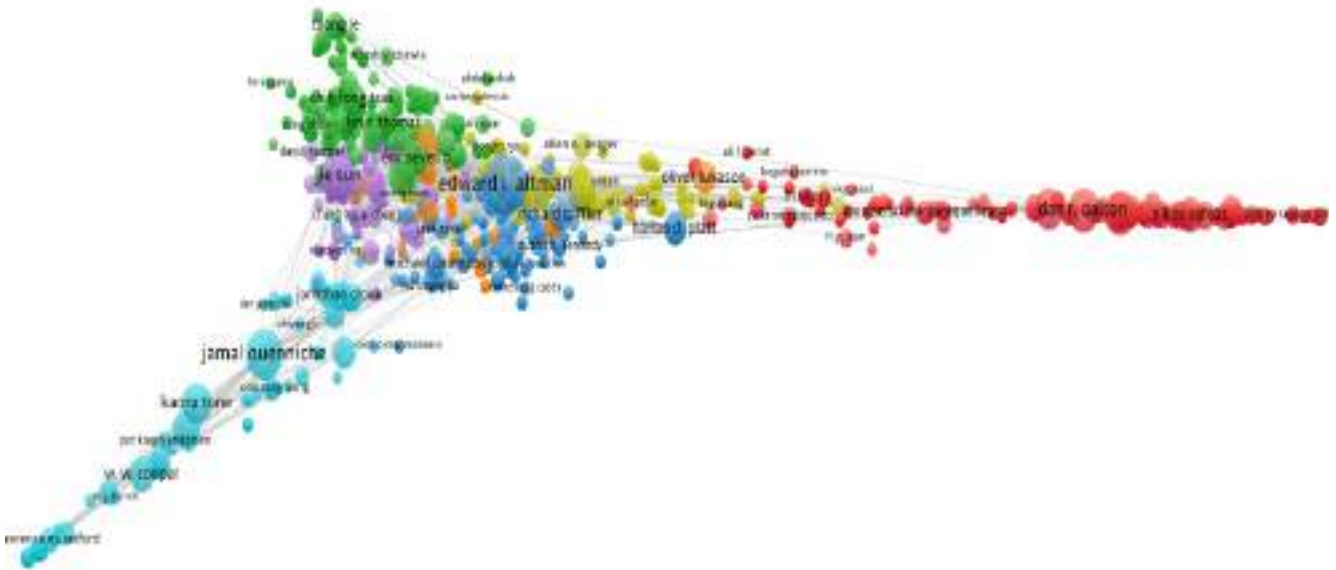


Figure 5. Citations network visualization

Bankruptcy prediction models applied in India

In the late 1960s^(10,2,36) and others advanced bankruptcy prediction models. Altman⁽⁵⁾ Financial distress or bankruptcy prediction usually uses a two-stage process. Initially, the first stage involves identifying the most effective financial ratio predictors. Subsequently, in the second stage, suitable statistical methods are developed to enhance estimators for improved prediction accuracy. Many bankruptcy prediction models exist, including univariate, multivariate, discriminant, decision tree, and logistic regression. In a univariate model of 30 financial ratios⁽¹⁰⁾ found that net income to total assets ratio and working capital funds flow to total assets ratio are the best predictors of bankruptcy. Beaver made four assumptions about distressed enterprises. Altman⁽²⁾ established the multiple discriminant approach and the bankruptcy measuring score (z-score). Altman's approach used profitability variables to predict bankruptcy risk, classifying firms 90 % of the time. Altman's approach assumes sample data normality, which can lead to incorrect predictions if a variable is non-normal.⁽⁴⁵⁾ Three logit models were used to forecast company failure at different time intervals.⁽³⁶⁾ Despite mixed findings, the Logit model demonstrated advantages over discriminant analysis, providing a probability of bankruptcy. In the 1980s and 1990s, logit analysis was compared to neural networks and became popular. Altman⁽⁵⁾ found Logit and neural network techniques equivalent and useful for distress classification and prediction. Recent studies have explored innovative methodologies, such as duration models incorporating macroeconomic dependencies⁽³⁵⁾, and Partial Least Squares with Support Vector Machine (PLS-SVM) for corporate distress.^(60,8) compared discriminant, neural network, and logistic models for listed Indian firms, finding neural networks to be the most accurate. Concurrently, bankruptcy reforms are underway globally, including in India, to enhance transparency and efficiency in bankruptcy procedures. A recent study used financial parameters to forecast Indian corporate distress from 2006 to 2015. The study applies both logistic and Bayesian techniques, revealing superior predictive performance and sharper model estimates with Bayesian logistic modelling compared to traditional logistic regression.⁽⁵²⁾ Shows summarised review of bankruptcy prediction research in india in shown table 4.

Table 4. Shows summarised review of bankruptcy prediction research in india

Author(s)	Summarized Introduction	Methods Used	Limitations	Results
Shrivastava ⁽⁵²⁾	Bayesian Logistic model predicts Indian corporate hardship. Uses Capital IQ panel dataset for distress prediction. Bayesian vs. Logistic prediction models.	Predicting distress with Bayesian and logistic models. Adding firm-specific parameters to detect early distress. Financial ratio testing for Indian conditions. Logistic and Bayesian logistic model theory.	Low distressed entity proportion lowers modeling robustness. Limited bankruptcy data for Indian corporations.	Bayesian model predicts distressed Indian enterprises better than Logistic. Bayesian framework requires prior distributions and convergence checks.

Shrivastav ⁽⁵¹⁾	Research focuses on Indian bank bankruptcy prediction and stress quantification.	Relief feature selection algorithm. SVM with linear and radial basis function kernels.	Failure data on Indian banks is scarce compared to surviving banks. Replicating the model may provide distinct SVM forms and confounding interpretations.	SVM with linear kernel: 94.44 % predictive accuracy, 75 sensitivity, 100 specificity. SVM with radial basis function kernel: 71.43 % forecasting accuracy.
Shetty ⁽⁴⁶⁾	Investigated non-financial parameters of Indian company financial trouble prediction. Examined board independence and ownership structure in financial distress prediction.	We created binary logistic regression models M1 and M2. The cut-off point was estimated using the Liu technique.	The circumstances did not specify restrictions.	The addition of non-financial factors enhanced financial distress prediction model efficacy, with Model 1 outperforming Model 2 in AUC and sensitivity. A model containing both financial and non-financial indicators is recommended for prediction.
Shetty ⁽⁴⁸⁾	The paper analyzes IT/ITES bankruptcy using a modified DEA model. Focus on company bankruptcy early warning systems. Introduces bankruptcy to find underperforming DMUs.	A changed directional distance DEA Statistical methods, neural networks, CBR, decision trees	Traditional bankruptcy prediction models are not compared in the study. No discussion of generalizing the bankruptcy assessment approach.	Bankruptcy scores predict firm bankruptcy. The most likely to fail is Logix Microsystems. HP Globalsoft Ltd. is least likely to fail.
Charalambakis ⁽¹⁴⁾	Compares UK and Indian accounting and market data to predict insolvency. Tests models' ability to predict non-US financial problems. Examines UK financial hardship prediction models.	Book leverage and equity market variables hazard model in-sample and out-of-sample static and dynamic logit models to forecast. Estimating bankruptcy risk using accounting ratios and market data. Stock volatility, EDF use, relative size, and excess returns.	Indian market data fails to anticipate insolvency. Profitability and leverage accounting variables definition-sensitive.	Risk model with book leverage and equity market variables forecasts best in the UK. India: Profitability-FRISK model accurately predicts financial crisis. Indian market data fails to anticipate insolvency.
Bapat ⁽⁸⁾	The paper evaluates Indian company bankruptcy prediction models utilizing financial ratios. MDA, logistic regression, and neural network models. Among models, neural network classifies best.	MDA, Logistic regression, Neural network	There is no comprehensive corporate bankruptcy policy in India. Exclude financial institutions, delisted corporations, and incomplete data.	A neural network beat logistic regression and discriminant analysis. Before bankruptcy, descriptive data compared bankrupt and non-bankrupt enterprises. The pre-bankruptcy classification accuracy dropped from 70.45 % to 61.36.
Balasubramanian ⁽⁶⁾	Predicting Indian listed company financial trouble using financial and non-financial characteristics. Combining financial and non-financial parameters improves prediction.	Financial and non-financial conditional logit regression. Comparing logistic regression classifiers with and without non-financial variables.	Short sample size and duration. Limited prediction to one year ahead. Not addressing macroeconomic factors like GDP growth.	The accuracy of financial variable models was 85.19 and 86.11. The accuracy of financial and non-financial models was 89.81 % and 91.67 %. Net asset value, long-term debt-equity ratio, and ROI are key determinants.

Reserve Bank of India (RBI) observed that Indian banks for over a decade, exhibited robust capitalization and regulation, integral to daily economic activities. Given the sector's interconnectedness and the potential for major failures to pose operational and financial risks, the RBI has implemented measures like Prompt Corrective Action (PCA) and capital infusion, exemplified by the Rs. 2,11 trillion recapitalization package for public sector banks in October 2017. Given the historical context, such as the 2007-2008 financial crisis, the RBI's proactive stance underscores the imperative of close supervision and preemptive strategies. Bankruptcy prediction assumes critical importance in this context, necessitating the development of precise and efficient models to measure financial distress. While traditional techniques like finance and accounting ratios have been utilized, they are limited in methodology. A significant body of literature, including works^(2, 32) explores bankruptcy

prediction using statistical methods and, more recently, machine learning techniques.⁽⁴⁴⁾ This work introduces a new approach to stress quantification and bankruptcy prediction using SVM with the right kernels for Indian banks. Notably, the study employs the Relief Algorithm for feature selection, a nonparametric approach distinct from previous parametric methods. Furthermore, the SVM model is fine-tuned using 5-fold cross-validation, enhancing generalization by establishing an optimal cut-off level. The study introduces a geometric analysis of the SVM technique, facilitating stress quantification and regulatory oversight. Organized into sections encompassing introduction, literature review, methodology, empirical results, conclusions, and limitations, the study emphasizes the importance of early warning systems for stakeholders. Utilizing SVM, the study employs a two-step feature selection process and achieves promising predictive accuracies, with SVMLK outperforming SVMRK. Notably, SVMLK identifies key features such as Provision for Loan Interest Income (Tire -1) and Tier -1 CAR(t-1). Also, a new stress quantification method is presented in the study, which allows us to compare the financial health of different banks and gives us a geometric interpretation of the decision boundary, so we can see what modifications are needed to keep banks from failure. These findings furnish actionable insights for bank management to preempt potential failures and safeguard financial stability.⁽⁵¹⁾

Corporate bankruptcy is a major economic risk. To avoid losses, governments, investors, and shareholders use bankruptcy analysis to make financial decisions. While DEA is normally used to examine the efficiency of decision-making units (DMUs), this study tweaks the directional distance formula to evaluate the risk of bankruptcy. On a scale from 0 to 1, the offered method has the lowest relative efficiency of any comprehensive non-oriented, non-radial directional distance model. Diverging from conventional DEA approaches that identify the best relative efficiencies, our model identifies underperforming DMUs and delineates an inefficiency frontier. This economic theory-based bankruptcy assessment model uses the worst relative efficiency measures and pessimistic performance ratings. In India's IT and IT-enabled services (ITES) sector, Hewlett-Packard Globalsoft Ltd. is least likely to fail, while Logix Microsystems is most likely. The paper provides a precise bankruptcy measure as an early warning system and emphasizes the need to identify failing enterprises. The analysis uses 1998-2006 three-year moving averages for robustness and consistency. The worst-performing enterprises may not go bankrupt, but their financial vulnerability requires performance improvements. The report admits drawbacks like missing data, which may exclude some firms. For future study, we suggest using time-series data for a wider range of enterprises to track bankruptcy frontier changes, maybe through Malmquist productivity index changes. This study introduces a bankruptcy prediction model that combines statistical and artificial intelligence methodologies to help stakeholders analyze and mitigate bankruptcy risk.⁽⁴⁶⁾

Scholars are increasingly using DEA operational research to assess organizations' bankruptcy risks. DEA does not assume the functional form of interactions between various input and output variables, unlike traditional approaches. Many technologies have been developed to warn creditors of enterprises at risk of bankruptcy or failure. Financial ratios and MDA were first used to predict bankruptcy.⁽²⁾ The discriminant analysis assumes linearity, multivariate normality, and predictive variable independence, which many financial ratios lack. Hazard models have been used to assess bankruptcy risk to overcome these constraints.⁽⁵³⁾ Shumway's model outperformed Altman's in prediction.⁽¹³⁾ Used a variable returns to scale (VRS) DEA model to assess the financial stability of US Department of Defense civil sector air fleet participation. The VRS DEA model has constraints such as reduced translation invariance.⁽⁴⁰⁾ For out-of-sample bankruptcy predictions,⁽⁴¹⁾ suggested an additive DEA model that outperformed logistic regression. This paper recommends modifying⁽⁴⁷⁾ the directional distance formulation of DEA for bankruptcy prediction. Our methodology identifies underperforming DMUs and establishes an inefficiency frontier by measuring the worst relative efficiency from zero to one, unlike previous DEA methods. This approach follows economic theory and introduces a precise bankruptcy measure for early warning. As a case study, we apply this paradigm to Indian IT and IT-enabled services organizations. Our study evaluates bankruptcy prediction models in the UK and India, adding to the literature. Consistent with earlier findings, a model combining book leverage and market-based characteristics predicts UK businesses well. A model using only market variables outperforms multivariate models with multiple predictors. Compared to other models, the hazard model with market-related factors identifies more insolvent enterprises with reduced misclassification rates in-sample and out-of-sample. Furthermore, we find that models based on market-based variables perform better than those relying solely on accounting ratios or combining different predictors. This shows the importance of market data in bankruptcy prediction models, especially amid economic volatility. As the Indian economy continues to grow, such predictive models play a crucial role in assessing and mitigating bankruptcy risks for firms operating in dynamic economic environments.⁽⁴⁸⁾

Researchers are using the operational research method DEA to analyze corporate bankruptcy risk.⁽⁴⁹⁾ DEA does not assume the functional form that characterizes the interactions between many input and output variables, unlike traditional approaches. As said, numerous systems have been created to alert creditors of enterprises at risk of bankruptcy or failure. Financial ratios and MDA were used in a study⁽²⁾ to forecast insolvency. Many financial ratios, however, do not adhere to the strong constraints of linearity, multivariate normality, and predictive variable independence that are imposed by discriminant analysis. Using data collected from UK

enterprises between 1996 and 2005, a basic hazard model was used to evaluate the likelihood of bankruptcy.⁽⁵⁶⁾ The outcome of the hazard model comparison with the z-score model demonstrated that Shumway's model outperformed Altman's bankruptcy prediction models in terms of predictive capability. Using financial ratios from 1988 to 1997 and a variable returns to scale (VRS) DEA model,⁽¹³⁾ assessed the robustness of the US Department of Defense's civil service air fleet. Bowlin solved the problem of negative financial ratio values by taking their absolute values and turning them into positive ones. The VRS DEA model shows limited translation invariance, as shown⁽⁴⁰⁾, leading to efficiency scores that are data transformation dependent. Using an additive DEA model, DEA was employed⁽⁴¹⁾ as a substitute approach to bankruptcy measurement. When it came to making predictions outside of the sample, the DEA model was much more effective than the logistic regression (LR) method. Here, we offer an improvement to the efficiency metric of the directional distance DEA formulation for bankruptcy prediction that was previously proposed.⁽⁴⁷⁾

Our methodology finds the weakest decision-making units (DMUs), quantifies their worst relative efficiency from 0 to 1, and establishes an inefficient frontier. This methodology differs from conventional DEA methods that find optimal relative efficiencies. This bankruptcy evaluation method follows economic theory and provides a complete and accurate bankruptcy metric that may serve as a warning system. Indian IT and ITES companies are used to apply our technique to the IT industry. Bankruptcy prediction models have a lot of data on US firms' financial difficulties, but not on their performance outside the US, notably in terms of new predictors and model performance. We assess these models' ability to predict financial problems for UK and Indian enterprises, two more developed economies. Their results demonstrate that, similar to Shumway's findings for the US, a model that includes book leverage and three market-based variables produces better predictions for UK firms. Multivariate models that include more than three predictors also perform worse than those that rely on the three market variables alone. Neither the Z-score nor EDF showed any enhanced predictive capability following the inclusion of variables to our top model. The hazard model's out-of-sample and in-sample forecasting ability is enhanced by book leverage and the three market components. With the least amount of misclassification, it correctly tally the most bankrupt enterprises. Finally, models that include market capitalization, stock return volatility, and excess returns outperform those that employ Z-score, EDF, or both.⁽¹⁴⁾

GDP rose from 4,8 % in 2005-06 to 7 % in 2007-08. By 2009, seven Indian companies had amassed \$60 billion in outsourced revenues, placing them among the top 15 technology outsourcing corporations. Indian software and service company Nasscom predicted US\$225 billion by 2020. IT, ITES, and BPO are India's fastest-growing commercial services, accounting for one-third of overall services output. Due to increased specialization and a big pool of highly qualified yet cost-effective human resources, the IT sector has grown rapidly to meet global customers' demand for India's service exports. Strong export revenue, a developing domestic market, and industrial expansion have all contributed to India's IT industry's recent success, positioning the country to become an IT powerhouse on a worldwide scale. The burgeoning IT prowess of India has spurred a surge in entrepreneurial ventures establishing IT companies within the country. The impending danger of company bankruptcy has been highlighted as one of the most serious threats to a national economy due to the global economic slump that has affected almost every country, including India. The study of corporate bankruptcies has gained paramount importance, given that the failure of numerous companies can engender economic and social ramifications for society at large. The IT companies that are most and least likely to go bankrupt are categorized in this study using the directional distance formulation of the DEA technique. This study develops and compares Neural network, MDA and LR bankruptcy prediction models for listed Indian companies. From 1991 to 2013, the dataset contains 72 matched pairs of businesses that went bankrupt and those that continued to be in business. Neural networks have 77,27 %, 63,64 %, and 65,91 % accuracy one, two, and three years before bankruptcy; logistic regression has 75,00 %, 59,09 %, and 61,36 %; and MDA has 70,45 %, 61,36 %, and 61,36 %. MDA and LR predict bankruptcy less accurately than neural networks for all three years prior. Given its comparative advantage, neural network modeling should be given more attention in professional circles to improve bankruptcy prediction for Indian enterprises. Future research endeavours could enhance this study by incorporating non-financial variables, as previous literature suggests their significant contribution to improving the prediction accuracies of bankruptcy models. Additionally, extending the scope beyond listed Indian companies to include relatively smaller private firms in India could further enrich the understanding of bankruptcy dynamics in the Indian context. One of the most investigated issues in finance and strategic management is bankruptcy prediction. The early 1930s and 1940s studies compared bankrupt and non-bankrupt firms' financial ratios, showing bankrupt firms had lower ratios. Subsequently, MDA emerged as the primary method in the 1970s, followed by a shift towards logistic regression analysis in the 1980s. Recent years have witnessed a mounting interest in using neural network approaches, yielding promising results in bankruptcy prediction. This study uses MDA, LR, and neural network methods to create bankruptcy prediction models for Indian listed companies to help investors, managers, bankers, lenders, auditors, and finance professionals make decisions.⁽⁸⁾

CONCLUSION

Bankruptcy prediction models have evolved significantly since the late 1960s, with seminal contributions from researchers like^(2,10,36) among others. These models typically employ a two-stage methodology, initially identifying effective financial ratio predictors and subsequently developing statistical methods for enhanced prediction accuracy. Bankruptcy prediction uses univariate models, multivariate models, discriminant analysis, decision trees, LR, and other methods. Beaver⁽¹⁰⁾ proposed a 30-financial-ratio univariate model, while⁽²⁾ introduced the multiple discriminant methodology, presenting Altman's z-score. Ohlson⁽³⁶⁾ introduced the logit model in bankruptcy prediction, demonstrating advantages over discriminant analysis. Subsequent studies explored innovative methodologies, such as duration models and PLS-SVM, for corporate distress prediction. In the Indian context⁽⁸⁾ for Indian listed enterprises, neural networks were the most accurate among discriminant, logistic, and neural networks. According to new research on early warning signs and distress prediction in India's corporate sector, Bayesian approaches are more effective than logistic regression. Given the importance of the banking sector in India and the potential systemic risks posed by major failures, the Reserve Bank of India (RBI) has implemented measures like capital infusion and Prompt Corrective Action (PCA) to ensure stability. This underscores the importance of precise bankruptcy prediction models for financial institutions. A recent study proposed an innovative bankruptcy predictive model tailored for Indian banks, employing a support vector machine (SVM) with appropriate kernels. This study employed the Relief Algorithm for feature selection and 5-fold cross-validation to enhance model accuracy and generalization. The study introduced a novel stress quantification technique, providing actionable insights for bank management to preempt potential failures. Another study used DEA's directional distance formulation to assess bankruptcy risk, creating a comprehensive early warning system. The study used this methodology to identify Indian IT and IT-enabled services enterprises at danger of failure and stressed proactive action. Research has shown that neural networks can forecast Indian company insolvency better than MDA and logistic regression.

Future research

Future research could enhance these models by incorporating non-financial variables and extending the scope to include smaller private firms in India. Bankruptcy prediction models play a crucial role in assessing and mitigating bankruptcy risks, particularly in dynamic economic environments like India. Continued research and innovation in this area are essential for the financial stability and resilience of Indian companies and institutions.

REFERENCES

1. Agarwal V, Taffler R. Comparing the performance of market-based and accounting-based bankruptcy prediction models. *Journal of banking & finance*. 2008 Aug 1; 32(8): 1541-1551. <https://doi.org/10.1016/j.jbankfin.2007.07.014>
2. Altman EI. Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The journal of finance*. 1968 Sep 1; 23(4): 589-609. <http://doi.org/10.1111/j.1540-6261.1968.tb00843.x>
3. Stojanovic L, Figun L, Trivan, J. Risk Management on Medjedja Dam on Tailing Storage Facility, Omarska Mine Prijedor. *Arhiv za tehničke nauke*. 2020; 1(22): 11-20. <https://doi.org/10.7251/afts.2020.1222.011S>
4. Altman EI, Haldeman RG, Narayanan P. ZETATM analysis A new model to identify bankruptcy risk of corporations. *Journal of banking & finance*. 1977 Jun 1; 1(1): 29-54. [https://doi.org/10.1016/0378-4266\(77\)90017-6](https://doi.org/10.1016/0378-4266(77)90017-6)
5. Altman EI, Marco G, Varetto F. Corporate distress diagnosis: Comparisons using linear discriminant analysis and neural networks (the Italian experience). *Journal of banking & finance*. 1994 May 1; 18(3): 505-529. [https://doi.org/10.1016/0378-4266\(94\)90007-8](https://doi.org/10.1016/0378-4266(94)90007-8)
6. Balasubramanian SA, GS R, PS, Natarajan T. Modeling corporate financial distress using financial and non-financial variables: The case of Indian listed companies. *International Journal of Law and Management*. 2019 Oct 23; 61(3/4): 457-484. <https://doi.org/10.1108/IJLMA-04-2018-0078>
7. Balcaen S, Ooghe H. 35 years of studies on business failure: an overview of the classic statistical methodologies and their related problems. *The British Accounting Review*. 2006 Mar 1; 38(1): 63-93. <https://doi.org/10.1016/j.bar.2005.09.001>
8. Bapat V, Nagale A. Comparison of bankruptcy prediction models: Evidence from India. *Accounting and*

Finance Research. 2014; 3(4): 91-98. <https://doi.org/10.5430/afr.v3n4p91>

9. Bauer J, Agarwal V. Are hazard models superior to traditional bankruptcy prediction approaches? A comprehensive test. *Journal of Banking & Finance*. 2014 Mar 1; 40: 432-442. <https://doi.org/10.1016/j.jbankfin.2013.12.013>

10. Beaver WH. Financial ratios as predictors of failure. *Journal of accounting research*. 1966 Jan 1: 71-111. <https://doi.org/10.2307/2490171>

11. Bellovary JL, Giacomino DE, Akers MD. A review of bankruptcy prediction studies: 1930 to present. *Journal of Financial Education*. 2007 Dec 1: 1-42.

12. Bharath ST, Shumway T. Forecasting default with the Merton distance to default model. *The Review of Financial Studies*. 2008 May 1; 21(3): 1339-1369. <https://doi.org/10.1093/rfs/hhn044>

13. Bowlin WF. Financial analysis of civil reserve air fleet participants using data envelopment analysis. *European Journal of Operational Research*. 2004 May 1; 154(3): 691-709. [https://doi.org/10.1016/S0377-2217\(02\)00814-7](https://doi.org/10.1016/S0377-2217(02)00814-7)

14. Charalambakis EC, Garrett I. On the prediction of financial distress in developed and emerging markets: Does the choice of accounting and market information matter? A comparison of UK and Indian firms. *Review of Quantitative Finance and Accounting*. 2016 Jul; 47: 1-28. <https://doi.org/10.1007/s11156-014-0492-y>

15. Chava S, Jarrow RA. Bankruptcy prediction with industry effects. *Review of finance*. 2004 Jan 1; 8(4): 537-569. <https://doi.org/10.2139/ssrn.287474>

16. Dissemination CF. Systematic reviews: CRD's guidance for undertaking reviews in healthcare. York: University of York NHS Centre for Reviews & Dissemination. 2009.

17. Ratih H, Ana A, Sulastri L, Thosporn S. Stock Market Trend Analysis and Machine Learning-based Predictive Evaluation. *Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications*. 2023; 14(3): 267-281.

18. Cultrera L, Brédart X. Bankruptcy prediction: the case of Belgian SMEs. *Review of Accounting and Finance*. 2016 Feb 8; 15(1): 101-119. <https://doi.org/10.1108/raf-06-2014-0059>

19. Elsevier. (2015). www.elsevier.com

20. Fletcher D, Goss E. Forecasting with neural networks: an application using bankruptcy data. *Information & Management*. 1993 Mar 1; 24(3): 159-167. [https://doi.org/10.1016/0378-7206\(93\)90064-Z](https://doi.org/10.1016/0378-7206(93)90064-Z)

21. Hillegeist SA, Keating EK, Cram DP, Lundstedt KG. Assessing the probability of bankruptcy. *Review of accounting studies*. 2004 Mar; 9: 5-34. <https://doi.org/10.1023/B:RAST.0000013627.90884.b7>

22. Hosaka T. Bankruptcy prediction using imaged financial ratios and convolutional neural networks. *Expert systems with applications*. 2019 Mar 1; 117: 287-299. <https://doi.org/10.1016/j.eswa.2018.09.039>

23. Jabeur SB. Bankruptcy prediction using partial least squares logistic regression. *Journal of Retailing and Consumer Services*. 2017 May 1; 36: 197-202. <https://doi.org/10.1016/j.jretconser.2017.02.005>

24. Johnsen T, Melicher RW. Predicting corporate bankruptcy and financial distress: Information value added by multinomial logit models. *Journal of economics and business*. 1994 Oct 1; 46(4): 269-286. [https://doi.org/10.1016/0148-6195\(94\)90038-8](https://doi.org/10.1016/0148-6195(94)90038-8)

25. Jones S. Corporate bankruptcy prediction: a high dimensional analysis. *Review of Accounting Studies*. 2017 Sep; 22: 1366-1422. <https://doi.org/10.1007/s11142-017-9407-1>

26. Kim SY. Prediction of hotel bankruptcy using support vector machine, artificial neural network, logistic regression, and multivariate discriminant analysis. *The Service Industries Journal*. 2011 Feb 1; 31(3): 441-468.

<https://doi.org/10.1080/02642060802712848>

27. Kumar PR, Ravi V. Bankruptcy prediction in banks and firms via statistical and intelligent techniques-A review. *European journal of operational research*. 2007 Jul 1; 180(1): 1-28. <https://doi.org/10.1016/j.ejor.2006.08.043>

28. Lee KC, Han I, Kwon Y. Hybrid neural network models for bankruptcy predictions. *Decision Support Systems*. 1996 Sep 1; 18(1): 63-72. [https://doi.org/10.1016/0167-9236\(96\)00018-8](https://doi.org/10.1016/0167-9236(96)00018-8)

29. Liang D, Lu CC, Tsai CF, Shih GA. Financial ratios and corporate governance indicators in bankruptcy prediction: A comprehensive study. *European journal of operational research*. 2016 Jul 16; 252(2): 561-572. <https://doi.org/10.1016/j.ejor.2016.01.012>

30. Lin F, Yeh CC, Lee MY. The use of hybrid manifold learning and support vector machines in the prediction of business failure. *Knowledge-Based Systems*. 2011 Feb 1; 24(1): 95-101. <https://doi.org/10.1016/j.knosys.2010.07.009>

31. Mensah YM. An examination of the stationarity of multivariate bankruptcy prediction models: A methodological study. *Journal of accounting research*. 1984 Apr 1: 380-395. <https://doi.org/10.2307/2490719>

32. Meyer PA, Pifer HW. Prediction of bank failures. *The journal of finance*. 1970 Sep; 25(4): 853-868. <https://doi.org/10.1111/j.1540-6261.1970.tb00558.x>

33. Kalinin O, Gonchar V, Abliazova N, Filipishyna L, Onofriichuk O, Maltsev M. Enhancing Economic Security through Digital Transformation in Investment Processes: Theoretical Perspectives and Methodological Approaches Integrating Environmental Sustainability. *Natural and Engineering Sciences*. 2024 May 5; 9(1): 26-45. <https://doi.org/10.28978/nesciences.1469858>

34. Min JH, Lee YC. Bankruptcy prediction using support vector machine with optimal choice of kernel function parameters. *Expert systems with applications*. 2005 May 1; 28(4): 603-614. <https://doi.org/10.1016/j.eswa.2004.12.008>

35. Nam CW, Kim TS, Park NJ, Lee HK. Bankruptcy prediction using a discrete-time duration model incorporating temporal and macroeconomic dependencies. *Journal of Forecasting*. 2008 Sep; 27(6): 493-506. <https://doi.org/10.1002/for.985>

36. Ohlson JA. Financial ratios and the probabilistic prediction of bankruptcy. *Journal of accounting research*. 1980 Apr 1: 109-131. <https://doi.org/10.2307/2490395>

37. Ouenniche J, Bouslah K, Perez-Gladish B, Xu B. A new VIKOR-based in-sample-out-of-sample classifier with application in bankruptcy prediction. *Annals of Operations Research*. 2021 Jan; 296: 495-512. <https://doi.org/10.1007/s10479-019-03223-0>

38. Ouenniche J, Pérez-Gladish B, Bouslah K. An out-of-sample framework for TOPSIS-based classifiers with application in bankruptcy prediction. *Technological Forecasting and Social Change*. 2018 Jun 1; 131: 111-116. <https://doi.org/10.1016/j.techfore.2017.05.034>

39. Pan WT. A new fruit fly optimization algorithm: taking the financial distress model as an example. *Knowledge-Based Systems*. 2012 Feb 1; 26: 69-74. <https://doi.org/10.1016/j.knosys.2011.07.001>

40. Pastor JT. Chapter 3 Translation invariance in data envelopment analysis: A generalization. *Annals of operations research*. 1996 Apr; 66: 91-102. <https://doi.org/10.1007/BF02187295>

41. Premachandra IM, Bhabra GS, Sueyoshi T. DEA as a tool for bankruptcy assessment: A comparative study with logistic regression technique. *European Journal of Operational Research*. 2009 Mar 1; 193(2): 412-424. <https://doi.org/10.1016/j.ejor.2007.11.036>

42. Premachandra IM, Chen Y, Watson J. DEA as a tool for predicting corporate failure and success: A case of bankruptcy assessment. *Omega*. 2011 Dec 1; 39(6): 620-626. <https://doi.org/10.1016/j.omega.2011.01.002>

43. Rashid A, Abbas Q. Predicting Bankruptcy in Pakistan. *Theoretical & Applied Economics*. 2011 Sep 1; 18(9): 103-128.
44. Kumar A, Joshi P, Bala A, Sudhakar Patil P, Jang Bahadur Saini DK, Joshi K. Smart Transaction through an ATM Machine using Face Recognition. *Indian Journal of Information Sources and Services*. 2023; 13(2): 7-13.
45. Sheppard JP. Strategy and bankruptcy: An exploration into organizational death. *Journal of Management*. 1994 Dec 1; 20(4): 795-833. [https://doi.org/10.1016/0149-2063\(94\)90031-0](https://doi.org/10.1016/0149-2063(94)90031-0)
46. Shetty SH, Vincent TN. The role of board independence and ownership structure in improving the efficacy of corporate financial distress prediction model: evidence from India. *Journal of Risk and Financial Management*. 2021 Jul 19; 14(7): 333. <https://doi.org/10.3390/jrfm14070333>
47. Shetty U, Pakkala T. Generalized efficiency measurements of directional distance formulation of data envelopment analysis. *Proceedings in the 57th session of ISI*. 2009.
48. Shetty U, Pakkala TP, Mallikarjunappa T. A modified directional distance formulation of DEA to assess bankruptcy: An application to IT/ITES companies in India. *Expert Systems with Applications*. 2012 Feb 1; 39(2): 1988-1997. <https://doi.org/10.1016/j.eswa.2011.08.043>
49. Eckhart M, Brenner B, Ekelhart A, Weippl E. Quantitative security risk assessment for industrial control systems: Research opportunities and challenges. *Journal of Internet Services and Information Security*. 2019; 9(3): 52-73.
50. Shin KS, Lee TS, Kim HJ. An application of support vector machines in bankruptcy prediction model. *Expert systems with applications*. 2005 Jan 1; 28(1): 127-135. <https://doi.org/10.1016/j.eswa.2004.08.009>
51. Shrivastav SK, Ramudu PJ. Bankruptcy prediction and stress quantification using support vector machine: Evidence from Indian banks. *Risks*. 2020 May 22; 8(2): 52. <https://www.mdpi.com/2227-9091/8/2/52>
52. Shrivastava A, Kumar K, Kumar N. Business distress prediction using bayesian logistic model for Indian firms. *Risks*. 2018 Oct 9; 6(4): 113. <https://doi.org/10.3390/risks6040113>
53. Shumway T. Forecasting bankruptcy more accurately: A simple hazard model. *The journal of business*. 2001 Jan; 74(1): 101-124. <https://doi.org/10.1086/209665>
54. Taffler RJ. The assessment of company solvency and performance using a statistical model. *Accounting and Business Research*. 1983 Sep 1; 13(52): 295-308. <https://doi.org/10.1080/00014788.1983.9729767>
55. Tam KY, Kiang MY. Managerial applications of neural networks: the case of bank failure predictions. *Management science*. 1992 Jul; 38(7): 926-247. <https://doi.org/10.1287/mnsc.38.7.926>
56. Shumway T. Forecasting bankruptcy more accurately: A simple hazard model. *The journal of business*. 2001 Jan; 74(1): 101-124. <https://doi.org/10.1086/209665>
57. Webster J, Watson RT. Analyzing the past to prepare for the future: Writing a literature review. *MIS quarterly*. 2002 Jun 1. <https://www.jstor.org/stable/4132319>
58. Wilson RL, Sharda R. Bankruptcy prediction using neural networks. *Decision support systems*. 1994 Jun 1; 11(5): 545-557. [https://doi.org/10.1016/0167-9236\(94\)90024-8](https://doi.org/10.1016/0167-9236(94)90024-8)
59. Wu Y, Gaunt C, Gray S. A comparison of alternative bankruptcy prediction models. *Journal of Contemporary Accounting & Economics*. 2010 Jun 1; 6(1): 34-45. <https://doi.org/10.1016/j.jcae.2010.04.002>
60. Yang Z, You W, Ji G. Using partial least squares and support vector machines for bankruptcy prediction. *Expert Systems with Applications*. 2011 Jul 1; 38(7): 8336-8342. <https://doi.org/10.1016/j.eswa.2011.01.021>

FINANCING

The authors did not receive financing for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORSHIP CONTRIBUTION

Conceptualization: N Sathyanarayana, Raja Narayana.

Data curation: N Sathyanarayana, Raja Narayana.

Formal analysis: N Sathyanarayana, Raja Narayana.

Acquisition of funds: N. Sathyanarayana.

Research: N Sathyanarayana, Raja Narayana.

Methodology: N Sathyanarayana, Raja Narayana.

Project management: N Sathyanarayana, Raja Narayana.

Resources: N Sathyanarayana, Raja Narayana.

Software: N Sathyanarayana, Raja Narayana.

Supervision: Raja Narayana.

Validation: Raja Narayana.

Display: N Sathyanarayana, Raja Narayana.

Drafting - original draft: N Sathyanarayana.

Writing - proofreading and editing: Raja Narayana.

A STUDY ON AWARENESS AND PERCEPTION OF STAKEHOLDERS TOWARDS CRYPTO CURRENCY IN BENGALURU

Dr. Rajath B S, Assistant Professor, School of Commerce and Management Studies, Dayananda Sagar University, Bengaluru
rajathbelur-scms@dsu.edu.in

Mr. Harsha R, Assistant Professor, Faculty of Management and Commerce, PES University, Bengaluru
harshar@pes.edu

Abstract

Cryptocurrency is a virtual cash which depends on block chain innovation. It is decentralized implying that no authority is there behind it to manage and control it. Cryptocurrency curiously emerged as bitcoin first in the year 2009 and its advancement is considerably more prepared. However, they procured notoriety recently. Cryptographic cashworks in a decentralized manner so there is no authority behind it. In light of which the public power areas of strength for isn't computerized cash. Advanceddash has emerged as a promising endeavor because as it might be seen that whether or not the world goes down, computerized cash doesn't. For example, by virtue of in general pandemic COVID-19.

However, this degree of computerized cash is purposeless when the public power and the Reserve Bank of India (RBI) isn't solid of it. The Reserve Bank was giving fliers to dissuade the crypto monetary sponsor for a really long time until it decided to limit all of its substances from supporting advanced cash trades. This round was set to the side by the fair Supreme Court of India as it was considered disproportionate. Today there is a prerequisite for a regulatory framework which is maintained by both the Reserve Bank of India as well as the public power. Since, computerized cash is waiting for a really long time and it cannot be denied completely. Along these lines, why not immediate it. Earlier individuals used to put resources into gold as a resource for safeguard their cash against expansion. Over the recent years, more individuals viewed Bitcoin as a superior elective resource. Indeed, even institutional financial backers are changing their money into Bitcoin over completely to safeguard their funds against expansion.

Keywords: Cryptographic, Computerized Cash, Block Chain Innovation.

REVIEW OF LITERATURE

Worakamol Wisetsri .et.al (2022) the paper's affirmation of the emerging idiosyncrasy of computerized monetary standards. The climb of computerized monetary standards' worth open accessible and the creating affirmation round the field open some of mentioning conditions and stresses for business and business monetary issues. The examinations changed into recognized by means of the method depiction, composing evaluation, and investigated. This paper discusses the fundamental upgrades inside the educational assessments associated with the Present Scenario of Cryptocurrency, a short diagram of Cryptocurrency, computerized monetary standards through market capitalization, Cryptocurrencies Trending in Asia, Cryptocurrency in India, Cryptocurrency Exchanges, cryptographic cash oversees all around. Cryptographic cash inside the natural variables, and Cryptocurrency Security. The record similarly covers the responses of law making bodies and essential banks to this idiosyncrasy and the state of the art nation of authentic implications of computerized monetary standards in picked countries.

Atul Chaturvedi et.al (2022) based on the latest update, Indian Finance serve Nirmala Sitharaman pronounced in Union spending plan 2022-23 that Indian government will put 30% cost (the most raised charge piece in India) on pay delivered from cryptographic types of cash. Huge financial foundations, subject

matter experts and academicians have different opinions in such way. They ensure that it would spell the end of cryptographic currency market in India or it would be possible that RBI (Reserve Bank of India) may ship off its own crypto or high level money. So in this novel circumstance, in this article, the trip and future pieces of computerized money in India are inspected and we believe that it will be a reference for extra assessment and discussion around here.

Mohammad Hashemi Joo . et.al (2019) The justification behind this paper is to recognize the applications and responsibilities of blockchain development in finance when in doubt, and to perceive districts where the advancement can have a greater impact in portion systems. The makers do an extensive review of blockchain advancement and cryptographic cash, and take a gander at the viable purposes of blockchain development in a couple of cash disciplines including computerized money. The makers fundamentally evaluate the specific assessments on approaches to acting in advanced cash costs.

Advanced money is the key powerful usage of block chain development and can be used as the essential fuel of the overall money move association. Block chain is a dynamic development that can change the world with its solace, straightforwardness, precision and capability in speed and cost. The advancement of block chain use in finance depends upon extra acclimation and trust procured by a rising number of shown viable use cases and accolades as well as fitting regulative changes. This paper gives an expansive study of the responsibilities that block chain development has made and should make in the field still up in the air to build the worth of corporate bosses, monetary supporters, procedure makers and a general group.

Xiaochun Guo & Petko Donev (2020) Cryptographic currency, as an emerging social quirk, has attracted unprecedented assessment contemplations and starts to shape one more investigation district in the past 10 years. A serious review of the ongoing computerized cash composed works helps us with understanding the standard and the promising assessment inevitable destiny of this emerging field. This paper gives a productive study of the computerized cash composed works by using bibliometric and network examination methods. An amount of 833 dispersions from Web of Science Core Collection and Scopus have been accumulated in the stretch of time of January 2008 to June 2018. We investigate the expressive features, countries' responsibilities and joint exertion associations, maker collaboration associations and reference co-reference associations to recognize performers with basic effect in this field. The results show that advanced money research is experiencing surprising turn of events, but sensible composed endeavours between different countries and makers are at this point inadequate. The academic bases of the advanced cash region lay on the early-year composed works that give fundamental understandings to computerized cash, and that length different investigation fields. The examination shows that the energy research design bases on computerized money market assessment uniting market approaches to acting and trading characteristics.

Vaibhav S.et.al (2021) as the web is ending up being more open and worthwhile, greater amounts of people and associations are moving towards automated trades. Automated portion methodologies are speedier, more affordable and extensively more useful. Thusly, it's not stunning that fresher kinds of cutting edge portion systems are rapidly being made. Exactly when contemplated no other system approaches the goliath that is cryptographic cash. Advanced monetary forms like Bitcoin and Ethereum are among the most renowned sorts of mechanized portions. Cryptographic types of cash could be advanced in India as a viable decision for cutting edge cash, yet it has the two potential gains and drawbacks which ought to be perceived. Through the strategy for composing review, this investigation paper will separate the computerized cash, its working and play out a general report among China and India. Moreover, it considers the continuous status well as the degree of cryptographic cash in India.

Dr. Shilpi Agrawal (2019) negligible over 10 years has passed since Blockchain delivered its marvel Bitcoin, yet Bitcoin despite all the exposure forgot to transform into an essential overall advanced money for everyday presence to enable clients in general to purchase things organizations on the web, move cash and direct business with the two individuals and components inside the space of seconds without going through

access related issues and financial load of high worth based costs.

Blockchain's close by association with Bitcoin has been genuinely negative on the dynamic advancement to encounter its real potential, but by and by it is the best an open door for blockchain to move past Bitcoin. Blockchain spread record advancement can be used in various regions that are by and large under government control. Believe it or not, different instruments and applications we are so accustomed with using or seeing around could be decentralized through blockchain to make a paperless digitalized world; as a side goal, this could really help with decreasing an overall temperature modification as well.

Web, displaying asset the leaders, traffic light, utilities and government upheld retirement can be for the most part decentralized through blockchain to give more capable and unhindered induction to individual and straightforwardly accessible reports. Blockchain has colossal entryways and can take incredible designs from here on out, yet gave that regulators, managers, public banks and various pieces of governing bodies grant it to end up working.

Mohammad Hasan & Ruzaina Khan (2020) Purpose - The essential inspiration driving the survey is to describe the different checks in gatherings of Bitcoins and give the fitting explanations to the issues looked by Bitcoin clients in India. The audit studies investigate on the gathering of Bitcoin as a method of trades and theories. A study of composing has been finished to explore different existing Bitcoin. A relevant examination has been driven on Bitcoin and its gathering by individuals in different countries. AHP has been used to propose the model and for pieces of information. Bitcoin gathering is at this point a dismissed area of assessment. This assessment has attempted to explore the fundamental drivers of the non-gathering of Bitcoin in different countries.

STATEMENT OF THE PROBLEM

Since cryptocurrency was added to the Union Budget of India in the year 2022 as a taxable income, the statement of problem of this research would be to understand the perception of stakeholders towards the cryptocurrency market, their understanding of the block chain technology, their opinion on the 30% tax slab added on all profits made by an individual or a business.

Indian government confined computerized cash and banks to execute with crypto exchanges across India making a mind boggling buzz among the youngsters as indicated by the above record. RBI encountered a risk of people's hold reserves changing over into electronic cash from this point forward denoting economy's wealth. Tax avoidance and fakes being the fundamental thought of blacklist provoked make a step against these computerized monetary forms. Meanwhile couple of exchanges of India are in consistent rush to return the decision of RBI.

NEED FOR THE STUDY

In The Union Budget of 2022 Cryptocurrency was included as a taxable income and this study is to get a perception of stakeholders towards cryptocurrency in India. Since this is newly added regime and the tax slab on all profits made by cryptocurrency users is 30%, it is an interesting way to figure out what the stakeholders thoughts towards this digital currency would be.

It's feasible to get incredibly wealthy by putting resources into digital currency in 2022 yet you could likewise lose the entirety of your cash. Putting resources into crypto resources is unsafe yet additionally possibly incredibly productive. Cryptographic money is a wise speculation if you have any desire to acquire direct openness to the interest for advanced cash. Be that as it may, cryptographic currency is huge and it isn't going away, or be confined to 100 years at least: trades are fast, exceptional, secure and all over the planet, which essentially license the help of records without risk of data being stolen. Illegal activities have been reduced. This study would give light to all these aspects.

SCOPE OF THE STUDY

Digital currency is portrayed as a sort of cutting edge virtual money that exists electronically or for all intents and purposes and uses cryptography to get trades. The computerized money doesn't rely upon banks or another central situation to really look at these trades. It doesn't have a central giving or overseeing authority. It uses an exceptional kind of decentralized system to record trades. Cryptographic cash is a P2P (Peer- to-Peer) system that licenses anyone wherever to send/get portions.

Cryptographic types of cash use scattered openly available report called a blockchain to run. Right when clients move the advanced cash saves, their trades are kept in this open record (Blockchain). A blockchain includes a record of the large number of invigorated and held trades by cash holders. A mining association is used to make units of cryptographic cash. As per studies, the cryptographic cash gathering of the computerized money market has extended by over 880% between June 2020 to June 2021 all over the planet. If we examine the estimations in India, you will be flabbergasted to realize that in something like a year the nation has experienced an improvement of around 400%.

In India, around 15 million people have made a premium in private cryptographic cash property. There is a premium in adolescents about cryptographic cash gathering. As indicated by Finders, the young age having a spot with the age social event of 18 to 34 that includes more than 40% of clients generally through the world. In India, during continuous years, the utilization of advancement, including blockchain, to fuel financial trades has extended through and through. Such improvement has not escaped everyone's notice by most regulators, for example, the Reserve Bank of India.

While the continuous government has upheld movement to encourage a robotized or credit just economy, advanced cash regardless of everything stays an oddity.

OBJECTIVES OF THE STUDY

- To study the difference in understanding among stakeholders of the cryptocurrency market all together.
- To analyze the reason behind the 30% tax levied on all profits made from the cryptocurrency market
- To give light to RBI and Supreme Court's stands on Cryptocurrency and why it was banned in 2019.

RESEARCH METHODOLOGY

- **Type of Research** – A Descriptive Research
- **Sample design** - A sample size of 86 stakeholders on the cryptocurrency market will be selected for the study.
- **Sampling Method** – Simple Random Sampling
- **Method of data collection-**
- **Primary data collection tools:** The primary data has been accumulated through coordinated research questionnaire. This survey was circled to the everyday pay workers and very few experts were before long counseled.
- **Secondary data:** The required secondary data is taken from the previous research made on cryptocurrency in India. It is based on second hand information. The data collected is from journals, research reports, magazine, articles and books on cryptocurrency in India.
- **Period of study** - The study was conducted from March 2023 to April 2023.
- **Data analysis techniques** – Correlation analysis between Dependent and the independent variables i.e. Perception of stakeholders and the cryptocurrency itself.

1.1 Table showing markets that stakeholders trade

Capital Markets	Percentage	Number of Respondents
Stock Market	52.94%	45
Crypto Market	25.90%	23
Forex Market	10.58%	9
NFT	10.58%	9

Authors' calculation

1.1 Graph showing markets that stakeholders trade



Authors' calculation

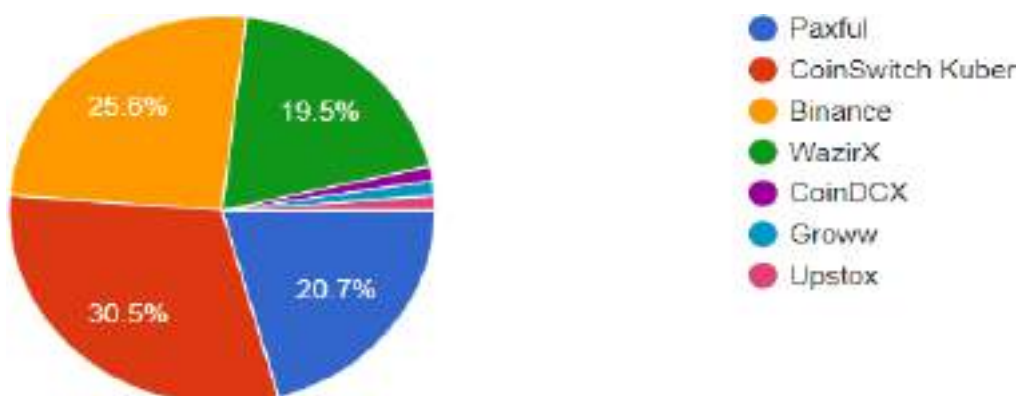
It is found that majority of the respondents i.e 52.94% of the traders prefer the stock market but 25.90% of them trade on the crypto market in India which is a step forward for cryptocurrency traders in India.

1.2 Table showing the brokerage sites used by stakeholders to trade

Brokers	Percentage	Respondents
Paxful	20.7 %	17
CoinSwitchKuber	30.5 %	26
Binance	25.6 %	23
WzirX	19.5 %	17
CoinDCX	1.2 %	1
Groww	1.2 %	1
Upstock	1.2 %	1

Authors' calculation

1.2 Graph showing the brokerage sites used by stakeholders to trade



Authors' calculation

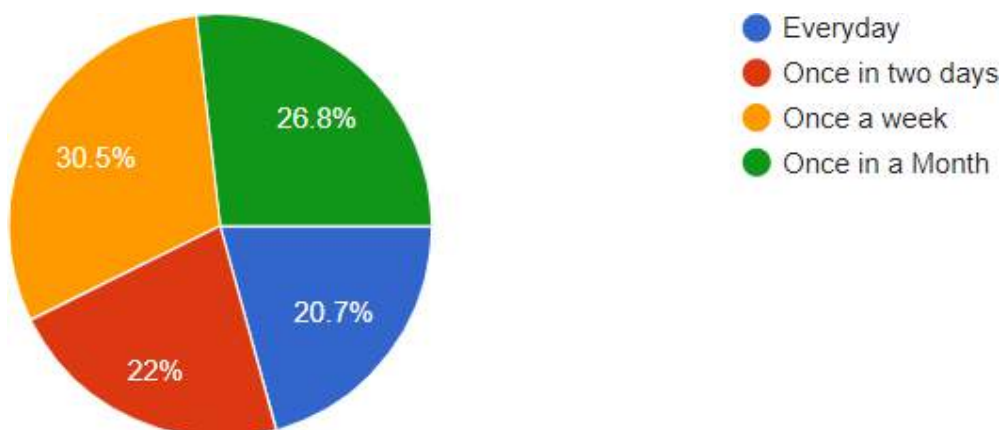
30.5% of cryptocurrency traders use CoinSwitch Kuber as their brokers because the platform believes in the principle that the everyday man can make cryptocurrency investments and make their money work for them.

1.3 Table showing frequency the respondents trade on the cryptocurrency market

Frequency of Trade	Percentage	Respondents
Everyday	20.7 %	17
Once in 2 days	22 %	18
Once in a week	30.5%	27
Once in a Month	26.8 %	24

Authors' calculation

1.3 Graph showing frequency the respondents trade on the cryptocurrency market



Authors' calculation

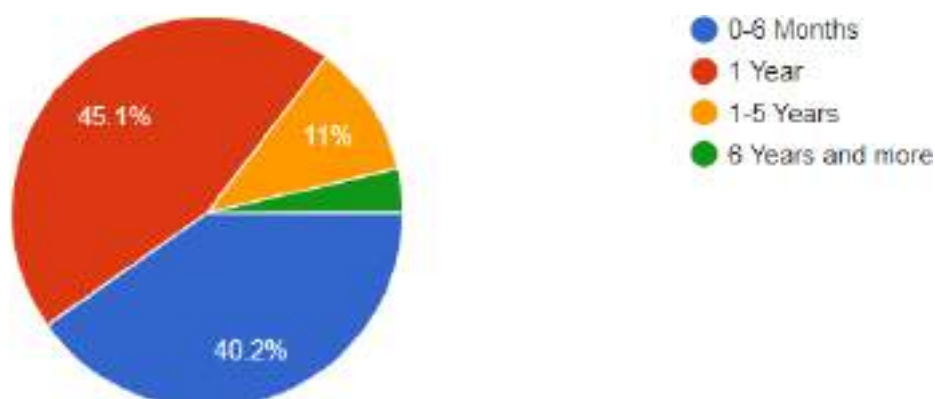
30.5% of the users tend to trade only one in a week whereas every day or intraday traders happen to be at the lowest at almost 20.7% this gives justification to the fact that most of the respondents were into range trading rather than day trading.

1.4 Table showing from how long the stakeholders have been trading on the cryptocurrency market

Trade Duration	Percentage	Respondents
0-6 Months	40.2 %	34
1 Year	45.1 %	38
1- 5 Years	11 %	11
6 Years and more	3.7%	3

Authors' calculation

1.4 Graph showing from how long the stakeholders have been trading on the cryptocurrency market



Authors' calculation

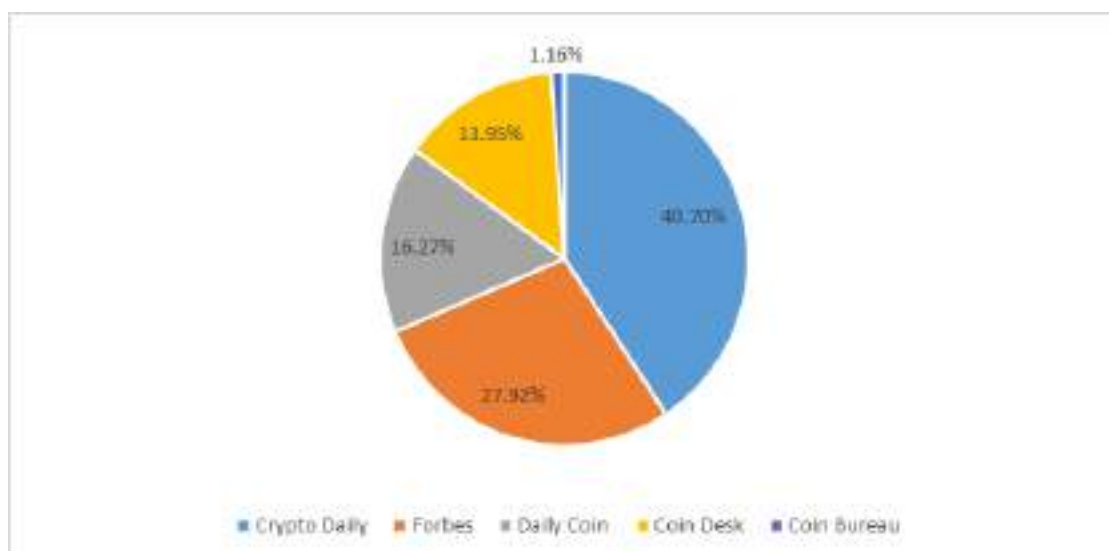
Most of these cryptocurrency traders happen to be fairly new to this market and we can see that 45.1% of the respondents have been in the market for only 1 year and 40.2% of the respondents have been in the market for only 6 months or lesser.

1.5 Table showing the most commonly used source for the fundamental analysis by respondents

Fundamental Websites	Percentage	Respondents
Crypto Daily	40.69 %	35
Forbes	27.91 %	24
Daily Coin	16.27 %	14
Coin Desk	13.95 %	12
Coin Bureau	1.16%	1

Authors' calculation

1.5 Graph showing the most commonly used source for the fundamental analysis by respondents



Authors' calculation

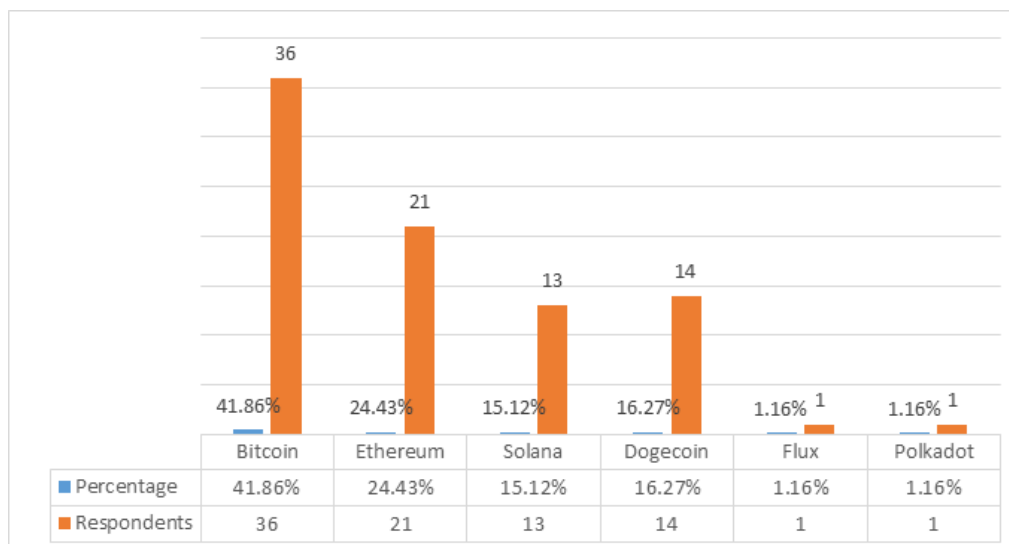
Most traders use crypto daily for their fundamental analysis since it is most popular among the websites and have accurate information in context to cryptocurrencies i.e 40.69% of respondents.

1.6 Table showing the Coins or Tokens the respondents made their profits off

Currencies	Percentage	Respondents
Bitcoin	41.86%	36
Ethereum	24.43%	21
Solana	15.12%	13
Dogecoin	16.27%	14
Flux	1.16%	1
Polkadot	1.16%	1

Authors' calculation

1.6 Graph showing the Coins or Tokens the respondents made their profits off



Authors' calculation

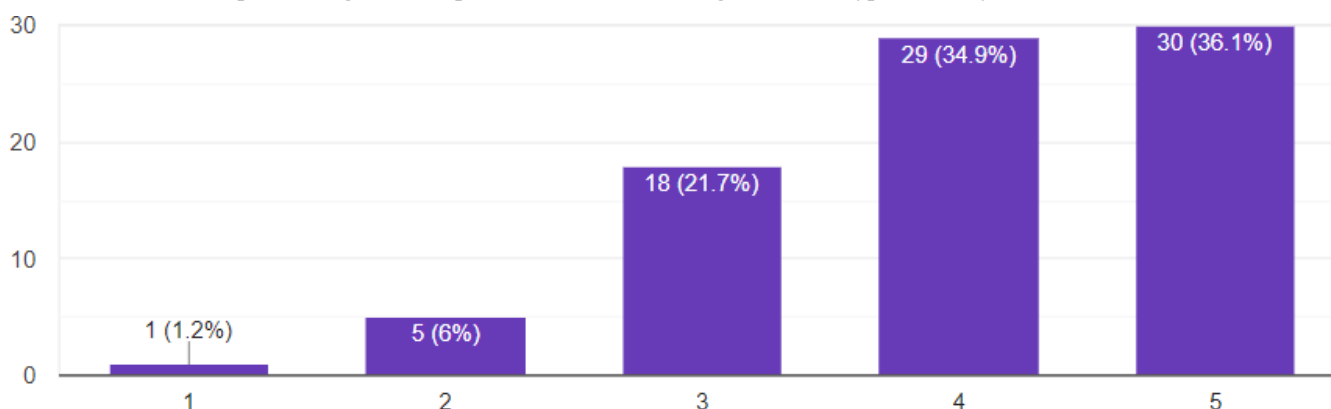
Since Bitcoin is a safer and guarantee trade most individuals have made their profits on that particular coin itself as portrayed in the chart it has 41.5% of the responses.

1.7 Table showing the Perception of stakeholders to figure out if Cryptocurrency is a wise investment

Investments in Cryptocurrency	Percentage	Respondents
Strongly Disagree	1.20%	1
Disagree	6%	5
Neutral	21.70%	18
Agree	34.90%	29
Strongly Agree	36.10%	30

Authors' calculation

1.7 Graph showing the Perception of stakeholders to figure out if Cryptocurrency is a wise investment



Authors' calculation

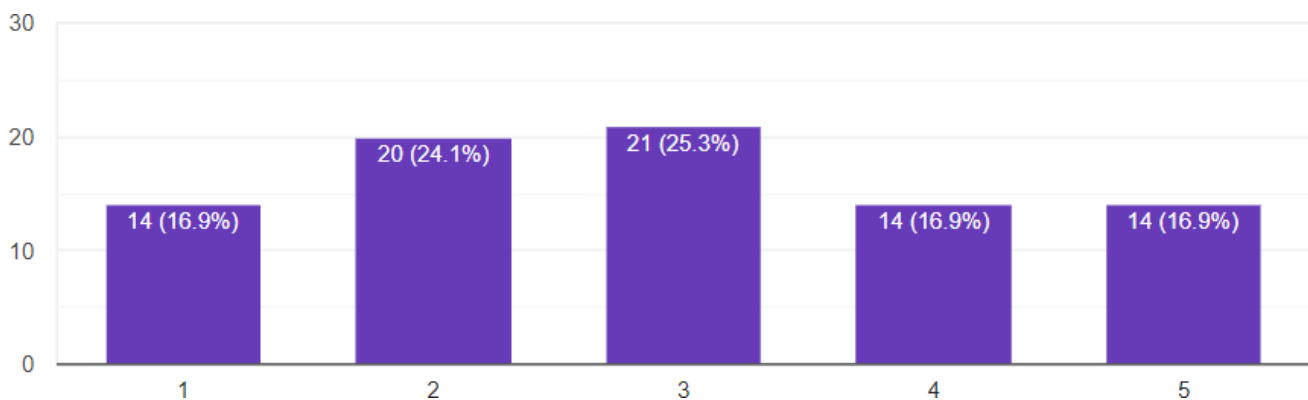
we can see that the highest percentage of these traders i.e. 36.1%, believe that crypto currency is a wise investment choice as long as the investments are based on detailed researches for fundamental and technical analysis in order to make the most off of the cryptocurrency market.

1.8 Table showing the Perception of stakeholder towards the newly implied tax regime

Investments in Cryptocurrency	Percentage	Respondents
Strongly Disagree	16.90%	14
Disagree	24.10%	20
Neutral	25.30%	21
Agree	16.90%	14
Strongly Agree	16.90%	14

Authors' calculation

1.8 Graph showing the Perception of stakeholder towards the newly implied tax regime



Authors' calculation

There is a mixed opinion on the 30% tax implementation on all profits off of crypto trades but neutrality has the highest response at 25.3% as it is believed that the government can use that as a medium of growth since cryptocurrency profits can be a large sum and 30% tax on that amount can be a big sum as well.

TESTING OF HYPOTHESIS

Independent Variable – Cryptocurrency in India

Dependent Variable – Perception of Stake holders

H0 - Variations in the cryptocurrency capital market or any information or decision regarding Cryptocurrency does not affect the Perception of cryptocurrency stake holders

H1 - Perception of stakeholders in the cryptocurrency capital market in India is dependent in the actions or decisions involving Cryptocurrency in India.

Correlation analysis Table 1.9

Correlations

		In	De
In	Pearson Correlation	1	.530**
	Sig. (2-tailed)		<.001
	N	86	86
De	Pearson Correlation	.530**	1
	Sig. (2-tailed)	<.001	
	N	86	86

** . Correlation is significant at the 0.01 level (2-tailed).

Authors' calculation

The correlation is significant at the level 0.01. Since it is below 0.05 it proves the null hypothesis false and the alternate hypothesis is true. Therefore, Perception of stakeholders in the cryptocurrency capital market in India is dependent in the actions or decisions involving Crypto currency in India.

RESERVE BANK OF INDIA'S TAKE ON CRYPTOCURRENCY

The Reserve Bank of India (RBI) has commonly provoked about the potential risks suggested with the use of computerized cash. However, in 2018 Reserve Bank made a firm walk by denying its overseen substances from supporting trades associated with cryptographic cash and offering any kinds of help dealing with the same. This blacklist was seen as dreadful by the computerized money holders and monetary patrons and not long after petitions were archived in the good Supreme Court of India.

REASON FOR BAN

The Reserve Bank is responsible for financial strength and credit structure in India. It moreover supervises foreign exchanges under the Foreign exchange the management act, 1999. There was a basic number of stunts associated with computerized types of cash watching out. These stunts are raised further by the demonetization in India. Ponzi plans are also one justification for this monetary blacklist. Ponzi plans are generally decisive in which premium is paid to the past monetary sponsor by the money contributed by the later monetary supporters.

GOVERNMENT SCHEMES REGARDING CRYPTOCURRENCY

Stand of Indian government had been certain that they don't need digital money as a lawful delicate. Additionally, they need to deter their residents from putting and managing in something similar. There was a financial prohibition on digital forms of money from July 2018 to March 2020. On March 4, the Supreme Court lifted the boycott and through that occurrence, the public authority ought to have perceived that they can't put an outright limitation on digital currencies. A panel was shaped to concentrate on the utilization of digital currency and safeguards, measures or guidelines to be taken. The board sent its report on 28 February, 2019 suggesting denial of all private digital forms of money, aside from any virtual monetary standards gave by the state.

The Cryptocurrency and Regulation of Official Digital Currency Bill, 2021 (ODC Bill) has been proposed with the objective of making a facilitative system for production of the authority advanced cash to be given by the Federal Reserve Bank of India (RBI) and deny all private cryptographic forms of money in India. Notwithstanding, it'll support and utilize hidden digital currency advances.

FINDINGS

- It is found that majority of the respondents i.e 52.94% of the traders prefer the stock market but 25.90% of them trade on the crypto market in India which is a step forward for cryptocurrency traders in India.
- 30.5% of cryptocurrency traders use CoinSwitch Kuber as their brokers because the platform believes in the principle that the everyday man can make cryptocurrency investments and make their money work for them.
- 30.5% of the users tend to trade only one in a week whereas every day or intraday traders happen to be at the lowest at almost 20.7% this gives justification to the fact that most of the respondents were into range trading rather than day trading.
- Most of these cryptocurrency traders happen to be fairly new to this market and we can see that 45.1% of the respondents have been in the market for only 1 year and 40.2% of the respondents have been in the market for only 6 months or lesser.

- Most traders use crypto daily for their fundamental analysis since it is most popular among the websites and have accurate information in context to cryptocurrencies i.e 40.69% of respondents.
- Since Bitcoin is a safer and guarantee trade most individuals have made their profits on that particular coin itself has 41.5% of the responses.
- There is a mixed opinion on the 30% tax implementation on all profits off of crypto trades but neutrality has the highest response at 25.3% as it is believed that the government can use that as a medium of growth since cryptocurrency profits can be a large sum and 30% tax on that amount can be a big sum as well.

CONCLUSIONS

Cryptography plays a vital and critical role in achieving the primary aims of security goals, such as authentication, integrity, confidentiality, and non-repudiation. Cryptographic algorithms are developed in order to achieve these goals. Cryptography has the important purpose of providing reliable, strong, and robust network and data security. In this paper, we demonstrated a review of some of the research that has been conducted in the field of cryptography as well as of how the various algorithms used in cryptography for different security purposes work. Cryptography will continue to emerge with IT and business plans in regard to protecting personal, financial, medical, and e-commerce data and providing a respectable level of privacy and difference in understanding among stakeholders of the crypto currency market all together.

SUGGESTIONS

- India needs an administrative structure very much like different nations need.
- It's a well-known fact that a ton of Indian financial backers are there who are investing resources into cryptographic money and hanging tight for their chance, however the public authority doesn't believe they should proceed.
- Government requirements to recognize that this could be the device Indian economy was sitting tight for.
- At first sight the public authority is just taking a gander at the negative side of digital currency that it very well may be utilized for illegal exercises like tax evasion and fear subsidizing however it has some control over these downsides by carrying a system to control the utilization of cryptographic money.

REFERENCES

- [1] Atul Chaturvedi, Varun Shukla, Manoj Kumar Mishra "Journey of Cryptocurrency in India in View of Financial Budget" 2022
- [2] B. Preneel, Understanding Cryptography: A Textbook for Students and Practitioners, London: Springer, 2010.
- [3] Christopher Alcantara & Caroline Dick "Decolonization in a Digital Age" Canadian Journal of Law and Society, 2022
- [4] J. Katz and Y. Lindell, Introduction to Modern Cryptography, London: Taylor & Francis Group, LLC, 2008.
- [5] Kevin Helms 'Crypto Can Boost Indian Economy - How Banning Will Hurt it' Vol-68-Issue-1-January-2020
- [6] Mohammad Hashemi Joo, Yuka Nishikawa, Krishnan Dandapani, "Cryptocurrency, a successful application of blockchain technology" Managerial Finance, 27 August 2019
- [7] N. Sharma, Prabhjot and H. Kaur, "A Review of Information Security using Cryptography Technique," International Journal of Advanced Research in Computer Science, vol. 8, no. Special Issue, pp. 323-326, 2017.

- [8] S. J. Lincke and A. Hollan, "Network Security: Focus on Security, Skills, and Stability," in 37th ASEE/IEEE Frontiers in Education Conference, Milwaukee, 2007.
- [9] Vaibhav S, PVGN Pavan Kumar, Lakshya Tewari, Pronika "Blockchain based Cryptocurrency Scope in India" Published by, IEEE. 2021.
- [10] Worakamol Wisetsri, C.Vijai, Kasidit, Chueinwittaya, Puttithorn Jirayus "CRYPTOCURRENCY - AN OVERVIEW" Volume 6, No. 2, 2022.
- [11] Xiaochun Guo & Petko Donev, "Bibliometrics and Network Analysis of Cryptocurrency Research" Journal of Systems Science and Complexity, 04 August 2020

A STUDY ON THE PARADIGM SHIFT AMONG URBAN YOUTH FROM MOVIE SCREENING THEATERS TO OTT PLATFORM

Dr. Rajath B. S., Assistant Professor, School of Commerce and Management Studies
Dayananda Sagar University, Bangalore

Abstract

Theatre, sound film, cinema, multiplex or massive screen, nomenclature or name, this word has invariably been the central stage of amusement. These centres mirror social life and culture quite amusement platforms. can they be components of the past? With the arrival of the immoderate (OTT) platform and on-line streaming services (both international and domestic) like Jio Cinema, Hot Star, Netflix, Amazon Prime, Voot and Zee5, cinemas. OTT media services square measure a speedily growing media platform that square measure gaining momentum with each passing day. This paper makes an attempt to induce a higher understanding of the trends and patterns relating the usage of OTT platforms among the urban youth. to know the paradigm shift among the urban youth from movie screening theatre to OTT platform.

Keywords – OTT platform, movie screening theatre, pandemic, youth

INTRODUCTION

OTT stands for “Over the Top” and refers to any streaming service that delivers content over the net. By most definitions identified these days, OTT merely refers to any video streaming service delivering content to the users over the net. Originally, this happened aboard a standard platform like cable TV, thus ‘over the top’.

In previous years, a shopper would confiscate a cable subscription and their cable TV supplier would be answerable for handiness the provision and availability of programming. within the epoch, users will register for services like Netflix or Spotify and access their offerings over the net. The cable supplier currently solely provides the net association and has no ability to manage what you consume. OTT associate degree isn't any longer an experiment or a web geek's fancy. Today, tv is progressively delivered over the net and new media corporations area unit connection the race towards market dominance. OTT conjointly permits access to measure streaming. These work very similar to channels in regular TV; however, the content is streamed exploitation the net association to the audience's OTT devices / set-top boxes.

In general, OTT has matured massively over the eight years, with revenues growing exponentially from 6.1 billion U.S. dollars in 2010 to over 10 times that quantity in 2018. Today, the OTT business is booming because the technology has become a dominant channel for video consumption aboard Pay-tv and ancient broadcast services. With a twenty eighth Year-on-Year growth in total time spent streaming on OTT, the media revenue is predicted to succeed in 158.84 billion by 2024, over double the sixty-seven.8 bn generated in 2018.

Movies on the opposite hand, communicated to individuals in lots. It showcased the lives of individuals round the world in an exceedingly method that it had been felt by all. Movies area unit a style of recreation for individuals young and recent. Theatre contends a vital during this evolution of entrainment. Theatre bloomed from taking part in one picture show for months to dynamic movies in days, supported the demand of individuals. This affected significantly by televisions followed by a powerful blow that attended web and (over-the-top) OTT platforms like Netflix, Amazon prime, Jio movies and Sun NXT, etc.

Movie theatres are an excellent supply of recreation for an extended time. And, currently with dynamic times and increase in OTT platforms and streaming apps in Asian country, the competition is obtaining powerful. during this race of providing nice content to the viewers, there's a clash between OTT Platform Vs Theatres. thanks to the rise within the range of picture show watchers, the longer term of picture shows streaming apps, OTT Platforms and picture show theatres appearance terribly bright.

India is one in every of the fastest-growing nations within the world, be it in any side. Indians have limitless love for recreation and particularly movies in their lives. For Indian families, looking movies in theatres equals to a family outing wherever they'll pay time with their families. Now, with the introduction of the many new picture show streaming apps in Asian country, the longer term of films, picture show theatres and OTT Platforms is wanting far better.

OTT Platforms and Streaming Apps have taken several steps to realize quality and widen their base in Asian country. several of the Streaming Apps area unit putting in place their studios to supply additional content. a very important reason that pulls the viewers and helps the OTT Platforms to grow in Asian country is original content. All the Streaming Apps supply an outsized type of original internet series and flicks in numerous genres. several streaming apps conjointly supply shows and flicks in native languages. They partner with native production corporations and as a result, create their movies and series. several telecommunication corporations have conjointly introduced their OTT platforms and streaming apps to supply content to the viewers.

ADVANTAGES OF OTT PLATFORM

Reduced cost

There are thousands of programs accessible with a monthly subscription. Free access to international web series, shows, live sports and your favourite movies on the go is one of the biggest benefits of the streaming platform. Also, there **is** no monthly cable operator billing or confusion. Anyone who wants to watch online digital content can self-register and pay a monthly or annual subscription amount, making it cost-effective.

Crisp sound and Picture quality

All OTT platforms maintain high resolution content quality. The faster the speed, the better the audio and visual content as the service is delivered online. Movie video and audio quality is usually high. This is a big advantage when using OTT platforms such as HBO and Netflix. On the plus side, you can customize the video and audio quality to your liking.

Instant Playback

Instant viewing is another advantage of the OTT platform, as you can request to watch a movie or show at any time, regardless of when it is released. You can watch your favourite web series as many times as you like. There are no annoying waits in long lines of tickets at the cinema or annoying ads while filming a movie on TV. Instant and unlimited access to movies on the go. Some platforms charge a flat monthly fee and in return you get full access to those programs.

Multi- platform service

The OTT platform gives you plenty of freedom to see where you want, how you want it, and when you want it. If you don't have time to log in to your laptop or desktop, you can take a quick look at your smartphone. These media services are easily accessible via mobile phones, laptops, smart TVs, and other audio-visual devices connected to the Internet. This service is synonymous with Video on Demand (SVoD) service, and digital content is accessible internationally.

Original content

If you have an account on an OTT platform like HBO, you'll need to sign up for a real service. By paying a small subscription, you get a variety of original content that can only be accessed after approval. Account owners can manage things themselves without the intervention of external sources.

DISADVANTAGES OF OTT PLATFORM

Online Limitations

If you have an internet connection, you can enjoy the streaming platform. The disadvantage of streaming media from a website is that the media is only available online. This option restricts access to the material

to anyone who does not have an online presence. You also need a streaming platform account to watch your favourite shows.

Poor network can impact your viewing

Unstable connections are another drawback of online streaming. Content is HD quality, which makes it very difficult to watch the media uninterrupted if the network speed is slow. Media streaming requires a stable internet connection. If you want an HD experience, you need an internet connection of at least 2 MBPS. Otherwise, you will have buffering issues.

Online security

In addition to HBO, Netflix and other OTT platforms, some are unreliable. Thousands of such platforms are insecure, as sensitive information tends to be leaked during subscription payments. Cybercrime can also occur on platforms that require personal information such as bank details. Many reputable platforms are working to enhance security, but many need to be fine-tuned.

No Censorship

The OTT platform operates independently without following government guidelines. There is no age limit for the number of viewers. The sole purpose is to include content that attracts more viewers. One of the worrisome drawbacks of the OTT platform is the limited content. Such content can harm underage users.

Users waste too much on OTT platforms

Given that many web series, movies and shows are released weekly, users are more likely to waste time on the OTT platform. When the web series ends, there is another web series in the recommended segment. People who spend more time streaming live video tend to be more engrossed in online content than socially active in real life.

MAJOR STREAMING SERVICES IN INDIA

I. Prime Video

Prime Video could be a VoD service owned and operated by Amazon. In India, Prime Video hosts over two,000 movies and four hundred TV shows. the price of the subscription is Rs 129 per month. or annual Rs. 999. India, with over ten million subscribers, is that the world's largest marketplace for Prime Video. In Associate in Nursing annual letter to shareholders, Amazon founder and chief operating officer Jeff Bezos states that Republic of India is that the company's 's most useful market outside the us (Bezos)., 2019).

II. Hotstar

Hotstar is ideal for observance movies, daily series, live sports, and news channels. Users will produce an account to look at content at no cost with ads. On the opposite hand, with the Hotstar Premium subscription, monthly Rs. 199 or annual Rs. 999, you'll need ad-free access to exclusive international movies and television shows. Hotstar downloads exceeded four hundred million in 2019, and one among the highest draw factors was livestreaming cricket matches. throughout the Indian Premier League (IPL) 2019, the platform recorded three hundred million active viewers.

NETFLIX

Netflix entered Republic of India in January 2016. Its distinctive point is that the abundance of original movies and television shows it offers. at first lacking abundant of India-focused or localized content, Netflix has created the most important investment ever in Republic of India to form a lot of original content. Netflix is way costlier than all its competitors. As a result, has conjointly launched a cheap, mobile-only version of the service solely in Republic of India. arrange is priced at Rs 199 and aims to produce smartphone users with a singular and customized expertise.

JIO CINEMA AND JIO TV

Reliance Jio Mobile information Service is bundled with varied OTT apps that meet the varied wants of consumers, like JioTV, JioCinema, and JioSaavn. Content provided by the service is primarily dedicated to Indian viewers. JioTV offers 647 live TV channels. that is nearly double the number of channels offered by competitors. JioCinema hosts over 10,000 movies and television shows. Jio features a semipermanent content agreement with Disney Walter Elias Disney filmmaker film producer movie maker Republic of India and hosts a frenzied Disney branded space on the house page that contains content that spans Disney movies and anime series.

DIFFERENT OTT PLAYERS

Eros currently has the foremost content compared to different OTT services in Republic of India. Hosts over 11,000 movies, 100,000 albums and a hundred TV shows. Eros currently was awarded the “Best OTT Platform of 2019” at Brits Asian Media Awards. Hooq could be a lesser-known challenger within the market, launched in Republic of India long before different services. Hooq offers over ten,000 titles together with movies and fashionable DC superhero TV shows. Voot could be a streaming service owned by Viacom eighteen. It hosts programs like the subsequent that are already on air on TV channel: B. Colours, MTV, record player, etc. Voot has conjointly started manufacturing an ingenious series beneath the name Voot Originals. ALTBalaji could be a VoD platform operated by Balaji Telefilms Ltd. Works. angular position Balaj at twenty-five per month or three hundred rupees annually is that the most cost-effective of all OTT players in Republic of India. The platform has over 250 hours of original content and new shows are discharged monthly.

REVIEW OF LITERATURE

Singh D. P. (2019), the advent of the Internet is rapidly changing the trend of movies in India. Internet service price cuts lay the foundation for boosting OTT services such as Netflix, Hotstar, Zee5, Amazon Prime and AltBalaji. Many companies produce video content specifically for these OTT services. These new ventures are changing the format of Indian television and movies. OTT services analyse video content viewed by users and continue to provide content of similar genres. People who match are enjoying the service for free. Therefore, like Hotter, OTT offers very limited content for free. Subscription fees for these services are also very cheap. Users can enjoy a variety of international and domestic content. Action and comedy are the most popular movie genres. According to a survey, users watch OTT services an average of two hours a day. The Web service is displayed more often in OTT services. Genres such as young romance, action, and urban dramas belong to the top leagues. Most users watch content at night. Entertainment is the most important reason to use OTT. The second most important reason to use it is the device’s mobility. Third, about the availability of on-demand content.

Chang, P. C., & Chang, H. Y. (2020), Over-the-top (OTT) TV offerings are pervasive in neighbourhood and international markets. Compared with conventional media consumption, OTT structures find the money for customers extra manage over content material choice at a inexpensive price. However, discussions of OTT offerings are confined and do now no longer display the antecedents and effects of OTT use from character perspectives. Therefore, this has a look at advanced an empirical version with the aid of using integrating perceived interactivity, perceived cost, pleasure, and continuance utilization. After gathering information from 230 OTT customers, we showed maximum of the researcher’s proposed hypotheses and that perceived platform interactivity is the maximum crucial indicator of OTT use. OTT customers can also additionally select interacting with content material and the social network from a cost perspective. Perceived interactivity and perceived cost are sturdy signs of pleasure and continuance utilization of OTT offerings. Implications for teachers and practitioners are discussed.

Kumari, T. (2020), The present study aims to grasp the changes in pattern of content consumption behaviour of shopper once the introduction of OTT services in Republic of India and conjointly the factors tributary to the success of OTT services. The findings of the study shows that majority of users (88%) agrees

that emergence of OTT platforms have affected their tv and movie watching habits. wise phones unit the foremost most popular device for watching OTT channels and majority of viewers unit getting dark users. The findings of the study not entirely provide associate insight on the foremost necessary factor's tributary to the success of OTT services but put together the reasons for people not adopting to OTT services. Content openness, worth and lack of technological readiness unit rising as major barriers in adoption of OTT services in Republic of India. the current study suggests that the long-standing time of OTT services is bright in Republic of India and gift users likewise as non-users' unit willing to use OTT services in future.

Parikh, N. (2020), this analysis tries to review the increase of OTT platforms throughout the pandemic. it's vital to understand the extent of increase within the quality of OTT platforms throughout pandemic to understand their future scope. the survive result indicates that folks used OTT over the other platforms out of tv and YouTube to pass their time or for diversion. Most of them seasoned a rise in their consumption times and were wanting forward for movies to be free on OTT at constant time as in cinemas. folks were conjointly okay with observation movies on OTT instead of cinema. except for some it relied on the flick. this analysis has shown that there's a large scope for OTT platforms within the future and therefore the pandemic has contended a serious role in it

Sharma (2020), the ongoing COVID 19 crisis has forced Multiplex to close. As a result, production companies are now releasing directly to the OTT platform. This is a worrying issue across multiplexes as users may be broadcasting. Traditional window pattern. Both INOX and PVR have issued official statements addressing this issue. According to experts, this is a solution to the short-term needs of the film industry addressing the financial difficulties. This is a win-win situation for OTT players who need fresh content and for filmmakers who have finished production but couldn't release it. But once things get back to normal, this is not a long-term paradigm shift. The Cinema brings more revenue to the production company compared to the OTT platform. This is an important factor, so once the market is released from the crisis of COVID 19- , the film will be shown in theatres as before. In fact, multiplex services can surge for about days after returning to normal.

Chakraborty, I., Verma, et al., (2022), Digital platforms have transformed business. OTT (Over-the-top) platforms such as Netflix, Amazon Prime, and Google are entering the entertainment industry. As a result, traditional media players have adopted this concept and developed their own OTT Media Platform (OMP). Thanks to the favourable environment, OMP has grown several times. For example, there are almost 40 different OTT platforms in India. OMP competes for new markets, new customers, and technology and supports existing businesses. Therefore, to maintain and grow in this competitive environment, OMPs must understand customer preferences and business drivers. This study examines the readiness of customers to use the new OTT media platform (WUNO). This study is based on the results of a survey of 1310 respondents in 11 Indian states. The desire to use the new OMP (WUNO) depends on the content, subscription, age, language, time spent on OMP and current OMP usage. Individual selections and features of OMP feature current use and WUNO. It is recommended to use when the OMP function is presented as a combination of the WUNO model and personalized according to the needs of the customer. Research findings are useful for existing and new OTT platforms

RESEARCH DESIGN

Objectives of the study

- The prime objective to conduct this research is to understand various factors which effects the paradigm shift among urban youth from movie screening theatre to OTT platforms.
- To understand the psychology of urban youth preference to watch content available on OTT platforms instead of watching it in the movie theatres.

- To study and evaluate comparative audience preferences and trends around OTT v/s movie screening theatre
- To examine the factors influencing to prefer OTT platform.

STATEMENT OF THE PROBLEM

As fast as technology is changing, the faster we are also changing our habits. Today it is the age of OTT where every person has a smart phone in which he can watch any kind of content anytime. The dominance of watching movies in the cinema hall has always remained. But now this domination is suspected. Most big-ticket movies in the USA have been pushed to later this year, some even to next year. Similarly, in India, the theatrical release of all major films has been indefinitely postponed. But OTT platforms are buzzing with activity. Especially after the lockdown in India, with the OTT channel gaining such a large number of viewers, especially the urban youth, people have gained a new kind of viewing experience, which can be said if it continues after this so there will be a lot of concern for cinema hall owners. To determine the paradigm shift Among the urban youth from OTT platform to movie screening theatre.

SCOPE OF THE STUDY

This study is to highlight the scope of OTT platform and the extent of their consumption amongst the urban youth. This study will help to understand how OTT platforms have taken over the world of movie screening entertainment.

RESEARCH DESIGN AND METHODOLOGY

The study has used both primary data and secondary data.

Primary data: the primary data has been collected through random sampling, from the sample respondents through the schedule with the help of a questionnaire which was distributed online.

Secondary data: the secondary data has been collected from standard reference book and various websites.

Tool used for data collection: A structured questionnaire carrying 15 questions and the questionnaire was administered via google form.

Tools used for analysis: the tools for data analysis are tables, graphs and pie charts

Method used: Survey method was used to carry out the primary research.

Sampling: The study is conducted among youth aging between 18-24 which are mostly students to infer their consumption of different OTT platforms. The study is conducted through distribution of questionnaires online and a total of 120 responses were collected.

The entire survey was conducted within a timeframe of two weeks and this sample was evaluated for the purpose of the study.

LIMITATIONS OF THE STUDY:

- This study is limited to urban Bangalore respondents of which are youth from age 18- 24. So, findings and suggestions given on the basis of the study cannot be extrapolated to the entire population.
- The primary data collected may be biased.
- The time is fixed constrain is a huge constrain which affected the analysis, the limited time made the analysis a little rigid. The primary source of data collection being students and employees in the educational setting, might not have time to invest in giving interviews and filling questionnaires, and thus such a detailed study might not be possible.

- The participants were reluctant to share their personal information, the primary data providers might be reluctant in sharing personal details about themselves. Therefore, to extract information and find people who willingly want to provide information might be a tedious information.

Hypothesis

H01: There is a paradigm shift among urban youth from movie screening theatre to OTT platform.

HA1: There isn't a paradigm shift among urban youth from movie screening theatre to OTT platform.

ANALYSIS AND INTERPRETATION

Age group of the respondents

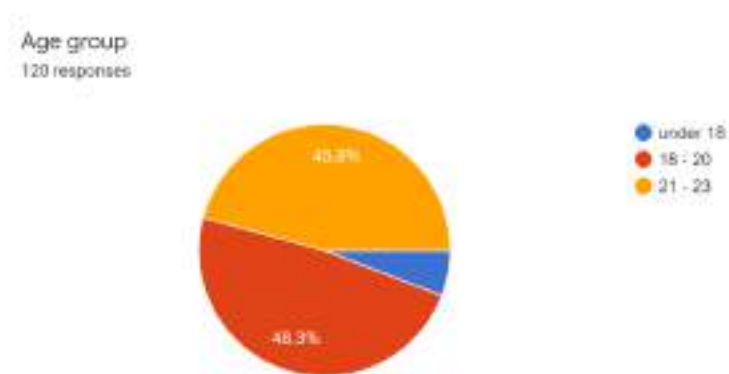


Figure 1.1

The above figure shows that most of our respondent who are a part of our research study belong to the age category of 18-20. It is usually assumed that consumers belonging to this age category are more in touch with the latest happenings in OTT platforms and hence have provided valuable inputs in the making of this research study

GENDER OF THE RESPONDENTS

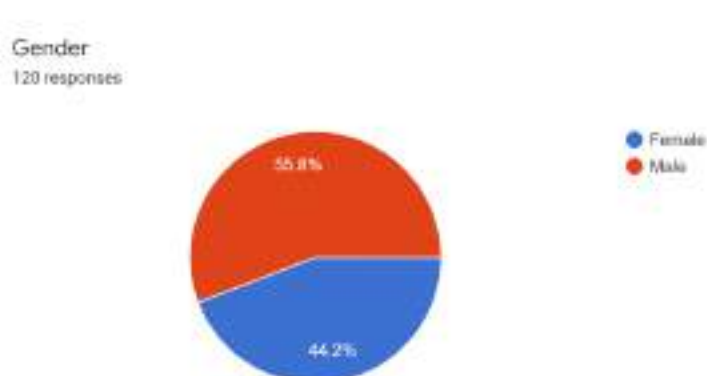


Figure 1.2

The above figure shows that most of our respondent who are a part of our research study are male. There are 44.2% female respondents and 55.8% male respondents.

OCCUPATION STATUS OF RESPONDENTS

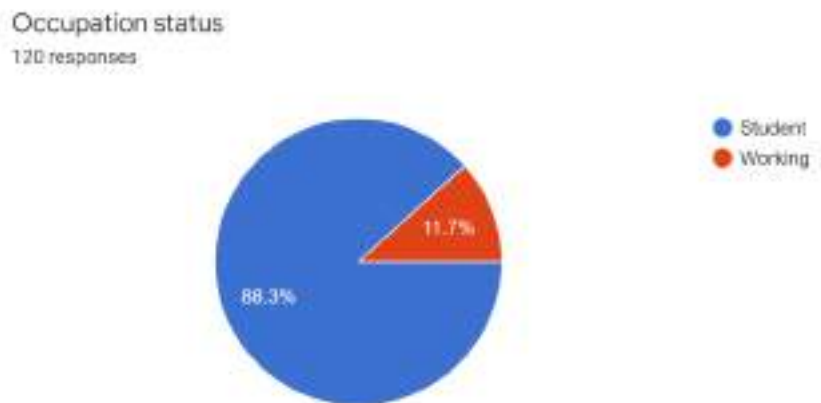


Figure 1.3

The above figure shows that majority of the respondents are students and only 11.7% of the respondents are working.

TIME SPENT ON OTT PLATFORM

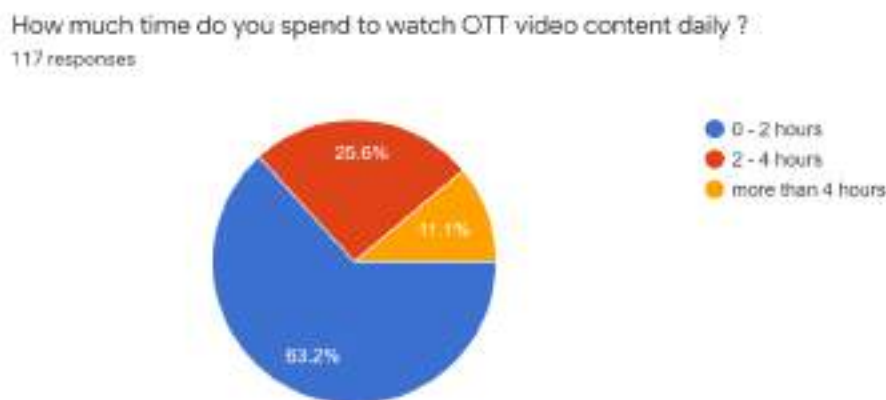


Figure 1.4

From the above question, we can infer that on an average, consumers spend roughly 1 to 2 hours consuming content available on the OTT platforms. i.e., 63.2% out of the total respondents of the consumers spend at least 1 to 2 hours logged in to OTT platforms.

NUMBER OF OTT CHANNELS SUBSCRIBED

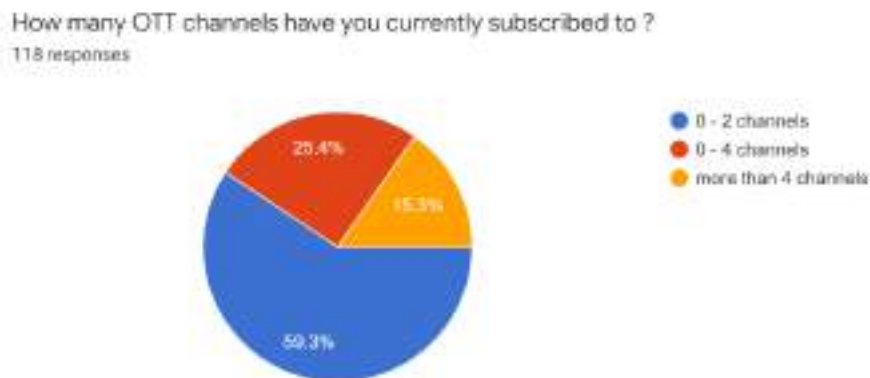


Figure 1.5

The above figure shows that 59.3% respondents have subscribed to 0-2 channels of Ott platform. There are at least 15.3% respondents who have subscribed for more than 4 channels. With this chart we can understand that everyone has at least one channel of Ott subscription.

CONVENIENCE OF WATCHING MOVIES ON OTT PLATFORM COMPARED TO OTHER TRADITIONAL MEDIUM.

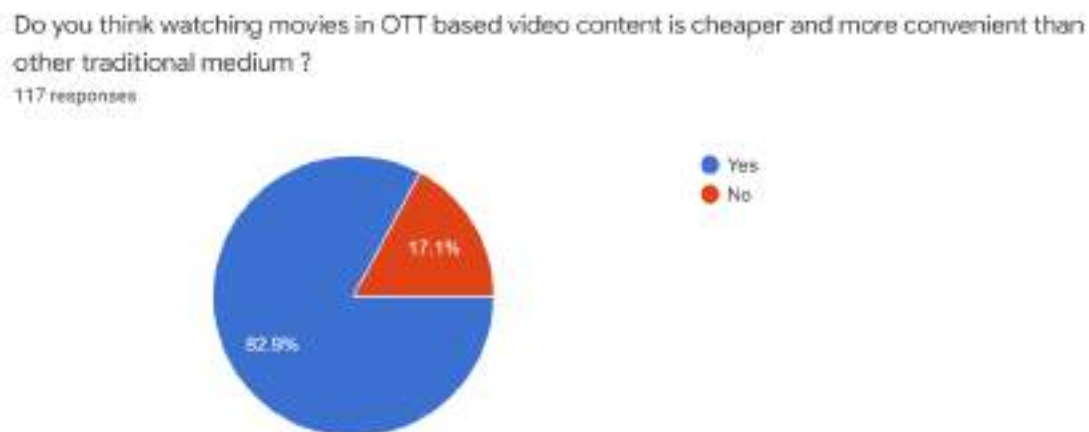


Figure 1.6

The above figure shows 82.9% respondents i.e., majority of the respondents agree that watching movies in OTT based video content is cheaper and more convenient than the other traditional medium. Since Ott platform is cheaper and convenient it is one of the main reasons why people prefer it.

PREFERENCE OF WATCHING MOVIES ON OTT THAN IN THE MOVIE THEATRES

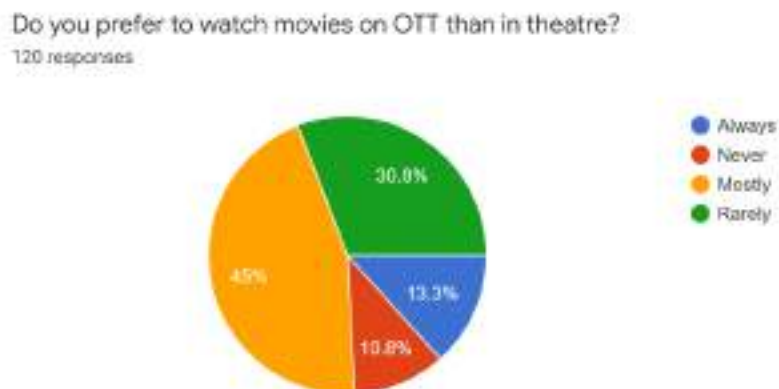


Figure 1.7

The above figure shows that 45% of the respondents mostly wish to watch movies on OTT than in theatres. 30.8% of the respondents watch movies on OTT rarely. 13.3% of the respondents always wish to watch movies on OTT than in comparison with theatres. A portion of 10.8% of respondents never wish to watch movies on OTT than in theatres.

OTT PLATFORM CHALLENGING THE COLLECTIVE MOVIE WATCHING HABIT.

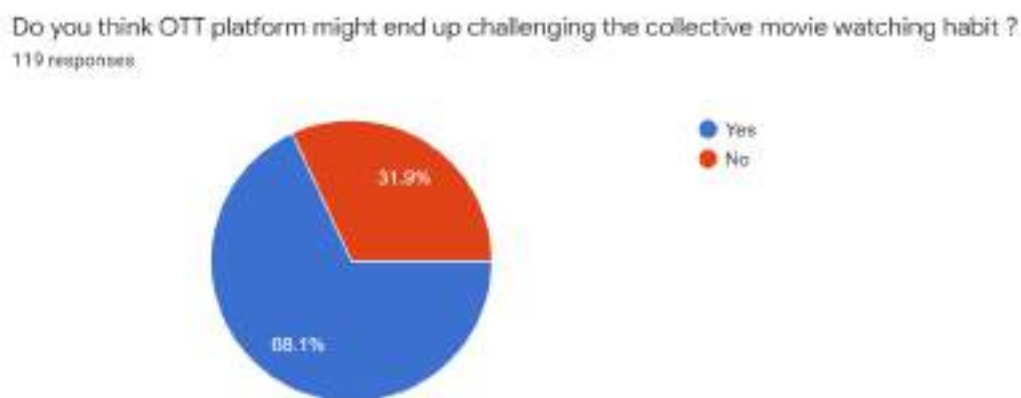


Figure 1.8

The above figure shows that 68.1% respondents believe that the Ott platform might end up challenging the collective movie watching habit. 31.9% respondents disagree.

VISITING THE MOVIE THEATRE WITH FAMILY AND FRIENDS AS FREQUENTLY AS BEFORE

Would you go to the movie theatre to watch a movie with your friends and family as frequently as before ?
119 responses

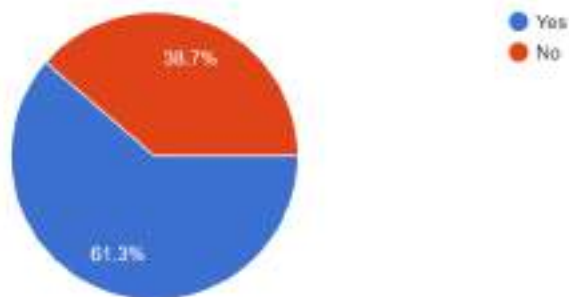


Figure 1.9

The above figure shows that 61.3% of respondents would go to the movie theatre with friends and family as frequently as before. 38.7% of respondents would not.

DECREASE IN CINEMA HALL FOOTFALLS DUE TO OTT PLATFORM IN FUTURE.

Will there be a decrease in cinema hall footfalls due to OTT platform in future ?
120 responses

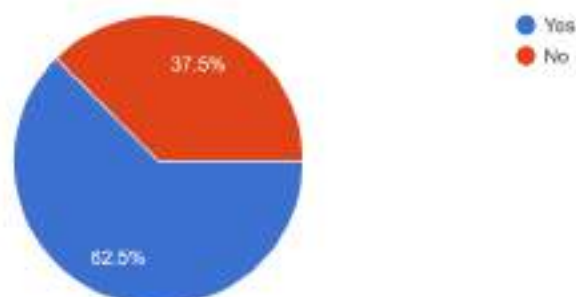


Figure 1.10

The above figure shows that 62.5% of respondents agree that there will be decrease in cinema hall footfalls due to OTT platform in future. 37.5% of respondents disagree.

BENEFITS OF OTT PLATFORM

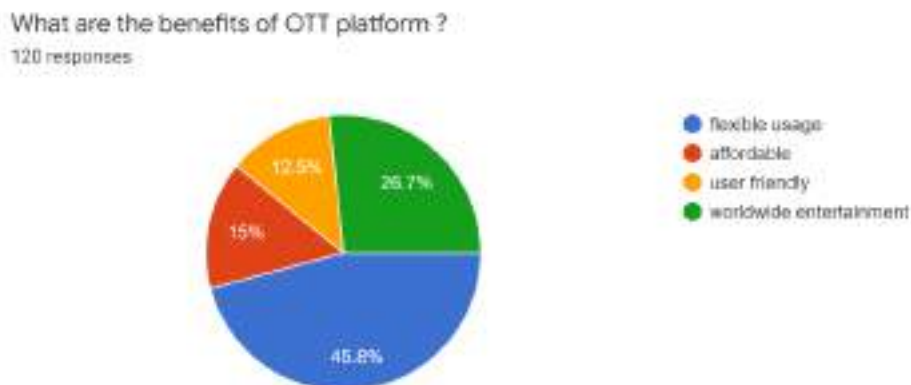


Figure 1.11

The user friendliness of the OTT platforms is the main attraction & benefit majority of the respondents have. 45% of the respondents loved the benefit of having flexibility in the usage of OTT platforms. 26% of the respondents are attracted with the availability of worldwide entertainment via these platforms and 15% of total respondents likes the less costly entertainment provided via these OTT platforms.

COMMENCEMENT OF USAGE.

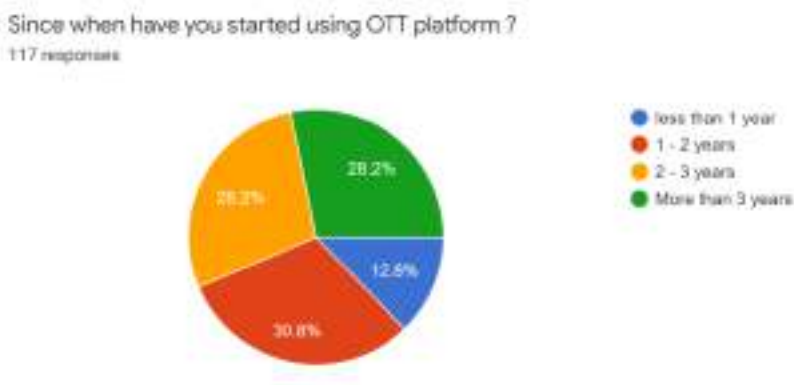


Figure 1.12

12.8% of the respondents have started using OTT platforms in & below 1 year which means after the arrival of pandemic. 30.8% of the respondents have been using for 1-2 years and 28.2% of respondents have been using OTT platforms for 2-3 years. There are 28.8% of respondents who have been using the OTT for above 3 years.

CHANGE IN USAGE OF OTT AFTER PANDEMIC.

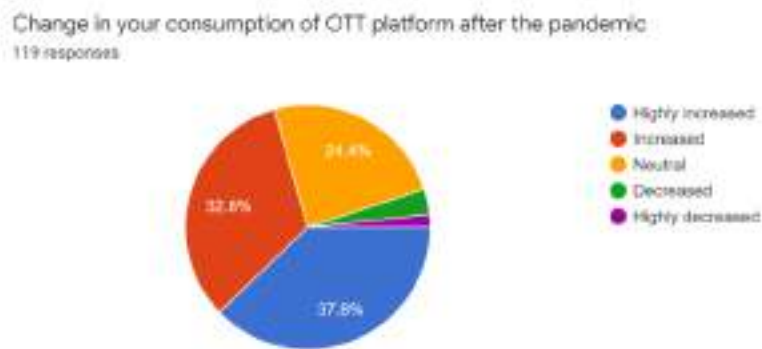


Figure 1.13

The above figure shows 37.8% of the respondents has highly increased their consumption of OTT platforms after the arrival of pandemic. 32.8% of the respondents have increased their usage after COVID-19 pandemic. 24% of the respondents have been staying neutral on their OTT platforms usage. The most important fact is very few i.e. 3.4% of respondents have decreased and 1.7% of respondents have highly decreased their OTT consumption after arrival of the COVID-19 pandemic.

FUTURE USAGE OF OTT PLATFORM

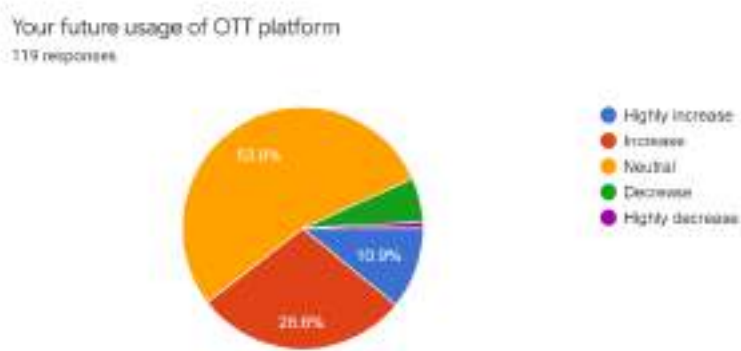


Figure 1.14

The above figure shows that 53.8% of respondents will stay neutral in their future usage of OTT platform. 28.6% of respondents will increase and 10.9% of respondents will highly increase their future usage of OTT. The most important fact is very few i.e. 5.9% of respondents will decrease and 0.8% of respondents will highly decrease in future usage of OTT.

OTT EXPERIENCE RATING.

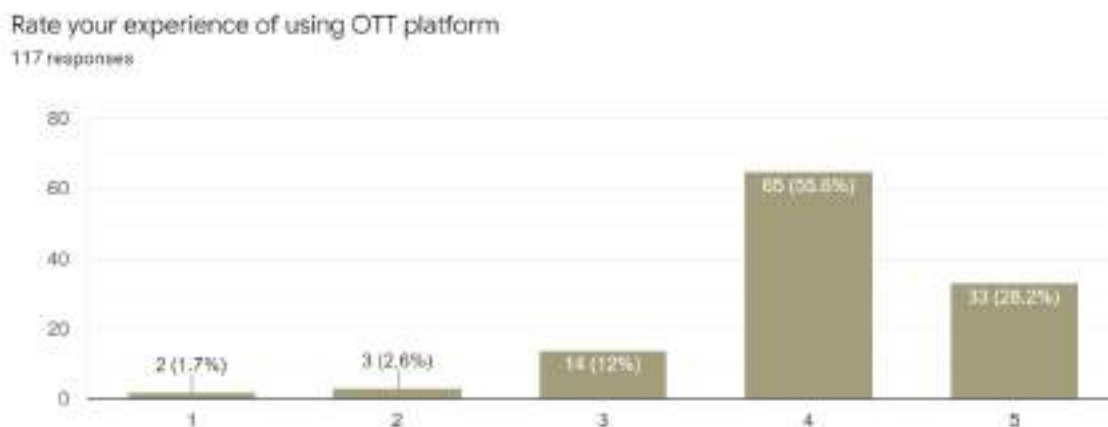


Figure 1.15

55.6% of the respondents have given a rating of 4 out of 5 as their OTT experience. 28.2% of the respondents were fully satisfied with their experience and they gave a 5-star rating. 12% of the respondents gave a 3-star rating. 2.6% of respondents weren't happy with the experience and they gave 2-star ratings. 1.7% of respondents were not at all happy with the experience and they gave 1- star rating. None of the respondents made the experience on OTT given a zero rating.

SUMMARY OF FINDINGS

When it involves OTT platforms, on a mean each user holds minimum of two OTT platforms and that they frequently pay 1-2 hours daily. the largest advantage of OTT platforms is that customers access plenty of content in an exceedingly in a very freemium model wherever OTT platforms supply free content with a selected assortment and there would be an incentive to change to the paying subscription. This model has seen a modification towards viewers viewing behaviours because it ends up in accessing the model of paid subscription. The key issue that gives a plus over look in movie theatres area unit convenience and quality for viewers UN agency want OTT platforms. OTT platforms have allowed users, at their own convenience, to access a range of content at low expense.

When it involves movie theatres, Majority of the viewers opting to look at a moving picture within the theatre once it's a extremely content driven moving picture. Thus, a modification in client look habits may be seen wherever theatres were extremely most well-liked for commercial/big star movies, however currently it replaced by content driven movies. Reviews and Ratings plays a vital issue and it becomes a deciding issue for the new age audience to look at a moving picture in theatre. The viewers UN agency want movie theatres believe that theatrical expertise, screen size & sound quality and atmosphere area unit the necessary factors that makes a footing over look in OTT platforms. movie theatres provide the users to look at a movie theatre with a very transformative expertise.

Current generation doesn't have the patience to attend for a show or movie to air on a linear platform like tv. This viewer desires the content instant and on-demand. that's what our study reveals that thanks to some such reasons the expansion of OTT can solely increase in Asian nation. All the reports and articles that I actually have scan and bear, the sole issue understood is that in Asian nation, the OTT video streaming service

can still unfold its feet and it's progressing to have an enormous impact on our ancient medium like tv and Cinema Hall. The sturdy attachment of OTT to the audience within the internment amount has any confirmed this reality. Smartphone penetration, international collaborations between media moguls and digital quality of the medium, price effectiveness and access liberty (anywhere at any time) is additionally one in all the explanations behind growth of streaming media in Asian nation.

From the information, it may be same that the urban youth like look content principally in OTT platforms and sometimes in movie theatres. Almost 62.5% of respondents believe that OTT platforms area unit an intermission to movie theatres. Convenience is that the biggest reason behind the employment of extraordinary application. Second biggest reason is selection of big selection of content. Third on is availableness of content on demand. Reasons behind the modification area unit convenience of service, personal medium and availableness of international content.

RECOMMENDATION

- Theatre and distributors associations ought to propose a rule to unharness on OTT platforms solely once one hundred days of its theatrical unharness.
- Digital streaming platforms, particularly for people who relish binge-watching, have undoubtedly created look movies cheap, easy, and usable on the go.
- The average speed ought to be enhanced as a result of India's average speed is incredibly poor and typically a five- second lag in video streaming owing to loading would have an effect on a fourth of its audience to a content publisher.
- In the trade, it's extremely recognized that smaller films and extremely risky films ought to solely be discharged on OTT platforms, whereas larger films will solely be discharged in theatres and OTT platforms. Since producers receive a secure commitment and a salary once smaller films area unit noninheritable by OTT platforms, thus once a smaller film is discharged in theatres, it needs plenty of prices and will increase the budget of the film, that in essence could be a pressure issue for producers to induce the cash back.
- Movie theatres ought to embrace new services and implement totally different approaches for drawing viewers in theatres. Reducing price tag prices, choosing quality content, technical innovations and safety precautions area unit the essential issues which will be taken into consideration by the theatre operators that may bring the audience back to the theatres.
- Better and effective subscription plans area unit to be introduced to cope up with the requirement for a majority of users United Nations agency area unit often intense OTT platforms.
- The shoppers ought to be created privy to the negative impact of sharing login details with others and additionally implement steps for resisting constant.

CONCLUSION

As India is that the world's largest growing OTT trade, this momentum is used by the many increases within the introduction of latest OTT players within the market and speedy changes in providing of individualized content. Even the smaller OTT platforms area unit raising capital from international investors and creating a major impact on the market. it's quite evident that the arrival of COVID-19 pandemic has motor-assisted the OTT platforms with the enhanced consumption of those by the youth and OTT turning into the foremost most well-liked medium. the main edges incurred from the OTT platforms area unit the flexibleness of usage, availableness of society & worldwide recreation and subscription to the easy unlimited content. additionally, very important area unit factors like increasing penetration of smartphones and availableness of net information at competitive costs in India.

Movies and net series area unit the foremost watched on OTT among the youth, that area unit most well-liked because of the provision of the first content. Netflix, Amazon Prime Video and Disney+hotstar area unit the very best consumed OTT platforms as they satisfy their shoppers with the most effective quality contents and user friendliness. there's additionally an enormous rise within the arrival of regional OTT players within the market. Most of the present users of the OTT platforms area unit quite happy with their expertise and majority of the shoppers tend to extend their consumption of OTT in future. This trend will be with success explored by the various OTT platforms. The OTT can additionally bear several changes and advancements to induce the proper model.

REFERENCES

- [1] Aggarwal, K. (2020, November 16). Direct to Digital: Will OTTs Replace the Theatre Experience Post Pandemic? Youth ki Awaaz. <https://www.youthkiawaaz.com/2020/11/direct-to-digital-can-ott-replace-theatres/>
- [2] Awasya, G., Manoj, K & Patel, M.K. (2021). OTT Viewership and Pandemic: A study on New Trends of online video content and cinema hall footfalls [Paper Presentation], International Conference on Innovative Business Practice in the Digital Era.
- [3] Bilbil, E. T. (2018). Methodology for the Regulation of Over-the-top (OTT) Services: the need of a multi-dimensional perspective. *International Journal of Economics and Financial Issues*, 8(1), 101. <https://doi.org/10.32479/ijefi.5809>
- [4] Banerjee, S., Srivastava, R. (2019). Exploring Export potential of Indian movies: A comparative advantage analysis of the Indian Film industry, *Great Lakes Herald*, 13(4), 21-40.
- [5] Ball, M. (2020, March 29). 'The Impact of Covid-19 on the movie / theatre Industry'. <https://www.matthewball.vc/all/Covid-19movies>
- [6] Chang, P. C., & Chang, H. Y. (2020). Exploring the factors influencing continuance usage of Over-the-Top services: The interactivity, consumption value, and satisfaction perspectives. *International Journal of Technology and Human Interaction (IJTHI)*, 16(4), 118-138.
- [7] Chakraborty, I., Verma, R. K., Joshi, M. H., & Ilavarasan, P. V. (2022). Customers' Willingness to Use New OTT Media Platforms in India. In *ICT Systems and Sustainability* (pp. 751-760). Springer, Singapore
- [8] Farooqui, M. (2019, January 29). Will Single Screen Theatres in India Become History? *Money Control*.
- [9] Gangal, A. (2021, March 9). 'The Dependence of OTT on Bollywood has Reduced'. *Afaqs.com*. <https://www.afaqs.com/interviews/thedependence-of-ott-on-bollywood-has-reduced-ormax-medias-shailesh-kapoor>.
- [10] Kumari, T. (2020). A study on growth of over the top (OTT) video services in India. *International Journal of Latest Research in Humanities and Social Science (IJLRHSS)*, 3(9), 68-73.
- [11] Singh, D. (2020, April 06). How is coronavirus impacting the streaming platforms with an increasing appetite of viewers? Retrieved from *Financial express*.
- [12] Sharma, K. (2020, May 19). Will movies releasing directly on OTT platforms become a norm post-Covid? Experts think otherwise. Retrieved from *Business insider*.

A.I.-Powered Human Resource Management: Transforming Hiring and Candidate Selection in the IT Industry

Amol Murgai*

*School of Business and Management,
Christ University, Lavasa, Pune*

Manisha Shedge

*Department of Management,
Tilak Maharashtra Vidyapeeth, Pune*

Jyoti Mishra

*School of Commerce and Management Studies,
Dayananda Sagar University, Bengaluru*

Abstract: The emergence of artificial intelligence (AI) has significantly impacted several industries, including human resource management (HRM), in today's fast-paced and technologically-driven world. AI technologies are now transforming HRM, historically considered a people-centric field. This paper examines the dynamic interaction between HR and AI and its possible advantages and difficulties for businesses are adjusting to this new paradigm. We are currently seeing the extensive impacts of AI on human endeavours. It has developed into a formidable instrument for both people and organizations. Because AI can collect and arrange enormous volumes of data, it has made HR tasks more accessible and more efficient. This study evaluates how employees view artificial intelligence when hiring and choosing candidates. We also attempts to assess AI's function in hiring and choosing. It attempts to shed light on newly popular trend of AI in HRM. Surveys, publications, and journals were used to gather data. The study's conclusions imply that using AI tools during hiring and selection produces objective judgment. The majority of workers favor AI-based hiring and selection procedures over conventional ones. Some people believe that this approach lacks a human touch, though. This study is restricted to IT company HR executives only. The recruitment and selection process would be more efficient in locating and obtaining superior applicants if AI tools were used.

Keywords: Recruitment, Human Engagement, Resume Short-Listing Process, Biases, Chatbots, Technologies

1. Introduction

Human resources (HR) is one of the many areas that artificial intelligence (AI) has transformed. AI can save expenses, enhance decision-making, and expedite HR

* Corresponding author. Email: amol.murgai@christuniversity.in

procedures. The application of AI in HR departments and its advantages over conventional HR systems is discussed in this article. The hiring process is one of the main areas where AI is used in HR. HR personnel conduct initial interviews, evaluate resumes, and even anticipate a candidate's performance in a post using AI-powered recruitment tools. Using machine learning algorithms, these technologies analyze a large amount of data, such as resumes, job descriptions, and employee performance statistics. This allows them to spot trends and forecast which applicants would succeed in a specific position. This can minimize the possibility of human bias in the hiring process and save HR staff much time.

AI is also changing HR through increasing employee engagement. Chatbots and virtual assistants driven by AI have the potential to give staff members immediate access to support and information. HR personnel can focus on more complicated problems by using these tools to get answers to frequently asked queries about benefits or vacation policy. AI-powered chatbots can also raise employee engagement by making tailored recommendations based on an employee's interests and preferences. AI can also assist HR departments in strengthening their retention plans. AI-powered solutions that analyze employee data can pinpoint elements like a lack of career development possibilities or low job satisfaction that led to employee churn. HR departments may then utilize this data to create focused retention plans that will keep their top talent motivated and involved.

An AI-powered HR system has many advantages. First and foremost, by automating several repetitive HR procedures, AI may contribute to cost savings. HR departments may then be able to concentrate on more critical projects like engagement and employee development. AI-powered solutions that give HR staff access to data-driven insights can also aid in better decision-making. Better hiring choices, more successful employee engagement plans, and higher retention rates can result from this.

The potential of AI to lessen prejudice in HR is another advantage. Human bias has the potential to affect the hiring process significantly and result in discrimination against particular candidate groups; by concentrating on objective factors like a candidate's qualifications and experience, AI-powered recruiting technologies can aid in the elimination of prejudice. This can help ensure that each applicant is fairly assessed and that the most qualified individual is chosen for the position.

Artificial Intelligence (AI) and paradigm shift in HRM practices

Artificial Intelligence (AI) changes how businesses run and handle their employees. AI also promises to transform the recruiting, selection, training, and retention processes in human resource management (HRM). Organizations are adopting AI-based solutions more frequently to boost employee satisfaction and increase the effectiveness of HRM procedures.

Recruiting and Choosing

Recruiting and selection are two critical areas in HRM where AI influences. Employers can use AI-powered technologies to evaluate resumes, cover letters, and other application materials to find the best candidates. AI may also conduct online interviews to help with the initial screening process, saving time and resources for both the business and the candidate.

AI can assist in eliminating bias from the hiring process as well. It can help ensure that all applicants are judged on their talents and abilities rather than their background by identifying and eliminating biased wording from resumes and job descriptions. AI may also evaluate data on previous hiring decisions to spot bias trends and assist businesses in making more impartial recruiting decisions.

Education and Training

AI can also be utilized to improve employee training and development initiatives. AI-powered chatbots can offer staff individualized help and training, responding to their inquiries and offering performance evaluations. AI can also analyse employee data to find skill gaps and suggest training courses to assist workers in advancing their knowledge.

Management of Performance

Performance management is another area where AI may be helpful. It can identify patterns and trends in employee performance data analysis, including productivity, engagement, and attendance. This can assist managers in determining the areas in which staff members require assistance and give them focused coaching and feedback.

Holding On

Lastly, AI can assist businesses in increasing staff retention. AI can analyse employee satisfaction, engagement, and turnover data to pinpoint the causes of such events. Organizations can take action to enhance employee satisfaction and lower attrition rates based on this data.

Artificial intelligence (AI) for recruiting is the application of AI to the hiring process to automate or expedite certain aspects of the hiring process, exceptionally high-volume, repetitive tasks. Artificial Intelligence is an advanced human-designed method for automating mundane and significant tasks. It should go without saying that using artificial intelligence in recruiting reduces the time and effort required to find the right candidate for your company. When choosing the right candidate for the job, the last thing we want is for prejudice to cloud our judgment. Thankfully, several cutting-edge AI-based hiring solutions can help reduce that unconscious prejudice.

2. Methodology

The present study aims to investigate the impact of artificial intelligence recruitment. This deductive technique enabled the researcher to collect early information on how AI. Through established theory, it affected recruiting and was then able to compare and support this. To ensure a seamless research study, the researcher selected a population of recruitment managers from international I.T businesses in Pune. Researchers have established specific standards for the people where the manager should be a recruitment manager. Secondly, the organization must be a multinational computer corporation in Pune's IT sector. This aids in narrowing down the respondents who work for this company and specifying the area of the research study, Pune. We have chosen the three clusters: Hinjewadi, Kharadi, and Magarpatta I.T. parks. A sample of 250 IT human Resource managers was selected, and a set of questions were asked of them.

2.1. Statistical Test: Chi-square Test Hypothesis

H0: There is no correlation between time consumption, cost, and biases in the traditional recruitment process.

H1: There is a correlation between time consumption, cost and biases in the traditional recruitment process.

Table 1: Test Statistics, Chi-Square Test

	Value	df	Asymptomatic Significance (2– sided)
Pearson Chi-Square	16.441	8	.036
N of Valid cases	250		

Source: Primary data.

After testing the hypothesis, we rejected the null hypothesis due to the p-value, which is less than 0.01. Hence, the alternate theory seems to be accurate, which tells us that there is an association between how AI has changed the way recruitment used to happen and its manifestation into quality outputs in the recruitment process. To understand the association in detail, we refer to the below-mentioned table 2:

From table 2, we can see that as AI has changed, recruitment used to happen, and it has manifested into more quality outputs for recruitment purposes. Almost more than 90% of responding managers agree. This also suggests that there is indeed an association between how A.I have changed the recruitment process and the resulting improvements in the quality of outputs. Data from the table support this conclusion, showing that most (more than 90%) of responding managers share this opinion. This finding could have significant implications in the field of recruitment and HR. It implies that adopting A. I in recruitment

processes positively impact the quality of outcomes, including factors like the efficiency of candidate screening, reduced bias, improved matching of skills, and overall enhanced decision-making in the recruitment process.

Table 2: Opinion on Artificial Intelligence (AI) to convert inputs into high outputs involved in recruitment

Do you believe that A.I has changed the way recruitment use to happen? * The company uses Artificial Intelligence (AI) to convert inputs into high outputs involved in recruitment (Cross-tabulation)

		The company uses Artificial Intelligence (AI) to convert inputs into high outputs involved in recruitment			Total
		Neither agree nor disagree.	Agree	Strongly Agree	
Do you believe that A.I has changed the way recruitment use to happen?	Not at All	0	1	2	3
	Not much	0	1	21	22
	Neutral	0	1	34	35
	Quite a lot	1	14	110	125
	Very much	3	14	48	65
Total		4	31	215	250

Source: Primary data.

3. Conclusion

Technology has advanced, so artificial intelligence (AI) is used in many industries, including recruitment. Artificial intelligence (AI) technology enables organizations to reach diverse geographic areas in seconds. This widespread application of AI also enables organizations to search for the best candidates for open positions from a wider pool of candidates, including competitors, in certain cases. For instance, it is now simpler for organizations to contact candidates online and use various digital platforms to advertise open positions and find suitable candidates.

After analysing the managers' responses regarding their opinions of traditional recruitment processes, it was determined that they are labour-intensive because they require a lot of manpower and paperwork, which lengthens the recruitment process. In addition, because of the resources involved, the recruitment process cost is also high, and—above all—there is a risk of making mistakes because of how complicated the process is. This opens the door for the use of AI in the hiring process. We also conclude that AI reduces or eliminates manual or repetitive tasks associated with the recruitment process. Because automation is present and strategically replaces the workforce requirement from specific recruitment processes, biases are unlikely to occur.

References

- Blake, R. R, 1995, Memories of HRD. Training and Development, 22-28.
- Buzko, I., Dyachenko, Y., Petrova, M., Nenkov, N., Tuleninova, D. and Koeva, K, 2016, Artificial Intelligence technologies in human resource development. Computer Modelling & New Technologies, 26-29
- Jain, S, 2016, Big data analysis: Changing the way. International Journal of Research in Advanced Engineering and Technology, 2(6), 34-36.
- Jarrahi, M.H., 2018. Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making. Business Horizons, 61(4), 577-586.
- Lawler, J.J. and Elliot, R, 1996, Artificial intelligence in HRM: An experimental study of an expert system, Journal of Management, 22(1), 85-111.
- Marciano, V.M., 2017, The Origins and Development of Human Resource Management. Journal of Management Studies, 223-227
- Panayotopoulou, L., Vakola, M. and Galanaki, E, 2007, E-HR adoption and the role of HRM: evidence from Greece. Personnel Review, 36(2), 277–294.
- Stone, D. and Dulebohn, J., (2013, Emerging issues in theory and research on electronic human resource management (eHRM). Human Resource Management Review. 1–5.
- Tewari, I. and Review, M. P, 2020, Artificial Intelligence Reshaping Human Resource. International Conference on Advent Trends in Multidisciplinary Research and Innovation (ICATMRI), 1-4.
- Xiong, Y., Xia, S. and Wang, X, 2020, Artificial intelligence and business applications, an introduction. Int. J. Technology Management, 84 - 92.
- Zehir, C., Karaboğa, T. and Başar, D, 2020, The Transformation of Human Resource Management and Its Impact on Overall Business Performance: Big Data Analytics and AI Technologies in Strategic HRM. In U. Hacıoglu, Digital Business Strategies in Blockchain Ecosystems (pp. 265- 279).

**A STUDY ON OPPORTUNITIES AND CHALLENGES TO THE CORPORATE SECTORS
IN INDIA FOR THE IMPLEMENTATION OF IFRS (IND-AS)**

Dr. Rajath B.S. Assistant Professor

School of Commerce and Management Studies
Dayananda Sagar University, Bangalore rajathbelur@gmail.com

Dr. Devarajappa S. Assistant Professor & Coordinator M.Com. (IS)

Department of Studies and Research in Commerce Tumkur University, Tumakuru
devutta@gmail.com

Abstract

International Financial Reporting Standards (IFRS) is a common accounting language developed by the International Accounting Standards Board (IASB) to provide a common language for business transactions and financial reporting. The use of IFRS is aimed at improving the comparability, transparency, and understandability of financial information across the world (IASB, 2021). The goal of IFRS is to create accountability for all stakeholders of a company and serve society with reliable financial statements (Deloitte, 2021). The IFRS standards help in providing a level playing field for companies operating in different countries and enable easy comparison of financial information (Financial Times, 2021). The adoption of IFRS by organizations worldwide has been instrumental in improving the quality and consistency of financial reporting (KPMG, 2021).

The main objective of this study is to analyze the opportunities and challenges posed by the implementation of Ind-AS in India. The study aims to provide a comprehensive understanding of the impact of Ind-AS on the Indian corporate sector by exploring the various opportunities and challenges associated with its implementation. The study has provided some valuable insights into the preparedness of companies to comply with Ind-AS and the support provided by the regulatory authorities.

The researcher has used the quota sampling method by collecting response from junior level, middle level, and senior level management of selected companies. A sample size of 141 companies was chosen for the existing study.

The opinion on opportunities to corporate sectors in implementing IFRS and challenges faced by corporate sectors in implementing IFRS is analyzed using a frequency table. One sample t-test is applied to find whether companies have more opportunities and face challenges after implementing IFRS.

Keywords *Opportunities, Challenges, Corporate sectors, India, IFRS*

INTRODUCTION

The Indian corporate sector is undergoing a significant transformation with the implementation of the Indian Accounting Standards (Ind-AS) based on International Financial Reporting Standards (IFRS). The Ministry of Corporate Affairs (MCA) (2016) has made Ind-AS mandatory for specified companies from

1st April 2016. The implementation of Ind-AS is expected to improve the quality and comparability of financial reporting and increase the competitiveness of Indian companies in the global market (Adhikari and Bhat 2018). However, the transition to Ind-AS has also brought about various opportunities and challenges for the corporate sector in India (Farooqui and Farooqui 2017). Jain and Jain (2017) conduct a study of the preparedness of companies to implement Ind-AS. Banerjee (2019) provides an overview of the implementation and challenges of Ind-AS for Indian companies.

The study has done on a review of the existing literature on the implementation of Ind-AS and its impact on the Indian corporate sector. The study has employed qualitative research methods, such as interviews with experts in the field and surveys of companies, to gather information about the experiences of companies in implementing Ind-AS. The findings of this study have provided valuable insights for companies and stakeholders in the Indian corporate sector, as well as for regulatory authorities, in planning and executing the implementation of Ind-AS.

The implementation of Ind-AS is expected to bring about several opportunities for the Indian corporate sector, such as improved transparency and comparability of financial reporting, increased investor confidence, and enhanced access to global capital markets. The adoption of Ind-AS is also expected to lead to an improvement in the quality of financial information and reduce the possibility of financial misrepresentation.

However, the implementation of Ind-AS also poses several challenges for the Indian corporate sector, such as the costs associated with the transition, the complexity of the new standards, and the need for companies to develop new systems and processes to comply with Ind-AS. Companies may also face difficulties in adjusting to the changes brought about by Ind-AS, such as the need to restate previous financial statements, and the difficulty of providing reliable and accurate financial information in a timely manner.

REVIEW OF LITERATURE

According to **Naderian (2012)**, the progress of IFRS convergence as new accounting standards in India has been a step-by-step process, with contributions and efforts from multiple institutions in India. The benefits of adopting IFRS, as noted by the Institute of Chartered Accountants of India (ICAI), include cost savings, improved efficiency, and increased opportunities for Indian professionals abroad. The convergence process to IFRS in India involves various impacting areas such as accounting and reporting, IT systems and processes, business and finance, and people and communication. However, the full implementation of IFRS in India is taking time. The Ministry of Corporate Affairs (MCA) has announced the convergence of accounting standards to IFRS in three phases.

Venkateswar et al. (2012) outline the roadmap to IFRS convergence in India, which has been achieved in three phases. The authors highlight that the convergence process is facing challenges, such as resolution of taxation issues, and clear guidance from government agencies and administrators is needed for a smooth implementation by Indian companies. Strong leadership and clear goals are also necessary for the convergence to be successful.

Dsouza et al. (2014) point out that the convergence with IFRS in India has both benefits and challenges, as reviewed through national and international research papers. Companies are attracting global capital markets and a uniform financial system is necessary for their listing on various stock exchanges around the world. The authors highlight that timely adoption of IFRS requires coordination from various regulatory authorities and frameworks, such as SEBI, ICAI, Companies Act, IRDAI, and RBI.

Bhattacharya (2016) emphasizes the importance of adopting IFRS as a global financial accounting and reporting system, which is being enforced by regulators such as the International Accounting Standard Board (IASB). The author notes that a homogenous global reporting system will attract foreign funds to capital markets.

Sharma (2016) argues that the internationalization of the capital markets, due to the increase in the breadth and depth of international business, has led to a focus on foreign investment. The author studies the differences between local GAAP in India, US, and UK and IFRS, and concludes that it is the duty of international accounting bodies, such as IASB and FASB, to establish a universal and acceptable global accounting conceptual framework.

Sudalimuthu et al. (2011) conducted an empirical study to analyze auditor perceptions towards IFRS implementation and the challenges faced by organizations during implementation. The study, conducted in the district of Coimbatore, India, identifies education and training, high cost, expert personnel, and project planning as the issues faced by Indian companies during the implementation of IFRS. The authors conclude that the adoption of IFRS will benefit the corporate world, but there will be challenges in the convergence process, and all concerned parties should be ready to share responsibility.

According to **Goswami et al. (2011)**, the adoption of International Financial Reporting Standards (IFRS) in India was motivated by the global acceptance of IFRS by over 100 countries and the announcement by India's Institute of Chartered Accountants of India (ICAI) that IFRS would be mandatory for financial statements of listed companies starting April 1st, 2011. The authors concluded that the switch from traditional accounting procedures to IFRS brings several benefits, including standardization of auditing firms and employee training.

Bhattacharyya (2012) discussed the advantages and challenges of IFRS adoption in India, stating that guidance could be sought from countries with similar economic, political, and social conditions that have already adopted IFRS.

Yadav et al. (2012) found that the conversion from Indian GAAP to IFRS has both benefits and challenges. They strongly recommended convergence with IFRS and provided suggestions, such as providing training to stakeholders and incorporating IFRS in higher education, to overcome the challenges.

Sarkar (2012) conducted a study on corporate reporting in the context of IFRS convergence and found that it is an important aspect of corporate entities to provide clear financial information to stakeholders and prevent corporate failures. Adoption of IFRS convergence leads to more reliable and transparent financial reporting and helps restore trust and confidence among stakeholders.

Marulkar (2013) stated that the adoption of AS-IFRS has increased significantly due to globalization and provided a roadmap for IFRS adoption in India, highlighting the challenges that may arise. The author emphasized the importance of IFRS convergence and the role of training institutes and academicians in achieving successful implementation of IFRS.

Srivastava (2013) discussed the origin and worldwide acceptance of IFRS, including in India where it has been required for financial statements since April 1st, 2012. The author reviewed the benefits of IFRS implementation for the economy, investors, and industry, and concluded that the Indian government has established a roadmap for IFRS adoption based on a company's net worth to promote financial exchange and foreign investment.

Sambaru et al. (2014) examined the significance of IFRS in the Indian business environment and compared IFRS and GAAP principles. The authors found that Indian accountants and businessmen see the need for IFRS convergence due to globalization and the listing of Indian companies on global stock exchanges. They noted the advantages and disadvantages of the IFRS transition, including increased financial reporting quality and comparability, and lower cost of capital, but also recognized challenges such as the need for legislative and regulatory changes and a lack of IFRS expertise.

Vinayagamoorthy (2014) noted that India, as one of the largest countries in the world, is undergoing IFRS convergence and that public interest firms, such as listed corporations and financial institutions, were required to adopt IFRS starting April 1st, 2011, according to ICAI. The researcher highlighted the route map established by the Ministry of Corporate Affairs for a smooth migration to IFRS.

Nagalakshmi (2014) discusses the widespread recognition of the IFRS adopted by the IASB as a standard for financial reporting and its increasing popularity. The author explores the benefits and challenges of implementing IFRS in India and the requirements for successful implementation. The author presents the conceptual framework of IFRS and the plans for its integration and adoption in India, highlighting the need for IFRS to take into consideration the GAAP of different nations in its review for the benefit of users. The author suggests that IFRS should be included in undergraduate and postgraduate courses and that the issue of tax liabilities should be resolved as a result of convergence. The author concludes that convergence with IFRS is strongly advised in light of the global economy and India's position.

Palak (2015) investigates the benefits of IFRS convergence and advocates for increased foreign direct investment (FDI) in the economy. The paper finds that the adoption of IFRS boosts investors' confidence and attracts cross-border financial transactions, which will attract FDI to Indian companies and help in the development of the Indian economy.

Huddar (2016) adds that adopting IFRS will bring Indian firms in line with global corporations and increase the country's marketability for foreign investment. The author highlights eight challenges in the adoption of IFRS and concludes that the implementation of IFRS will greatly affect the future and that both the firm management and corporate governance must be accountable for the implementation of strategies.

Abhinaya et al. (2016) argue that the adoption of IFRS in India will ensure justice to investors and create opportunities for employment generation in the country as India could become a leader in accounting back office through business process outsourcing (BPO). The authors discuss the benefits and challenges of the move to IFRS, the Indian approach to IFRS, and the decision to converge. Over 100 countries have already implemented IFRS and reaped its benefits, and the ICAI and MCA have approved the timeline for India's transition to IFRS by 2011. The authors acknowledge that the adoption of IFRS by Indian corporations will be difficult at first, but ultimately profitable in the long run.

Sharma (2016) provides an Indian perspective of IFRS by evaluating events in India through ICAI and MCA announcements. The author aims to understand the definition of IFRS, the evolution of IFRS, the nations that comply with IFRS, and the applicability of Indian Accounting Standards from 2016-17 onwards. The author concludes that Indian Accounting Standards are seen as a superior means of implementing IFRS in India.

Bapna (2017) states that the implementation of IFRS will improve the quality of accounting and profitability in the world's financial markets. The author acknowledges that implementing IFRS in India will be challenging, but highlights the need for sufficient education and information for Indian accounting professionals to supervise transformation initiatives for Indian corporations. The author concludes that the adoption of IFRS will benefit international investors by improving the relevance, openness, accuracy, and comparability of financial reporting.

Sruthiya et al. (2017) aim to investigate implementation issues in India and offer solutions. The authors identify several significant implementation issues, including cost, investor pessimism towards IFRS, and a lack of consistency in accounting guidelines in India. The authors propose providing adequate IFRS training and instruction for accounting professionals and workers and altering the taxation structure to align with IFRS. The research is based on secondary data, a literature analysis, and personal interviews with experts.

According to **Keerthana et al. (2018)**, the authors aimed to understand the perspective of a selected group of respondents towards the advantages and disadvantages of IFRS adoption in India. They found that the acceptance of IFRS will be successful, but there will be inherent challenges. The authors concluded that not only the adoption of IFRS is important but also educating related parties and having an efficient administrative system.

Shana Shimin (2018) states that IFRS is necessary in India for FDI, economic development, and the globalization of business firms. The author explored the current form of IFRS convergence in India, and analyzed the advantages and drawbacks of IFRS integration and its impact on Indian corporates. The author found that most countries are following IFRS as a standard reporting system, but only a few have fully accepted it. The author recommends convergence with IFRS.

Jayachitra S. (2018) attempted to bring out the future of IFRS in India. The study stated that IFRS is already in use in many areas of the world, including India. IFRS convergence has grown in relevance

globally as investor's desire comparable accounting rules, and corporations seek worldwide finance. The absence of agreement in GAAP methods resulted in comparable financial reports from different companies, leading to the standardization of accounting practices and the acceptance of IFRS as a global accounting language.

According to **Gupta A.K. et al. (2019)**, the observation of Indian Accounting Standards compared to IFRS by Indian enterprises found that the Ministry of Corporate Affairs has announced compulsory notifications for Ind-AS, effective for the accounting period ending March 31, 2016, for specified entities. This implementation will benefit Indian companies globally, leading to easier and cheaper flow of funds.

RESEARCH QUESTION

What are the opportunities and challenges to the Indian corporate sectors for the implementation of IFRS?

OBJECTIVE OF THE STUDY

The present study entitled — A study on opportunities and challenges to the corporate sectors in India for the implementation of IFRS (Ind-AS) with the following objective:

- To study the opportunities and challenges to the corporate sectors for the implementation of IFRS.

SCOPE OF THE STUDY

The proposed research work on — A study on opportunities and challenges to the corporate sectors in India for the implementation of IFRS (Ind-AS) is intended to be carried out on selected Bombay Stock Exchange (BSE) listed companies in Karnataka. The purpose of this research is to examine the impact of IFRS on companies. This study intends to study of opportunities and challenges to the corporate sectors for the implementation of IFRS.

The scope of this research is restricted to selected Bombay Stock Exchange (BSE) listed companies in Karnataka. The BSE-listed companies have to publish their annual reports in the Indian Accounting Standards (Ind-AS) as per the notification of the Ministry of Corporate Affairs (MCA) dated 16 February 2015. This research has significantly contributed to the prospective users of the impact of IFRS on the opportunities and challenges to Indian corporates.

HYPOTHESIS OF THE STUDY

In the background of the objective of the study and based on the preliminary survey of Literature, the following hypothesis has been formulated:

H₀: There is no significant difference in opportunities and challenges faced by selected companies in Implementing IFRS

H₁: There is a significant difference in opportunities and challenges faced by selected companies in Implementing IFRS

RESEARCH DESIGN

The present study is primarily an empirical analysis looking at the opportunities and challenges faced by selected companies in implementing IFRS based on the primary data. The researcher has adopted a descriptive research design for the study. Descriptive research is done through a sample of respondents, who must be representatives of the selected companies. A descriptive research design has been adopted to conduct the study on the opportunities and challenges to the corporate sectors for the implementation of IFRS. The descriptive research is most suitable in the present context as the data required for the study and analysis is sorted out from primary data sources. The study used quota sampling method. The methodological issues of this study are presented below under the following head:

SAMPLING DESIGN

For the current study, the researcher selected through the empirical research consists of only BSE-listed companies in Karnataka based on the Bombay Stock Exchange (BSE) website www.bseindia.com as the base for selecting the sample size. There are 4467 BSE listed companies in India, out of which 141 listed companies in Karnataka as on 31-03-2019. All 141 listed companies in various sectors as per the classification of NIC has been used to study the opportunities and challenges to the corporate sectors for the implementation of IFRS, and the same are presented below.

Table – I: Classification of BSE Listed Companies as on 31-3-2019 as per National Industrial Classification (NIC) 2008

SL NO.	SEC	GROUP	INDIA	KARNATAKA
1	A	Agriculture, Forestry and Fishing	64	3
2	B	Mining and Quarrying	13	1
3	C	Manufacturing	2144	86
4	D	Electricity, Gas, Steam and Air-condition Supply	118	0
5	E	Water Supply; Sewerage, Waste Management and Remediation Activities	23	0
6	F	Construction	270	10
7	G	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	279	2
8	H	Transport and Storage	27	1
9	I	Accommodation and Food Service Activities	52	4
10	J	Information and Communication	228	19
11	K	Financial and Insurance Activities	661	10
12	L	Real Estate Activities	62	0
13	M	Professional, Scientific and Technical Activities	7	2
14	N	Administrative and Support Service Activities	7	0
15	O	Public Administration and Defence; Compulsory Social Security	42	0
16	P	Education	140	0

17	Q	Human Health and Social Work Activities	63	2
18	R	Arts, Entertainment and Recreation	9	1
19	S	Other Service Activities	59	0
20	T	Activities of Households as Employers; Undifferentiated Goods and Services-Producing Activities of Households for Own Use	106	0
21	U	Activities of Extraterritorial Organisations and Bodies	93	0
		Total	4467	141

Source: Authors calculation using secondary data

Out of 141 companies, 124 companies have responded to the primary survey, and 17 companies have not responded to the primary survey. Hence researcher considered 124 companies as primary respondents to analyze the opportunities and challenges to the corporate sectors for the implementation of IFRS.

DATA COLLECTION

The study is consisting of the primary data. To study the opportunities and challenges to corporate sectors for the implementation of IFRS, from each of the selected BSE listed companies in Karnataka, top-level and middle-level employees' opinions is considered from the offices located across Karnataka. For this purpose, a structured questionnaire is used.

DATA ANALYSIS

The researcher evaluated the data collected using the structured questionnaire and secondary data so as to achieve the objective of this study. The analysis has been carried out and presented under this objective. For the purpose of statistical analysis of the profile of companies that have implemented IFRS, descriptive statistics is used. The opinion on opportunities to corporate sectors in implementing IFRS and challenges faced by corporate sectors in implementing IFRS is analyzed using a frequency table. One sample t-test is applied to find whether companies have more opportunities and face challenges after implementing IFRS.

The present study has examined non-financial aspects of selected companies in Karnataka. For the purpose of examining non-financial parameters, the qualitative data of 124 companies have been used; the profile of the 124 selected companies is presented below.

PROFILE OF THE SELECTED COMPANIES

Origin of Company

It is observed that out of 124 respondents, 101 (81.5%) are Indian companies, whereas 23 (18.5%) are Foreign companies. Therefore, the majority, 81.5%, of the respondents' companies are of Indian origin.

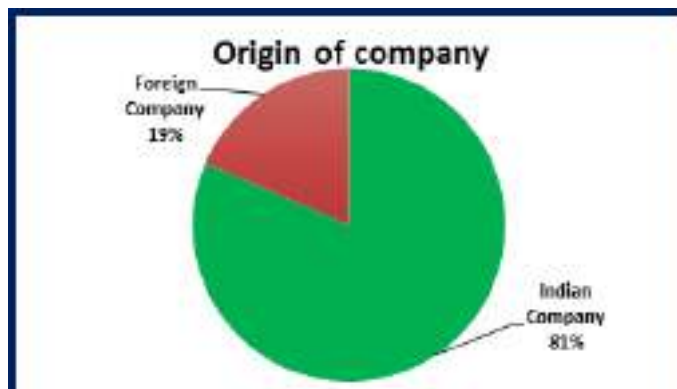
Table - II: Origin of Company

Origin of company	Number of Respondents	Percentage	Cumulative Percentage
Indian Company	101	81.5	81.5
Foreign Company	23	18.5	100.0

Total	124	100.0	

Source: Primary Data

Figure - I: Origin of Company



Types of Company

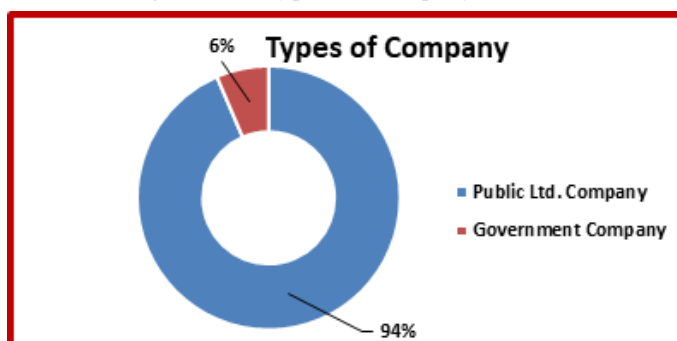
From the analysis made, it is found that out of 124 responses collected, 116 (93.5%) of the respondents are from public limited companies, whereas 8 (6.5%) of them are from government companies. Therefore, the majority, 93.5% of the respondents, have a public limited company.

Table: III: Types of Company

Types of Company	No of Respondents	Percentage	Cumulative Percentage
Public Ltd. Company	116	93.5	93.5
Government Company	8	6.5	100.0
Total	124	100.0	

Source: Primary Data

Figure - II: Types of Company



CAPITAL INVESTED

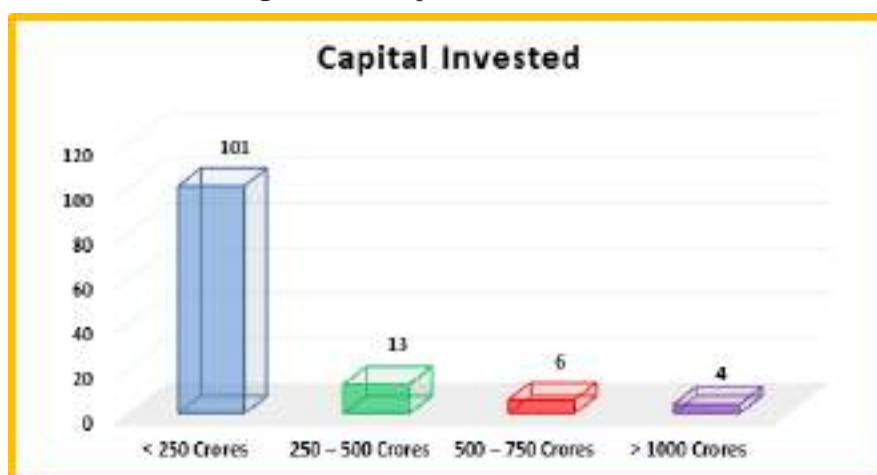
It is found that out of 124 responses collected, 101 (81.5%) of them have invested less than 250 crores, 13 (10.5%) of them have invested 250-500 crores, 6 (4.8%) of them have invested 500-750 crores, and 4 (3.2%) of them have invested more than 1000 crores. Therefore, the majority, 81.5%, of the respondents have invested less than 250 crores.

Table - IV: Capital Invested

Capital Invested	No of Respondents	Percentage	Cumulative Percentage
< 250 Crores	101	81.5	81.5
250 – 500 Crores	13	10.5	91.9
500 – 750 Crores	6	4.8	96.8
> 1000 Crores	4	3.2	100.0
Total	124	100.0	

Source: Primary Data

Figure - III: Capital Invested



NUMBER OF EMPLOYEES

From the analysis made, it is found that out of 124 responses collected, 65 (52.4%) of them have employed less than 1000 employees, 28 (22.6%) of them have employed more than 4000 employees, 18 (14.5%) of them have employed 1000-2000 employees, 9 (7.3%) of them have employed 2000-3000 employees, and 4 (3.2%) of them have employed 3000-4000 employees. Therefore, the majority, 52.4% of them, have employed less than 1000 employees.

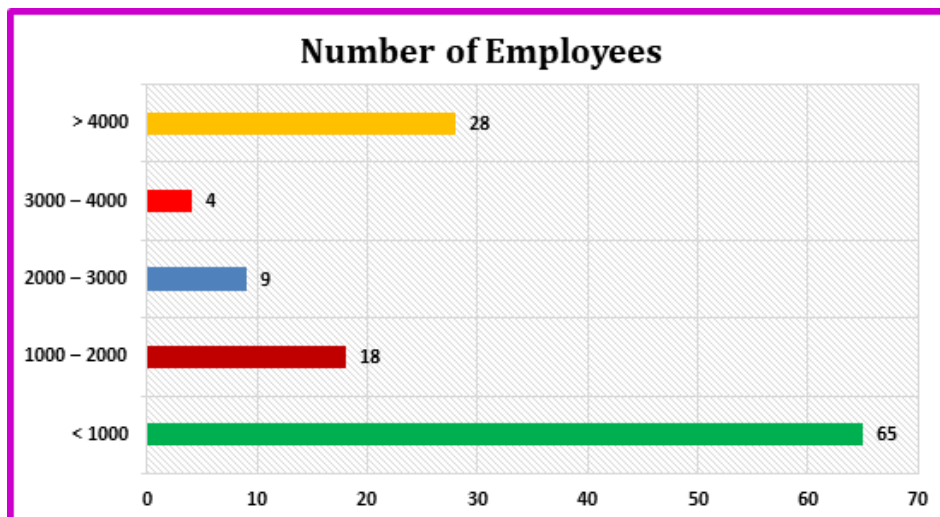
Table - V: Number of Employees

Number of Employees	No of Respondents	Percentage	Cumulative Percentage
< 1000	65	52.4	52.4

1000 – 2000	18	14.5	66.9
2000 – 3000	9	7.3	74.2
3000 – 4000	4	3.2	77.4
> 4000	28	22.6	100.0
Total	124	100.0	

Source: Primary Data

Figure - IV: Number of Employees



Turnover OR Annual Sales

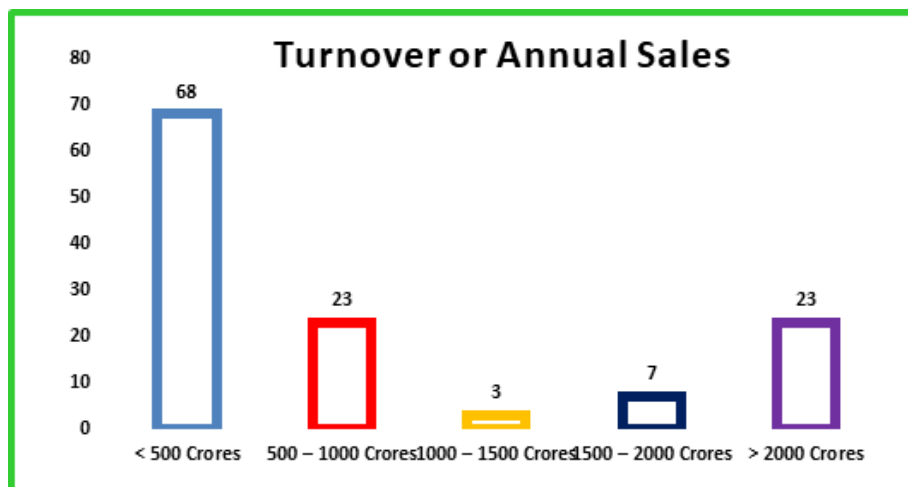
It is identified that out of 124 responses collected, 68 (54.8%) of them have sales of less than 500 crores, 23 (18.5%) each have sales of 500-1000 crores and more than 2000 crores, 7 (5.6%) have sales 1500-2000 crores, and 3 (2.4%) have sales 1000-1500 crores. Therefore majority, 54.8%, have sales of less than 500 crores.

Table - VI: Annual Sales Turnover

Turnover or Annual Sales	No of Respondents	Percentage	Cumulative Percentage
< 500 Crores	68	54.8	54.8
500 – 1000 Crores	23	18.5	73.4
1000 – 1500 Crores	3	2.4	75.8
1500 – 2000 Crores	7	5.6	81.5
> 2000 Crores	23	18.5	100.0
Total	124	100.0	

Source: Primary Data

Figure - V: Annual Sales Turnover



EMPLOYEE EXPERIENCE

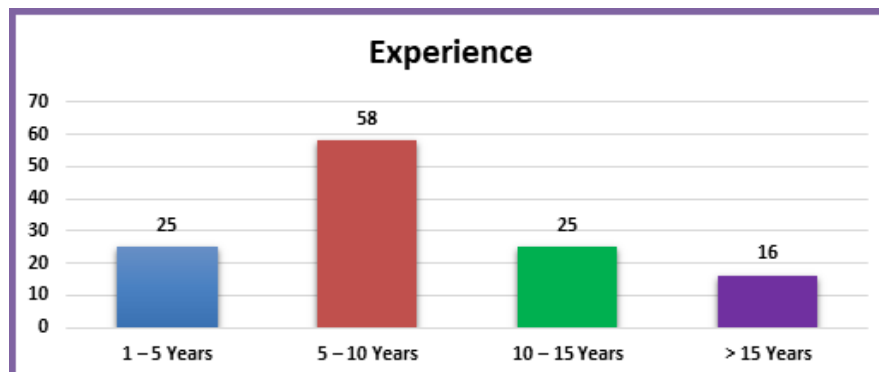
It is found that out of 124 responses collected, 58 (46.8%) have 5-10 years of experience, 25 (20.2%) each have 1-5 years and 10-15 years of experience, and 16 (12.9%) have more than 15 years of experience. Therefore, the majority, 46.8%, of the respondents have 5-10 years of experience.

Table - VII: Employee Experience

Experience	No of Respondents	Percentage	Cumulative Percentage
1 – 5 Years	25	20.2	20.2
5 – 10 Years	58	46.8	66.9
10 – 15 Years	25	20.2	87.1
> 15 Years	16	12.9	100.0
Total	124	100.0	

Source: Primary Data

Figure - VI: Employee Experience



Nature of Business

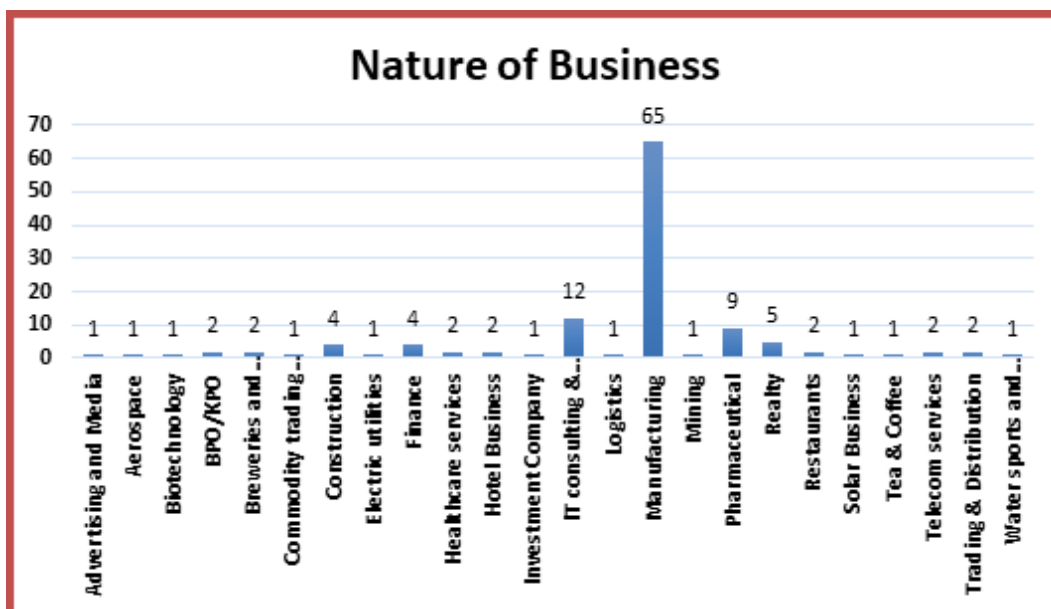
It is identified that out of 124 responses collected, 65 (52.4%) of them are different kinds of Manufacturers, 12 (9.7%) of them are IT consultants and software providers, 9 (7.3%) are running Pharmaceutical businesses, 5 (4%) are Realty business (Real Estate), 4 (3.2%) each is running construction and finance, 2 (1.6%) are in BPO/KPO, Breweries and distilleries, Healthcare services, Hotel Business, Restaurants, Telecom Services, and Trading and Distribution and 1 (0.8%) each are in Advertising and Media, Aerospace, Biotechnology, Commodity Trading distribution, Electric utilities, Investment company, logistics, Mining, Solar Business, Tea and Coffee and Water, Sports and Leisure Facilities. Therefore, the majority, 52.4% of them, are Different kinds of Manufacturers.

Table - VIII: Nature of Business

Nature of Business	No of Respondents	Percentage	Cumulative Percentage
Advertising and Media	1	.8	.8
Aerospace	1	.8	1.6
Biotechnology	1	.8	2.4
BPO/KPO	2	1.6	4.0
Breweries and distilleries	2	1.6	5.6
Commodity trading distribution	1	.8	6.5
Construction	4	3.2	9.7
Electric utilities	1	.8	10.5
Finance	4	3.2	13.7
Healthcare services	2	1.6	15.3
Hotel Business	2	1.6	16.9
Investment Company	1	.8	17.7
IT consulting & software	12	9.7	27.4
Logistics	1	.8	28.2
Manufacturing	65	52.4	80.6
Mining	1	.8	81.5
Pharmaceutical	9	7.3	88.7
Realty	5	4.0	92.7
Restaurants	2	1.6	94.4
Solar Business	1	.8	95.2
Tea & Coffee	1	.8	96.0
Telecom services	2	1.6	97.6
Trading & Distribution	2	1.6	99.2
Water sports and leisure facilities	1	.8	100.0
Total	124	100.0	

Source: Primary Data

Figure - VII: Nature of Business



IMPLEMENTATION OF IFRS

From the analysis made, it is found that out of 124 responses collected, 124 (100%) of the companies agree that they have implemented IFRS, and none of them stands due. Therefore, the majority, 100% of the respondents, have implemented IFRS.

Table - IX: Implementation of IFRS

Implementation of IFRS	No of Respondents	Percentage	Cumulative Percentage
Yes	124	100.0	100.0
No	0	0	
Total	124	100	

Source: Primary Data

DATA ANALYSIS

To analyze the opportunities and challenges to the corporate sectors for the implementation of IFRS, 124 companies' employees' response has been collected through the structured questionnaire and has been analyzed below with the help of various parameters. From the response collected it was observed that 100% of the respondents' have implemented IFRS in their companies'.

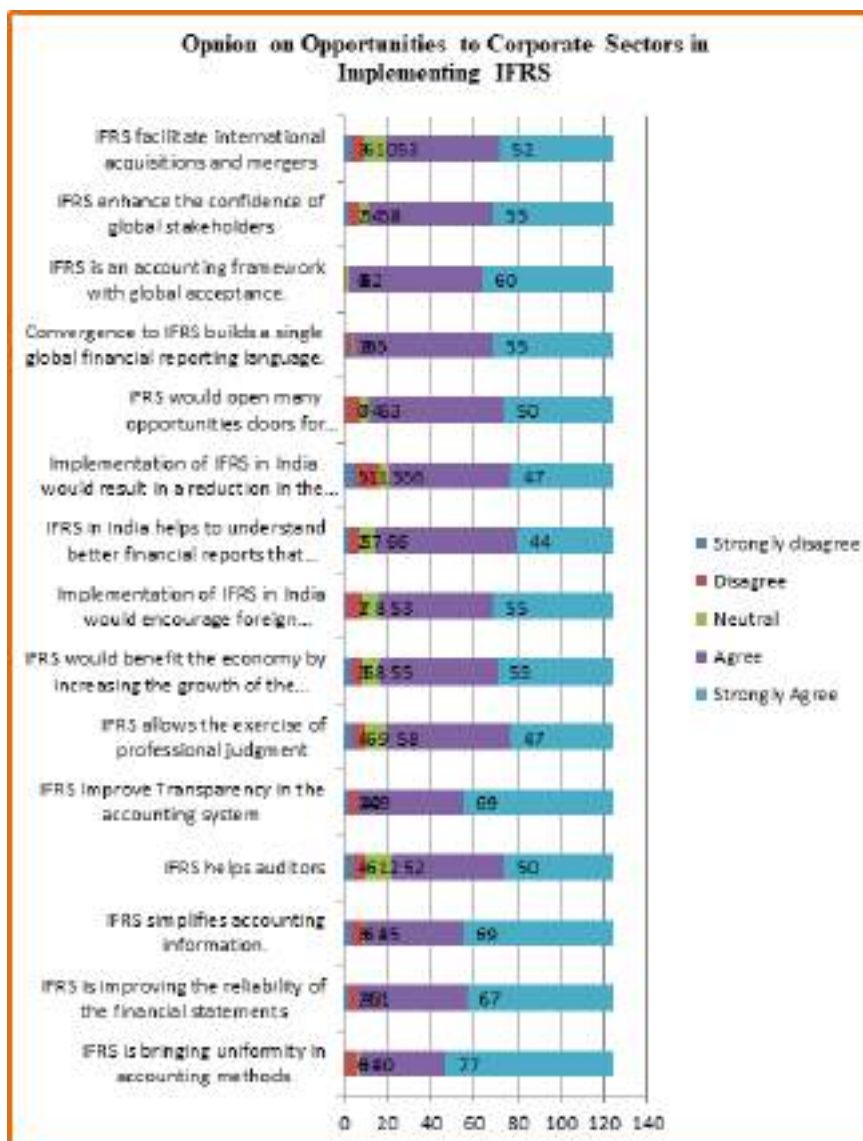
Table - X: Opportunities to Corporate Sectors in Implementing IFRS

Opportunities	SD	D	N	A	SA	Total
IFRS is bringing uniformity in accounting methods	0	6	1	40	77	124
	0.0%	4.8%	0.8%	32.3%	62.1%	100.0%

IFRS is improving the reliability of the financial statements	2	4	0	51	67	124
	1.6%	3.2%	0.0%	41.1%	54.0%	100.0%
IFRS simplifies accounting information.	3	6	1	45	69	124
	2.4%	4.8%	0.8%	36.3%	55.6%	100.0%
IFRS helps auditors	4	6	12	52	50	124
	3.2%	4.8%	9.7%	41.9%	40.3%	100.0%
IFRS Improve Transparency in the accounting system	2	4	0	49	69	124
	1.6%	3.2%	0.0%	39.5%	55.6%	100.0%
IFRS allows the exercise of professional judgment	4	6	9	58	47	124
	3.2%	4.8%	7.3%	46.8%	37.9%	100.0%
IFRS would benefit the economy by increasing the growth of the international business	3	5	8	55	53	124
	2.4%	4.0%	6.5%	44.4%	42.7%	100.0%
Implementation of IFRS in India would encourage foreign investment, which impacts foreign capital inflows into the country	1	7	8	53	55	124
	0.8%	5.6%	6.5%	42.7%	44.4%	100.0%
IFRS in India helps to understand better financial reports that would benefit investors who are willing to invest their money across the globe	2	5	7	66	44	124
	1.6%	4.0%	5.6%	53.2%	35.5%	100.0%
Implementation of IFRS in India would result in a reduction in the cost of compliance.	5	11	5	56	47	124
	4.0%	8.9%	4.0%	45.2%	37.9%	100.0%
IFRS would open many opportunities doors for professionals to serve international clients	0	7	4	63	50	124
	0.0%	5.6%	3.2%	50.8%	40.3%	100.0%
Convergence to IFRS builds a single global financial reporting language.	1	2	1	65	55	124
	0.8%	1.6%	0.8%	52.4%	44.4%	100.0%
IFRS is an accounting framework with global acceptance.	0	1	1	62	60	124
	0.0%	0.8%	0.8%	50.0%	48.4%	100.0%
IFRS enhance the confidence of global stakeholders	2	5	4	58	55	124
	1.6%	4.0%	3.2%	46.8%	44.4%	100.0%
IFRS facilitate international acquisitions and mergers	3	6	10	53	52	124
	2.4%	4.8%	8.1%	42.7%	41.9%	100.0%
Total	32	81	71	826	850	1860
	1.7%	4.4%	3.8%	44.4%	45.7%	100.0%

Source: Primary Data, Note: SD=strongly disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree)

Figure - VIII: Opportunities to Corporate Sectors in Implementing IFRS



The respondents have indicated positive sentiment and also as the opportunity for implementing IFRS in the corporate sector. From the total of 124 responses collected, 62.1% and 55.6% of the total respondents strongly agreed that IFRS is bringing uniformity and transparency in accounting methods. This opinion from the respondents indicates that IFRS is more convenient than older accounting standards. Nearly 55% of the respondents indicated that IFRS is improving the reliability of financial statements and simplifies accounting information. The respondents indicated that complex accounting rules are simplified and reliable in the IFRS accounting system. 42% agree that IFRS helps auditors and 46.8% agree that IFRS allows the exercise of professional judgment. 45% of the respondents agree that the implementation of IFRS in India would encourage foreign investment and benefit the economy by increasing the growth of international business. This result also proves that the respondents were in the notion that a global standard accounting information helps to increased foreign capital inflows into the country. 53.2% agree that IFRS in India helps to understand better financial reports that would benefit investors who are willing to invest

their money across the globe. 45.2% agree that the implementation of IFRS in India would result in a reduction in the cost of compliance and 50.8% agree that IFRS would open many opportunities and doors for professionals to serve international clients. The findings suggest that the similar accounting standards equivalent to international standards is likely to provide opportunity for Indian professionals. 52.4% agree that convergence to IFRS builds a single global financial reporting language. 50% agree that IFRS is an accounting framework with global acceptance. 46.8% agree that IFRS enhances the confidence of global stakeholders. 42.7% agree that IFRS facilitates international acquisitions and mergers. The respondents strongly associated their importance towards the IFRS accounting standards and believed that global accounting standard would facilitate in the cross boarder acquisitions and mergers transactions.

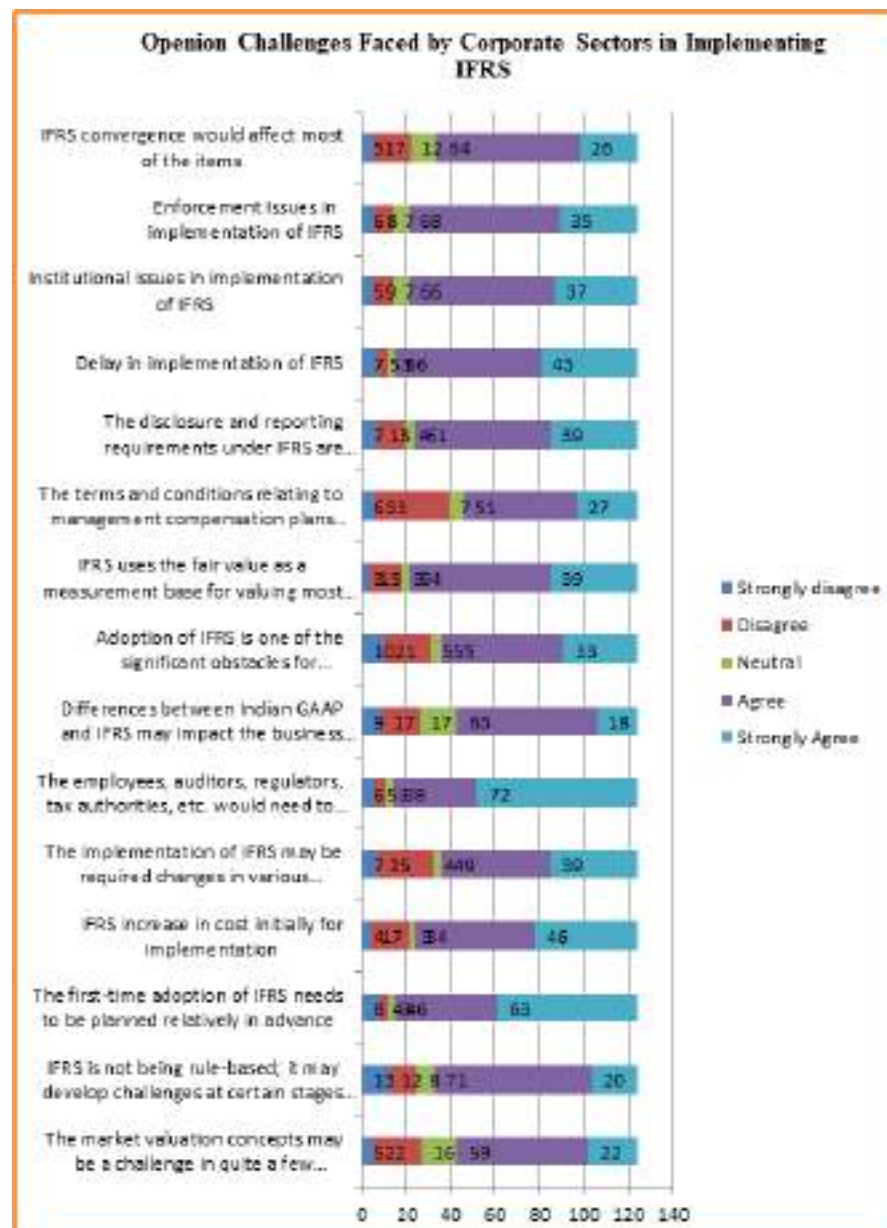
Table - XI: Challenges Faced by Corporate Sectors in Implementing IFRS

Challenges Faced	SD	D	N	A	SA	Total
The market valuation concepts may be a challenge in quite a few situations	5	22	16	59	22	124
	4.0%	17.7%	12.9%	47.6%	17.7%	100.0%
IFRS is not being rule-based; it may develop challenges at certain stages of implementation	13	12	8	71	20	124
	10.5%	9.7%	6.5%	57.3%	16.1%	100.0%
The first-time adoption of IFRS needs to be planned relatively in advance	8	4	3	46	63	124
	6.5%	3.2%	2.4%	37.1%	50.8%	100.0%
IFRS increase in cost initially for implementation	4	17	3	54	46	124
	3.2%	13.7%	2.4%	43.5%	37.1%	100.0%
The implementation of IFRS may be required changes in various regulations or laws.	7	25	4	49	39	124
	5.6%	20.2%	3.2%	39.5%	31.5%	100.0%
The employees, auditors, regulators, tax authorities would need to be aware of Seal and signature IFRS.	6	5	3	38	72	124
	4.8%	4.0%	2.4%	30.6%	58.1%	100.0%
Differences between Indian GAAP and IFRS may impact the business decision	9	17	17	63	18	124
	7.3%	13.7%	13.7%	50.8%	14.5%	100.0%
Adoption of IFRS is one of the significant obstacles for professionals because there is a lack of training facilities and academic programs on IFRS in India	10	21	5	55	33	124
	8.1%	16.9%	4.0%	44.4%	26.6%	100.0%
IFRS uses the fair value as a measurement base for valuing most of the items of financial statements	3	15	3	64	39	124
	2.4%	12.1%	2.4%	51.6%	31.5%	100.0%
The terms and conditions relating to management compensation plans would also have to be changed	6	33	7	51	27	124
	4.8%	26.6%	5.6%	41.1%	21.8%	100.0%
The disclosure and reporting requirements under IFRS are entirely different from the Indian reporting requirements	7	13	4	61	39	124
	5.6%	10.5%	3.2%	49.2%	31.5%	100.0%
Delay in implementation of IFRS	7	5	3	66	43	124
	5.6%	4.0%	2.4%	53.2%	34.7%	100.0%
Institutional Issues in implementation of IFRS	5	9	7	66	37	124
	4.0%	7.3%	5.6%	53.2%	29.8%	100.0%

Enforcement Issues in implementation of IFRS	6	8	7	68	35	124
	4.8%	6.5%	5.6%	54.8%	28.2%	100.0%
IFRS convergence would affect most of the items	5	17	12	64	26	124
	4.0%	13.7%	9.7%	51.6%	21.0%	100.0%
Total	101	223	102	875	559	1860
	5.4%	12.0%	5.5%	47.0%	30.1%	100.0%

Source: Primary Data, Note: SD=Strongly disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree)

Figure - IX: Challenges Faced by Corporate Sectors in Implementing IFRS



The respondents also highlighted few important challenges faced in the implementation of IFRS. In order to adopt global standard of accounting system (IFRS) from traditional accounting standard (GAAP) requires an immense time and knowledge. New principles and guidelines need to be analyzed to ensure the proper implementation of the IFRS accounting standard. 47.6% agree that the market valuation concepts may be a challenge in few scenarios. Market valuation is challenging concept in the new accounting standards as it follows the fair value of asset representation. 57.3% agree that IFRS is not being rule-based, where respondents emphasize that future challenges would arise at certain stages of implementation. 51% and 43.5% strongly agree that the first-time adoption of IFRS needs to be planned relatively in advance and cost would be high initially for implementation. Adoption of the new accounting standards will require proper planning and additional budgetary costs – as the new resources to be sought for the following implementation. 39.5% agree and strongly agree that the implementation of IFRS may be required changes in various regulations or laws. 58.1% strongly agree that the employees, auditors, regulators, tax authorities, etc., would need to be aware of IFRS. 51% agree that differences between Indian GAAP and IFRS may impact the business decision. The respondents identified that with change in the accounting standard the allocation of the funds or the business decision would vary in the long term. 44.4% agree that the adoption of IFRS is challenging due to lack of professional training facilities and academic programs on IFRS in India. As discussed earlier 51.6% of the respondents believe that that IFRS is challenging due to the usage of the fair value as a measurement for financial statements. 41.1% agree that the terms and conditions relating to management compensation plans would also have to be changed. 49.2% agree that the disclosure and reporting requirements under IFRS are entirely different from the Indian reporting requirements. 53.2% agree that delay in the implementation of IFRS. The implementation of the IFRS in the Indian context was found to be delayed when compared to other countries. Further, after implementation there was wide gap between implementation and mandatory filing of IFRS. 53.2% and 55% of the strongly agree that institutional issues and enforcement issues in the implementation of IFRS. 51.6% agree that IFRS convergence would affect most of the items. The respondents believe that financial statements would undergo systematic changes in the accounting head, where this would result in significant changes in the tax liability of the business entity.

The opinion on opportunities and challenges faced by corporate sectors in implementing IFRS is tested by applying a one-sample t-test. The table indicates the information about the results of descriptive statistics, whereas the Table presents the results of the one-sample t-test.

Table - XII: Group Statistics on Opportunities and Challenges to Corporate Sectors in Implementing IFRS

	N	Mean	Std. Deviation	Std. Error Mean
Opportunities	124	4.28	.539	.048
Challenges	124	3.84	.683	.061

Source: Authors own calculation

The average opinion value on **opportunities to corporate sectors in implementing IFRS** is 4.28 with a standard deviation of .539. The mean value is compared with the numerical value of 3, which is neutral; to test whether there is a significant difference in opportunities for corporate sectors in implementing IFRS.

The average opinion value on **challenges faced by corporate sectors in implementing IFRS** is 3.84, with a standard deviation of .683. The mean value is compared with the numerical value of 3, which is neutral, to test whether the corporate sector faces challenges in implementing IFRS.

TESTING OF HYPOTHESIS

H₀: There is no significant difference in various opportunities and challenges faced by selected companies in Implementing IFRS

H₁: There is a significant difference in various opportunities and challenges faced by selected companies in Implementing IFRS

This hypothesis has been tested by using One-Sample t-Test. The result of the t statistics is presented below

Table - XIII: One-Sample t-Test

	Test Value = 3				
	t	df	Sig. (2-tailed)		Mean Difference
Opportunities	26.458	123	.000		1.280
Challenges	13.753	123	.000	.843	

Source: Authors own calculation

Compared to the test value of 3, the mean value of the opinion on opportunities to corporate sectors in implementing IFRS differs and is higher than 3. The t values with 123 degrees of freedom s 26.458 and P-value less than 0.05. Therefore, it can be concluded that there is a significant difference in opportunities for corporate sectors in implementing IFRS. Compared to the test value of 3, the mean value of the opinion on challenges faced by corporate sectors in implementing IFRS differs and is higher than the t values with 123 degrees of freedom s 13.753 and P-value less than 0.05. Therefore, it can be concluded that the corporate sector faces challenges in implementing IFRS.

CONCLUSION

In conclusion, the implementation of Ind-AS in India represents a significant step forward for the Indian corporate sector, providing opportunities for improved financial reporting and increased competitiveness in the global market. However, the transition to Ind-AS also poses various challenges for companies, and the success of the implementation will depend on the ability of companies to effectively manage the transition and overcome the difficulties posed by the new standards. This study will provide valuable insights into the opportunities and challenges posed by the implementation of Ind-AS in India, and will help companies and stakeholders to effectively navigate the transition to the new accounting standards.

Companies are adopting International Financial Reporting Standards with a positive attitude and looking forward to a profitable move. The existing study “A study on opportunities and challenges to the corporate sectors in India for the implementation of IFRS (Ind-AS)” is mainly focused on the two major aspects such as — opportunities & challenges to the corporate sectors in India for the implementation of IFRS (Ind-AS). Analysis of the opportunities and challenges of selected companies there is a significant

difference in opportunities and challenges for corporate sectors in implementing IFRS. By considering the above statistics it can be concluded that the H1 is accepted.

REFERENCES

1. Abhinaya, L. P., Vidyashree, N. S., & Manu, H. (2016, March). IFRS in India-its impact on Indian corporate: benefits and challenges. In *National Seminar on "IND-AS: A Road Map for IFRS in India"* VVPGC.
2. Bhattacharyya, K. (2012). India's Adoption of International Financial Reporting Standards (IFRS): Advantages and Challenges. *Journal of Commerce and Management Thought*, 3(3), 475-479.
3. Bhattacharya, D. (2016). Adoption of IFRS in Global Scenario. *MUDRA: Journal of Finance and Accounting*, 3(1), 13-22.
4. Dsouza, J. J., & Ravinarayana, K. S. (2014). Convergence with IFRS: Benefits and Challenges. *Asian Journal of Management*, 5(3), 293-296.
5. Deloitte (2021). International Financial Reporting Standards (IFRS). Retrieved from <https://www2.deloitte.com/global/en/pages/audit/solutions/international-financial-reporting-standards.html>
6. Financial Times (2021). International Financial Reporting Standards (IFRS). Retrieved from [https://lexicon.ft.com/Term?term=International-Financial-Reporting-Standards-\(IFRS\)](https://lexicon.ft.com/Term?term=International-Financial-Reporting-Standards-(IFRS))
7. Goswami, S., & Sarkar, A. (2011). Ifrs and its adaptation in India: a study. *International Journal of Business Economics and Management Research*, 2(10), 88-99.
8. Gupta, A. K., & Pandey, A. K. (2019). Review on convergence of Indian accounting standards with IFRS by Indian companies. *ACADEMICIA: An International Multidisciplinary Research Journal*, 9(2), 38-41.
9. International Financial Reporting Standards (IFRS) Foundation (2021). International Financial Reporting Standards (IFRSs). [Online]. Available at: <https://www.ifrs.org/issued-standards/list-of-standards/> [Accessed: 2023-02-07].
10. IASB (2021). IFRS Foundation. Retrieved from <https://www.ifrs.org/about-us/what-we-do/>
11. Jayachitra, S. (2018). The future of IFRS in India. *ZENITH International Journal of Business Economics & Management Research*, 8(2), 81-99.
12. Kedar V Marulkar (2013). Globalization of Financial Reporting system through Implementing IFRS in India. *International Journal of Advance Research in Computer Science and Management Studies*. Volume 1, Issue 3, August 2013. ISSN: 2321-7782.
13. Keerthana, Ambily (2018) IFRS Adoption Opportunities and Challenges: An Indian Prospective. *International Journal of Pure And Applied Mathematics*, Volume 118 No.20 2018,4137-4148. ISSN. 1314-3395 (On-line version).
14. KPMG (2021). IFRS Standards.
15. Retrieved from <https://home.kpmg/xx/en/home/insights/2021/01/ifrs-standards.html>
16. Meenu Sambaru & Dr. N.V. Kavitha (2014). A study on IFRS in India. *International Journal of Innovative Research and Development*, ISSN 2278-0211 (online)
17. Ministry of Corporate Affairs (2016). The Companies (Indian Accounting Standards) Rules, 2015. [Online]. Available at: http://www.mca.gov.in/Ministry/pdf/Notification_IAS_22022016.pdf [Accessed: 2023-02-07].

18. Mukti Bapna (2017). A Study of IFRS and its adoption in India-Prospects and challenges. IJETSR, (IISN 2394-3386).
19. M. A. Farooqui and A. A. Farooqui (2017). "Transition to Ind-AS: Opportunities and Challenges for Indian Companies". Journal of Applied Accounting Research, vol. 16, no. 2, pp. 261-279.
20. M. K. S. Jain and S. K. Jain (2017). "Implementation of Ind-AS in India: A Study of Preparedness of Companies". International Journal of Economics, Commerce and Management, vol. 5, no. 2, pp. 1-12.
21. Naderian, A. (2012). Progress of IFRS convergence as a new accounting standard in India. Asian Journal of Development Matters, 6(1), 279-283.
22. Nagalakshmi (2014). IFRS – Implementation and challenges in India. Global Journal for research Analysis. Volume – 3, Issue – 11, Nov special issue – 2014. ISSN No. 2277 – 8160.
23. Palak, C. A. (2015). Impact of IFRS convergence in India on foreign direct investment. ACADEMICIA: An International Multidisciplinary Research Journal, 5(3), 310-315.
24. P. B. Adhikari and S. G. Bhat (2018). "Impact of Ind-AS Adoption on Financial Reporting: Evidence from Indian Listed Companies". Journal of Applied Accounting Research, vol. 17, no. 3, pp. 647-676.
25. Sudalaimuthu, S., & Jesintha, P. (2011). Auditors Perception towards International Financial Reporting Standards (IFRS): Benefits and Key challenges. Indian Journal of Accounting, 11(2), 27-35.
26. Sarkar, C. R. (2012). Corporate reporting in the context of ifrs convergence and new schedule VI compliance in India. South Asian Journal of Marketing & Management Research, 2(7), 226-235.
27. Sharma, S. (2016). A Comparative Study On Financial Reporting Practices In India, Us and Uk In Line With IFRS. International Journals Of Advanced Research, 4(8), 1532-1542.
28. Shailaja S Huddar (2016) IFRS in Indian Corporate sector – Challenges and Strategies. ISBN:978-93-5254-333-5
29. Sharma, A. (2016). Indian accounting standard-An Indian version of IFRS. International Journal of Advanced Research in Management and Social Sciences, 5(7), 32-40.
30. Sruthiya & Akhin (2017). IFRS implementation in India: Benefits and problems. IRA-International Journal of Management and Social Sciences (ISSN 2455-2267)
31. Shana Shimin (2018). A study on the Convergence of IFRS in India – Benefits and Challenges. National Journal of Multidisciplinary Research and Development. Volume 3: Issue 1: January 2018: Page No.26-28.
32. S. K. Banerjee (2019). "Ind-AS: An Overview of Implementation and Challenges for Indian Companies". Journal of Applied Financial Management, vol. 2, no. 2, pp. 33-40.
33. Venkateswar, S., & Hilborn, J. (2012). Road Map to IFRS Convergence in India–Realistic or Fantasy?. SMART Journal of Business Management Studies, 8(2), 1-10.
34. Vinay K Srivastava (2013). Adoption of International Financial Reporting Standards. Indian Journal of Accounting. Vol. XLIV (2) June 2013, ISSN-0972-1479, 88-94.
35. Vinayagamoorthy (2014). IFRS and Indian Current Scenario. International Journal of Scientific Research and Education. Volume II, Issue V, Page 753 – 760, 2014, ISSN(e): 2321-7545. <http://ijsae.in>
36. Yadav & Deependra Sharma (2012). Convergence to IFRS: What needs to be done by Indian corporate to meet the Emerging challenges? IJCEM (ISSN (online): 2230-7893)

OPPORTUNITIES AND CHALLENGES OF ISLAMIC BANKING IN INDIA – A STUDY

Dr. Rajath B. S. Assistant Professor, School of Commerce and Management Studies
Dayananda Sagar University, Bangalore

ABSTRACT

Islamic banking, the fastest growing sector in the financial field worldwide, is a new concept to the Indian economy which follows the conventional banking system. The global financial crisis made countries across the globe to review, contemplate and implement Islamic banking as an alternative to the conventional banking system. Though this system of banking, which is also called as Shariah compliant financing system, has numerous potential opportunities in India, it is yet to find its place in the Indian economy. The challenges in initiating the system of this interest free banking in India can be vanquished by essential amendments and steps. This paper attempts to explain Islamic banking and various modes of financing under it. The paper also discusses the potential opportunities and challenges of Islamic banking in India. It is hoped that the study will bring a difference in the conception of Islamic banking among the Indian population which will foster the implementation, development and growth of Islamic banking in India.

Keywords: Islamic banking, Shariah compliant financing, Riba, Haraam, Islamic finance, Conventional banking

INTRODUCTION

The finance and banking system across the globe is based on the interest system. This system works on the basic principle of money generating money. However, a banking concept that eliminates the use of interest in comparison to the conventional banking system has gained significance importance in several parts of the world. This concept of banking is known as Islamic banking or Shariah compliant financing. Shariah are the Islamic laws and rules that define certain obligations, prohibitions, recommendations and so on. The five core areas where Shariah aims at are religion, life, progeny and family, intellect and honour and wealth.

This study discusses about Islamic banking and the potential opportunities it provides to the Indian economy along with the challenges obstructing its efficient implementation. This paper aims at bringing a difference in the approach towards Islamic banking system for effective and efficient implementation, development and growth of Islamic banking in India.

HISTORY, GROWTH AND GLOBAL PRESENCE

The Islamic banking concept has been thought of as early as 1940 but it remained a notion and was not experimented as a system. The initiation of the first Islamic banking experiment, Nasir Social Bank, took place in 1963 in Egypt by Ahmad El Najjar. Thus, Egypt is regarded as the pioneer of modern Islamic banking. However, the Islamic banking practices seen across the globe today were started in 1975 when banks were established to operate under Shariah laws. In the 1980s, the Islamic financial institutions

underwent through a substantial phase of development when the high council of Organization of Islamic Conference (OIC) declared the Islamic insurance (Takaful) as Shariah compliant in 1985.

The growth of Islamic banking has been stimulated by the growing demand for Islamic banking products around the world. The past decade or so, saw an imminent change in the pace of growth of the Islamic banking industry as the demand, awareness and accessibility increased worldwide. The industry grew at an average rate of 15% during this period. Across the globe, the Middle East, South and South-East Asia is home to more than 50% of total Shariah compliant financing institutions. In GCC, Islamic financial institutions gained a growth of 6% compared to the growth of 4% for conventional banks.

At present, Islamic banking exists in more than 75 countries around the globe. Countries embracing Shariah compliant financing are adopting a dual strategy of banking where both conventional banking and Islamic banking go hand-in-hand. Internationally acclaimed banks have started offering Islamic banking products and services in European and West Asian countries and the USA. A consortium of Islamic banks was formed in the last decade which launched IIBR (Islamic Interbank Benchmark Rate), its alternative to LIBOR (London Inter-Bank Offered Rate).

The Islamic finance sector industry is estimated to be worth between 2 to 3 trillion USD. Countries like Singapore and Malaysia are remodelling their systems and structures to transform themselves into Islamic financial centres. They have planned to start Islamic Stock Index and offer Islamic insurance products. Developed countries like the USA, the UK and Germany have embraced Islamic banking as an alternative system to conventional banking. As new geographies open up for Islamic banking, it is forecasted that Islamic banking sector will flourish and the Islamic banking assets held by commercial banks will continue to grow.

In India, Islamic banking notion has been a topic of discussion for quite a long time. But as RBI forbids non-interest financing, this system of banking has not succeeded yet in India though several attempts have been made across the nation for recognition of Islamic banking. Although, in 2013, a NBFC, named Cheraman Financial Services Ltd., was incorporated in Kerala which functions in compliance with the Shariah law. At present, several Indian banks, financial institutions and other organisations are undertaking efforts to regulate the sector to implement Islamic banking as a full-fledged system.

DIFFERENCE BETWEEN ISLAMIC BANKING AND CONVENTIONAL BANKING

Conventional banking functions considering money as a commodity and thus their products are designed to sell customers money in different forms like loans, credit cards, financing, etc. Whereas, in Islamic banking money is considered as a medium of exchange and before making profit, the money earned should be converted to some sort of useful asset, which can be sold for profit later, in order to make it a legitimate business transaction in accordance with the Shariah law. This type of activity in Islamic banking brings labour and other resources into the picture and thus benefits are passed on to the society. Thus, Islamic banks deal in goods and documents and not in money whereas conventional banks deal in money and documents.

REVIEW OF LITERATURE

Review of literature aids in a lucid comprehension on the areas of the topic where researches have already been undertaken. It also paves way to the potential areas of the topic which are yet to be covered. With regard to this, a brief review on the works and studies published on Islamic banking globally and in India is presented below:

Siddiqui (1968), made the pioneer attempt in providing a legitimately detailed outline of Islamic banking. The model of Islamic banking he proposed was based on Mudarabah (Partnership) and Shirkah (Contracts). According to him, interest free banking could be a practicable substitute to interest-based banking and both Islamic banks and conventional banks could go hand-in-hand.

Mathews, et al. (2004), stated that Islamic banking has the potential to induce creativity and productivity in an economy as the system is based on the Islamic principles of sharing rewards and risk along with joint involvement in wealth creation for the society. Besides, profit and loss sharing contracts create value for all the parties involved in it along with promoting fairness.

Mohammad Faisal (2013), established that there is an extensive scope for Islamic banking in the Indian economy. Non-Muslims have acquired the highest impact of the knowledge dimension of Islamic banking in India and the study showed that consumers with better educational qualification had greater positive attitude towards Islamic banking in India.

Ponraj, Sriram et al. (2016), found that the wide disparity in the Indian banking system in terms of region, religion and languages can be exploited by implementing Islamic economic and banking principles. They stated that implementation of Islamic banking in India would be a positive mark on the banking landscape of the nation.

Edward and Almir (2017), stated that the Islamic finance sector is worth between two to three trillion US dollars. They reported that the ethical investment opportunities are attracting Muslims and non-Muslims alike. Muslims across the globe are also becoming more and more aware of the importance of following the Shariah laws and want to invest money in an Islamic way.

Narinder and Anupama (2017), stated that Islamic banking can grow easily in the Indian market upon networking of principles and boosting of innovative financial services entrepreneurs in the economy.

Ram, Mohammed et al. (2018), reported that the global Islamic banking assets attained a CAGR (Compounded Annual Growth Rate) of around 17 percent from 2009-13 according to the World Islamic Banking Competitiveness Report 2014-15. They also reported that Islamic banking will not flourish in India as long as there are no amendments in the banking and tax laws as it would be difficult for Islamic banks to meet the statutory liquidity requirements.

Gulzhan Musarva (2018), said Islamic banking have made a rapid growth in the past decade. But is yet to improve on the establishment of a common regulatory, tax, legislative and legal foundation. Integration of all Islamic financial markets and cost efficiency on implementation of the system is also an area of concern.

Mahammad and Jeevan (2019), stated Islamic banking is the fastest growing field in the finance industry and is one of the potential segments of international banking. They found that Islamic banking will be key for India in becoming a major economic giant in the world as it has the potential to increase financial inclusion. They also reported that adopting Islamic banking as a system would strengthen the market efficiency, competition and innovation.

Gincy Charles (2021), found that Islamic financial institutions have gained a rapid growth of 6 percent in the Middle East financial and banking sector compared to that of 4 percent for conventional banks. She also suggested that Islamic finance has a driving space in the Indian economy and it is necessary to create awareness about the concept of Islamic banking through informative seminars and workshops.

BASIC PRINCIPLES OF ISLAMIC BANKING

The following are the basic principles of Islamic banking laid down by the Shariah law:

- Interest (Riba) receipt and payment is strictly prohibited.
- Business is based on sharing of profits and losses.
- Business activities, investments and transactions should be Shariah compliant (Halal).
- Investments and engagements in industries and forbidden activities (Haraam) such as adult entertainment, alcohol and gambling are prohibited.
- Banks are not allowed to lend or lease any product that they own partially.
- Financial inclusion is an ultimate aim of Islamic banking and interest free loans are encouraged to achieve it.
- Debt trading is not allowed hence Islamic financial institutions have Islamic bonds (Sukuk) as their version of debt instruments.
- Modes of Islamic finance

i) Mudarabah: it is one of the most imminent Islamic modes of finance. It is a form of financing where an entrepreneur and investor join hands. It is usually a type of arrangement between two parties where, one party invests the capital and the other provide time, expertise and skills to manage the partnership between them. In Islamic banking, the depositor is known as Rub Al Mal (Investor) and the bank as Mudarib (Entrepreneur). So, the deposits received from the investors are used by the banks to make profits, which later would be shared with the depositors.

ii) Murabahah: it is a type of contract of sale between the banks and clients in Islamic banking. The term refers to a sale transaction in which the transaction is done at cost plus markup price. The banks buy asset on behalf of the clients for a price plus profit for the bank agreed between the parties. The client can repay the amount in installments. It is the most common financial operation of Islamic banks and their prime way of earning profits.

iii) Musharakah: it is a common Islamic banking product which is a form of joint venture. It is also known as participatory mode of finance or profit and loss sharing arrangement. The basic idea is to join the resources of the parties to generate profit. The profits earned from the business are shared based on pre-agreed ratios and losses are shared based on the contribution to the venture. The management of the joint venture can be executed by one or all parties.

iv) Takaful: it is the insurance product in Islamic banking. It is regarded as the Islamic insurance. It functions on the principle of cooperation and separation between shareholders' operations and the funds. The ownership and operations of the takaful fund are passed to the policyholders and they act as joint investors with the takaful operator. The policyholders do not premium unlike other insurances but contribute a pool of funds from which the claims are settled. The takaful operator, usually the bank or institution, receives a fee for operating the takaful fund and covering the costs incurred.

v) Ijarah: it is a lease agreement between the bank and the client in Islamic banking. In this type of arrangement, the bank would buy an asset on behalf of the client and allow the client to use the asset for a specified period of time and fee. The ownership remains with the bank. There are two types of common Ijarah products in Islamic banks, namely, AITAB (Al-Ijarah Thumma Al-Bay) and IMB (Ijarah Muntahiya Bil-Tamleek). In AITAB, the asset is sold to the client at the end of the lease period.

vi) Qard Hasan: it is a type of loan granted by Islamic banks based on goodwill of the client. But unlike the common loans, there is no interest or premium charged. The borrower has to repay only the borrowed amount. These loans do not consider the time value of money and are in compliance with the Shariah principle of prohibition of interest.

vii) Sukuk: it is the equivalent of conventional bond in Islamic banking. Conventionally, bonds bear interest but, since interest is not permissible, Sukuk provides the investor with the share of the underlying asset, the cash flows and the risk.

viii) Wadiah: the term Wadiah refers to the acceptance of money for safe keeping. The bank acts as the keeper and trustee of the funds and it shall be repaid on demand of the client. The banker may reward the customer with an appreciation (Hibah) for keeping the funds with the bank. This is similar to that of a savings account in conventional banks but without interest.

ix) Salam: it is the Islamic bank equivalent of a forward sale contract in which the payment for a particular good or asset is made in advance and the underlying asset is delivered at a specified date in the future. In Islamic banking, this is usually used in agriculture financing as the banks provide required materials and in return shall receive a part of the agricultural proceeds rather than interest.

x) Waqf: Waqf refers to the voluntary dedication of one's property or wealth for religious purposes. These properties cannot be sold, inherited or donated and should be used for Shariah compliant projects only.

SWOT ANALYSIS OF ISLAMIC BANKING

Strengths

- It is consistent with the Shariah law
- Ethical banking is the USP of Islamic banking
- Financial inclusion is a prime objective of Islamic banking
- Unlike conventional banks there is no debt-based financing

Weaknesses

- Lack of awareness of the concept among investors, institutions, governments and countries
- Lack of Shariah experts for timely advices and overlooking
- Absence of regulations in the industry

Opportunities

- Large population of Muslims around the world seeking for Shariah compliant banking
- Inclusive growth for the individuals in the economy
- Investors looking for ethical investments
- Increasing cash surplus in the GCC

Threats

- Political disruptions and turmoil
- Fierce competition from conventional banking

- Implementation of uniform civil codes will affect the system's adherence to Shariah laws and regulations
- Misconception as conduits for terrorism

RESEARCH DESIGN

OBJECTIVES OF THE STUDY

- To understand the basic concept and principles of Islamic banking and its relevance in the Indian economy.
- To identify the potential opportunities of Islamic banking in India.
- To analyse the challenges of Islamic banking in India and provide suggestions.
- To explore various financial products and modes of financing in Islamic banking.

SCOPE OF THE STUDY

The study is undertaken to analyse the opportunities and potential Islamic banking have in the Indian economy and to identify the challenges to be faced upon implementation of this concept as a system alternative to the existing conventional banking. Furthermore, various Islamic banking products are also examined to comprehend them better and understand their relevance.

RESEARCH METHODOLOGY

This study is principally based upon secondary data. The secondary data used in this study was collected from numerous sources of publications such as journals, research articles, internet, unpublished thesis and magazines.

LIMITATIONS OF THE STUDY

- The study is based on secondary data.
- The topic of study is not widely popular and familiar among the Indian population.
- The data cannot be generalized and is limited.
- Inadequate availability of data regarding the topic.

ISLAMIC BANKING IN INDIA

An overview

In India, the Reserve Bank of India (RBI) is the apex institution in the banking industry. The banks are regulated by the Banking Regulation Act of 1949. This act classifies financial institutions into i) Banks and ii) NBFIs (Non-Banking Financial Intermediaries). Other acts like the Reserve Bank of India Act 1934, Co-operative Societies Act 1961 and Negotiable Instruments Act 1881 further classifies the banks into nationalised, private, foreign and cooperative banks. All these banks function on the interest system of banking, i.e., conventional banking, and the laws favour to this system of banking with interest.

However, these prudent banking laws allow the functioning of Islamic banking, i.e., interest free banking, under the control and direct supervision of the Reserve Bank of India via Non-Banking Financial Intermediaries/Companies. Even before prominent Shariah compliant financial institutions were established across the world, the development of Islamic financial institutions had started in India. But due to the stringent and rigid banking laws in the country, these institutions were not able to grow above a par limit and those which had better growth lacked sustainability and eventually had to cease operations.

Although in 2009, the Kerala State Industrial Development Corporation (KSIDC) initiated the establishment of an Islamic bank, named Al-Baraka Financial Services, which aimed at functioning in compliance with the Shariah laws. But this government undertaking's inception was obstructed as it failed to get clearance from the Reserve Bank of India along with court rulings of a public interest litigation. However, the then Prime Minister Manmohan Singh asked the Reserve Bank of India to look into the prospects of having a banking system without interest, which boosted the undertaking's establishment. In 2013, a NBFC named Cheraman Financial Services Ltd. (previously Al-Baraka Financial Services) was established with KSIDC as its major stakeholder.

Fast forward to today, there are several financial and non-financial institutions and advisory organisations that function in compliance with the Shariah law and promote the concept of Islamic banking in India. Discussions and researches are being published on how Islamic banking can be established as a system. Furthermore, international banks are interested and are working to provide Islamic financial products and services to the Indian consumers.

OPPORTUNITIES OF ISLAMIC BANKING IN INDIA

India is the third largest Muslim populated country in the world behind Indonesia and Pakistan. In India, the Muslim community is the largest minority. The inception of Islamic banking in India thus will benefit the Muslim community to a large extent. The Shariah compliant financing could also be an alternative to the conventional banking system existing in the country and will provide the Indians with a wider range of choices in financial products. The various opportunities and advantages Islamic banking have in India are briefly given below:

i) Financial Inclusion

The Indian government's main focus has been on financial inclusion of everyone in the economy. The various governments have formulated and implemented numerous programs, plans and initiatives to achieve the financial inclusion goal. The conventional banking system is interest-based and for Muslims, as per the Shariah law, interest (Riba) is forbidden which resulted in certain Muslims remaining excluded from conventional banking system who will have idle wealth. Implementation of Islamic banking could bring the excluded people and their wealth into the economy facilitating the betterment of the Muslim community and aiding in the achievement of financial inclusion for all.

ii) Lack of Shariah compliant system

A significant part of the Muslim population in the country has made sedulous efforts in making the existing conventional banking system Shariah compliant. Refraining from investing in debt involved mutual funds, using zero interest accounts instead of savings accounts, donating the interest earned to

charity, etc. are some of those efforts. This is a huge opportunity with great potential for Islamic banking as they could provide a Shariah compliant system which would eliminate the efforts taken diligently by the Muslim community and enable ease of banking for them.

iii) Ethical investments avenue

The Shariah law prohibits investments in Haraam (forbidden) activities like gambling, pornography, weapon, alcohol, etc. Thus, Islamic banking is often regarded as an ethical investment avenue which promotes investments in real economic activities that will have an impact on the social well-being and economy as a whole.

iv) Inclusive growth

The objective of inclusive growth can be stimulated by initiating Islamic banking as providing credit would become easier and cheaper. Besides, Shariah compliant financing can also provide finance with little or no collateral helping in including the economically backward people into the economy and aiding their growth.

v) Significant flow of funds

The commencement of Islamic banking system will create investment avenues for the Muslim community and others alike. It will particularly aid in mobilizing the wealth from Muslims, who have little to no participation in the conventional banking system existing in the nation, which in turn will become the Islamic banking assets.

vi) Investments from foreign nations

The initiation of Islamic banking will channelize investments from across the globe, particularly from the Middle East and other Muslim dominated countries. At present, India is losing to the UK, the USA, Europe and other nations who are mobilizing investments from the GCC to their economies. Islamic banking will stimulate the investments of funds from the Islamic countries.

vii) Wider financial choices

Islamic banking will provide a wide range of financial products in the Indian market apart from the existing products offered by the conventional banking system. The Shariah compliant financing modes will also foster innovation, competition and efficiency in the Indian banking industry.

viii) Economic stability and GDP

Islamic banking would help in bringing stability in the Indian economy as the market has a growing GDP. With the necessary regulatory amendments and Indian population's awareness and acceptance of the Shariah compliant financing system, it could flourish in the Indian economy.

ix) Niche market opportunity

The Indian consumers' demand for niche products are always on the rise. Islamic banking products are bespoke to meet the Indian Muslim community's requirements who refrain from participating in the conventional banking system. Thus, the Indian Islamic banking could exploit the opportunity of a niche market.

CHALLENGES FOR ISLAMIC BANKING IN INDIA

Islamic banking is growing at a rapid rate across the world. Even though it will have to face certain challenges upon its initiation in India. This sector particularly will have to face fierce competition and issues as the conventional banking is focused on interest-based system. Inception of Islamic banking in India will be mainly challenged by the demand and supply conditions, legal and regulatory conditions and political and societal conditions. Certain challenges and hindrances the Shariah compliant financial institutions will have to face while imparting their services in India are briefly given below:

i) Amendments in the regulations and laws

India's banking industry is governed by strict banking and tax laws that provide regulations on functioning of the banks, monitor operations and determine the tax rates applicable. In order to implement Islamic banking in India, amendments would be required in the banking laws of the country as the Shariah compliant financing system prohibits interest-based banking. Many consider Islamic banking as infeasible in India due to this reason. However, the National Commission on Islamic Banking (NCIB) claimed in their report that amendments would only be required in tax laws to initiate Islamic banking in India. Nevertheless, amendments are necessary for the effortless inception of the Shariah compliant financing system in the nation.

ii) Political and social turmoil

A major challenge which has been hindering the inception of Islamic banking in India is the political and social scenario of the country. Implementation of Islamic banking can be exploited and manipulated as a political weapon since it can easily be pictured as a Muslim community pacifying project. Thus, any step taken regarding the initiation of Islamic banking in India will have nationwide political and social impact even though the Muslim community is the largest minority in the nation.

iii) Return is not pre-determined

In conventional banking system, the return on the deposits, usually in the form of interest, of the clients is pre-determined, i.e., the rate of return is fixed by the banks prior to the receipt of the deposit. Under the Shariah compliant financing system, the return will be determined only after the deposit is received. This will hinder in people approaching this banking system and will be a difficult obstacle for Islamic banking.

iv) Complying with SLR and other requirements

The Reserve Bank of India has certain requirements, like the statutory liquidity ratio (SLR) and cash reserve ratio (CRR), under which the banks are required to maintain predetermined and regularised rates of ratio for their functioning. The RBI mandates to hold these requirements in the form of cash, gold and government securities. Holding cash does not offer any return, gold prices keep fluctuating and hence is risky and government securities are interest bearing. Thus, all of these are not acceptable under the Shariah law which makes it difficult for the banks to meet with these requirements.

v) Misconception of Islamic banking

A major obstacle for the Shariah compliant financing system in prospering among the Indian consumers will be to overcome the misconception and fallacies regarding Islamic banking is only for the Muslim community. Verily, Islamic banking is meant for all people regardless of their religion, it should only be considered as an alternative system to the conventional banking system existing in the

nation. Though it is certain that the Muslims keeping out from the conventional system will particularly benefit from the implementation, Islamic banking is open for all and awareness must be raised regarding the same.

vi) Difficulty in interaction with the money market and banks

A complicated challenge Islamic banking will have to face while imparting its services in India is to interact and deal with the capital and money markets and the existing banks. The banks in India functions on the interest-based system of banking, i.e., conventional banking system. Furthermore, the capital and money markets in India are also primarily interest based. Islamic banks and the system will have to thrive under these circumstances not just for interactions but also to face fierce competitions.

vii) Channel for terrorism funding and activities

The initiation of Islamic banking may raise concerns regarding it is a conduit for terrorist groups to mobilize their funds to the Indian mainland to carry out their activities. Committees, discussions, debates, meetings, etc. are being carried out worldwide with respect to this in spite of Islamic banking growing at a rapid rate across the world.

viii) Lack of experts

Another impediment to the implementation of Islamic banking in India is the lack of experts in the nation to develop a proper regulatory framework.

RECOMMENDATIONS

Islamic banking is being implemented as an alternative to the conventional banking system across the globe and hence is growing at a rapid phase. The Shariah compliant financing system has numerous opportunities and challenges as well in India. The potential opportunities should be exploited and the challenges can be addressed with certain steps and amendments in the regulations. Based on the study, the following are the recommendations that can be suggested for an affluent initiation of Islamic banking in the nation:

- A major challenge impeding Islamic banking to be implemented in India is the current rigid and strict banking and tax laws and regulations. Necessary amendments should be brought in the existing laws for the successful initiation of Islamic banking in India.
- The government should take necessary steps, plans, programs, etc. to implement Islamic banking as an alternative system to the existing banking system by removing the hindrances. The Shariah compliant financing system can reduce the economic and social issues prevailing in India, with respect to wealth in particular.
- In order to make Islamic banking a full-fledged banking system in India, it is necessary to create awareness about the concept of Shariah compliant financing to the Indian population. Informative seminars, discussions, workshops and other initiatives should be conducted by government, financial institutions and other related organisations.
- Islamic banking presents itself as an alternative avenue for a large section of the Indian population currently remaining excluded from the conventional banking system. The goal of financial inclusion and inclusive growth could easily be achieved by the implementation of Islamic banking.

- In order to attract customers from the existing conventional banking system and maintain them, Islamic banks will have to provide better customer services and financial products than the conventional banks.

CONCLUSION

Indian economy is the fastest growing major economy in the world and the sixth largest economy in terms of GDP. The financial and banking system plays a vital role in the economic stability, development and growth of a nation. Indian conventional banking system has a lot of challenges and hassles involved in it. An overview of the Muslim community in the nation unveils that a mass of the Muslim population is financially excluded which has made them socially and economically backward. The initiation of Islamic banking in India will help in achieving the prime objective of the Indian economy, financial inclusion.

Inferring the study, it is evident that Islamic banking has diverse potential opportunities in the Indian economy. Its initiation will benefit the Muslim and non-Muslim communities alike as it will attract investments from foreign institutions and nations. The ethical and social viability with respect to the investments allowed in the Shariah compliant financing system make it similar to the socially responsible investments (SRIs) that are being widely emphasised worldwide. The concept of Islamic banking thus will have a strong impact in the Indian economic system's functioning and development.

The opening of doors for Islamic banking by removing the hindrances and challenges will improve the Indian economic structure. The SWOT analysis performed on Islamic banking in India visibly reveals that the strengths and opportunities supersede the weaknesses and threats. All these evidently point out that the hindrance on Islamic banking's implementation is more political than economic. In order to make the Shariah compliant financing system an alternative to the conventional banking system, which would strengthen the resiliency and soundness of the Indian economy, political and economic reforms are necessary beginning from the grassroot level.

India, being the third largest Muslim populated nation in the world, yet have not embraced Islamic banking as a system in the economy. As long as India stays reluctant in this regard, its long-term objective of financial inclusion and vision of becoming an economic giant will become uncertain, dubious and in vain. Further studies and researches should be conducted on the topic for Islamic banking to be established as a full-fledged banking system in India.

REFERENCES

- [1] Alizz Islamic Bank. Overview of Islamic Banking. ALIZZISLAMIC <https://alizzislamic.com/Knowledge-Centre/Overview#>
- [2] Bhasin, N. K. & Anupama (2017). Issues and Challenges in Implementation of Islamic Banking in India. AIMS International ISBN: 978-1-943295-08-1.
- [3] Charles, G. (2021). A Study on the Challenges and Opportunity of Islamic Finance in India. International Journal of Advance and Innovative Research, 6(1), 134-137
- [4] Faisal, M. (2013). Islamic Banking in India: Challenges and Opportunities.

- [5] Fraser, E. & Colan, A. (2017). Global Islamic Finance and Banking Course. Edgy Global, Australian Centre for Islamic Finance.
- [6] Hasan, D. Z. (2011, March 8). “BLOG OF KNOWLEDGE (Shari’ah, Law, Islamic Finance and Muslim News)”:
Islamic banking taking roots in India: Kerala launches interest free bank. ZULKIFLIHASAN
- [7] Mohammad, N. S. (1968). Islam ka Nazariyah e Milkiyat (Urdu). Lahore: Islamic Publications. 1, 173-175
- [8] Matthews, R., Tlemsani, I., Siddiqui, A., Shanmugam, B., Perumal, V., & Ridzwa, A. H. (2004). Islamic banking and the mortgage market in the UK. Islamic Banking: An International Perspective, Universiti Putra Malaysia Press, Serdang.
- [9] Pasha, S. (2011, November 22). UPDATE 1-Group launches first Islamic interbank benchmark. REUTERS
- [10] Ponraj, P., Sriram, S. & Sweety, A. D. (2016). A Study on Islamic Banking System With Reference to Seyad Shariat Finance Limited, Tirunelveli. PARIPEX – Indian Journal of Research (PIJAR), 5(1).
- [11] Singh, R., Khan, M. A. & Khan, M. J. A. (2018). Islamic Banking in India: Challenges And Remedies. Asian Journal of Management Applications and Research, 8(1).
- [12] Shahid, M., & Raj, J. (2019). Islamic banking in India: An overview. ZENITH International Journal of Multidisciplinary Research, 9(6), 246-252.

Sustainable Business Practices for Profitability: A Review

Article Details

Pub. Date	: Dec' 2023
Product Name	: The IJP Journal of Business Strategy
Product Type	: Article
Product Code	: IJBS041223
Author Name	: Suneeta Hegde and Poojithra Salanka
Availability	: YES
Subject/Domain	: Strategic Journals
Download Format	: PDF Format

Price

For delivery in electronic format: Rs. 50; For delivery through courier (within India): Rs. 50 + Rs. 25 for Shipping & Handling Charges

Download

To download this Article click on the button below:

[BUY THIS ARTICLE](#)

Abstract

Sustainability is a phenomenon of three major components-people, planet, and profit-which are in direct relationship with social, environmental, and economic factors. The natural urge of humans to give back to society pays off rich dividends to the organizations. The increased awareness of sustainability and global concerns around environmental, social, and governance (ESG) issues among institutional investors and employees in general has brought a greater focus on sustainable production. This, combined with statutory compulsion, has created avenues for research in this area. The study examines the nexus between statutory requirement and short-term profits in business. The purpose of the paper is not just to support the argument of sustainability with profit, but also explore the motivation derived



Investigating the Reasons for Customer Choices on Sustainable Clothing

Suneeta Hegde

Assistant Professor, Dayananda Sagar University, Bangalore

Email address: Suneethahegde-scms@dsu.edu.in

Abstract—This research paper accentuates the fact that human beings as a species, are naturally inclined to give back to society. According to Becker (1993), Individuals are not solely motivated by materialism or economic gains. Apart from investing in assets and education, individuals also invest in social capital for non-financial gains. In this context this study aims to identify different factors that influence customer choice of green clothing consumption. This study is an effort to validate the influence of functional, epistemic, and social circumstances. According to Becker, Individuals are often influenced by personal and social experiences (Becker 1996; Becker & Murphy, 2000). These principles are the foundation for examining the motivations of customers on sustainable clothing decisions. Research so far is mostly focused on the production mechanism, with little research on consumer's preferences. Relevant literature data indicates much of clothing consumption depends on public perceptions of sustainable clothing. There is little work on sampling and on actual consumers behavior habits on sustainable clothing. Therefore, this study focuses on exploring the values and motivations supporting a sustainable clothing consumption. The outcome of this study can positively impact production house strategy and marketing strategy in sustainable clothing space.

Keywords— Consumers of sustainable clothing, Environmental

important to understand customer motivation to buy these products to come up with clear strategies on selling, otherwise these inventories will add extra flabs to environmental pollution. Mindless production should be channelized to planned production by understanding customer motivation. The limited research investigates the motivations driving consumers to sustainable clothing. (Pederson & Gwozdz 2014), has researched investigating consumer responses to sustainable clothing. Research in the broader context of ethical consumption suggests personal values play a pivotal role in ethical decision-making (Connolly & Prothero 2008). However, their study gives ample of opportunity to substantiate it with quantitative evidences. The commercial value can be categorized under two attributes. One is quality value and second is product value. Where quality value is the price for the product quality and the material, whereas the product value is the value arrived by market comparisons. The customer choice is based on either of the two characteristics. The research tries to assess the facts with a survey-based approach for testing numerous quantitative aspects. The

Welcome Guest

[Register](#) | [Forgot Password?](#)

Measuring Implications of Statutory Compliance Like GST on Sustainability - A Case Study on Automobile Industry

[Journal of Entrepreneurship & Management](#)

Volume 13 Issue 1

Published: 2024

Author(s) Name: Suneeta Hegde, Deepthi Hegde, Pavithra Salanke | **Author(s) Affiliation:** Dayananda Sagar University, Bengaluru, Karnataka, India.



Locked



Subscribed



Available for All

Abstract

The pioneering step of implementation of GST in India, has brought initial producer's and service provider's and retailers in one tax regime reducing the burden of all other taxes, including the burden of CENVAT and service tax. GST is a Major step designed to streamline the taxation of goods and services. The changes in the tax structure led to the changes in the prices of goods. These changes were significant in few cases and they impacted the consumer behaviour largely. The objective of this paper is to study the consumer behaviour by analysing the impact of GST/Tax policies on automobile industry. The focus of the study is LMV (cars). The purchase pattern of cars is studied before and after the implementation of GST. The hypothesis-based research method is used and tested. The secondary data for the analysis of the production and sales is obtained from Web-based information, literature so far published in the journals is used to analyse the gap. The analysis is carried out using correlations methods such as t-test and paired t-test. This research should add significant value in understanding the implications of GST on purchase behaviour, the paper further tests possibilities of reduction of carbon footprints as an implication of policy change. The reduced number of vehicles will reduce the carbon footprint whereas the increased number of vehicles will increase the carbon footprint. Shift to electric vehicles and achieving green mobility is at the top of the agenda for developed nations. Countries like USA and China are incentivising green mobility through policy changes. India also supports green mobility by no tax and 5% GST. However, the green mobility policies should be enacted in sync with state and centre government. The results should help to understand LMV (Car) sector sales before and after GST and its implications.

Keywords: Goods and Services Tax, Case Study, Carbon Footprint, Policies, Light Motor Vehicle



[View PDF](#)



Morphological and Textural Data Fusion for Breast Cancer Classification Based on Inter and Intra group Variances

Gurudas VR¹ Shaila SG^{1*} Vadivel A²

¹Dayananda Sagar University, Bangalore, Karnataka, India

²GITAM School of Technology, GITAM University, Bangalore, Karnataka, India

* Corresponding author's Email: shaila-cse@dsu.edu.in

Abstract: Nowadays, the most predominant cancer disease is Breast Cancer that has a higher death rate and women gender is the most affected by this disease. But detecting Breast Cancer in early stage is challenging as the malignance growth at this stage occurs in the duct that are undetected as symptoms are less. This paper addresses the challenge of early detection of Breast Cancer cells by proposing the fusion scheme of morphological and texture features of the cells for analysis. Morphological features such as the shape and marginal characteristics of the mass are considered as per the Breast Imaging Reporting and Data System (BI-RADS) standard. Texture features of the mass were also extracted to understand the characteristics of pixel variation in the masses. These features are combined and its dimension is normalized using Exhaustive Feature Selection (EFS). The accuracy of the proposed feature on the INbreast dataset is 94.75% on an average. The accuracy for the Curated Breast Imaging Subset of Digital Database for Screening Mammography (CBIS-DDSM) Calc RoI dataset is 95% and for CBIS-DDSM Mass RoI dataset it is 94.5%. The result is further compared with contemporary methods and found that the fused feature is performing well.

Keywords: Breast cancer, Benign, Malignant, Mass, Shape, Texture, Fusion, CBIS-DDSM, INbreast.

1. Introduction

Breast Cancer is considered as the world's most predominant cancer disease with a higher death rate and it is known that women are the most affected gender by this disease. The Breast Cancer spreads all over the body and 1 among 8 women may be affected during their lifetime. World Health Organization (WHO) reports 2.3 million women were diagnosed in 2022 and there may be 6,85,000 deaths globally by the end of 2023 [1] (<https://www.who.int/news-room/fact-sheets/detail/breast-cancer>). Further, 7.8 million women have been diagnosed with Breast Cancer. In general, the malignance growth at the early stage occurs in the duct or lobule which are undetected as symptoms are less and has a low chance of spreading. Thus, early detection as well as treatment is challenging.

The most common and well-known screening techniques are Breast Self-Examination (BSE),

Clinical Breast Examination (CBE) and Digital Mammography (DM) [2]. Digital Mammography is widely used as the primary screening tool for detecting Breast Cancer as it is least expensive and very sensitive to small lesions. In recent times, Computer-Aided Diagnosis (CAD) systems are used commonly to guide radiologists for Breast Cancer diagnosis. Earlier, CAD systems have relied on handmade visual information which had challenges in predicting Breast Cancer in those images. Recent growths of CAD systems have used the Artificial Intelligence techniques that automatically identifies breast tumors using Ultrasound images [3]. Computerized techniques involve various stages such as ultrasound images pre-processing followed by segmentation, feature extraction and classification.

This paper addresses the challenge of early detection of Breast Cancer cells by proposing the fusion scheme of the low-level features for analysis of cancer area. The proposed framework use Mammogram images for detecting and analyzing

breast cancer. The proposed framework uses morphological and texture features of the masses for analysis. The masses are segmented and localized using well-known scheme. Morphological features such as the shape and marginal characteristics of the mass are considered. However, these characteristics alone may not be sufficient to improve the classification accuracy. Thus, texture features of the mass were also extracted to analyse the pixel variation characteristics in the masses. Non-parametric test is performed on the pixel distribution and texture features are extracted through Goodness of Fit Distribution (GFD), Independence of Attributes (IoA) and Homogeneity (HG). These features are combined and its dimension is normalized using Exhaustive Feature Selection (EFS). The dimensionality reduction is done based on its contribution in discriminating the mass. The machine learning techniques are used for the classification and the performance of fused feature on Curated Breast Imaging Subset of Digital Database for Screening Mammography (CBIS-DDSM) and INbreast datasets is found to be encouraging.

The rest of the paper is organized as follows. The literature is reviewed and presented in the next Section. The proposed approach is explained in Section 3, the experimental results are explained in Section 4 and the last Section concludes the paper.

2. Materials and methods

This section presents the reviews of the relevant and recent literatures on fusing various features. The authors in [4] have fused texture, morphological and histogram-based features for classifying tumors. However, the approach has taken more computational time it considered more features. The authors in [5] have extracted 41 morphological features and 96 texture features and classified the tumors using 7 classifiers. The performance resulted in poor accuracy. The authors in [6] have proposed a technique to segment breast masses based on the colour and intensity variation. The textural deviation and mathematical morphology have been obtained by extracting pixel features using colour histogram, however, the approach achieved in poor results. The authors in [7] have used segmentation methods to segment tumors in mammogram images. The segmentation methods have been grouped into classical segmentation, machine-learning based segmentation, supervised-unsupervised segmentation and deep-learning based segmentation. The classical segmentation includes edge-based, threshold-based and region-based. These segmentation schemes and the deep learning U-Net

model together have been used for training the mammogram images. The approach worked on small dataset. Authors in [8] have presented hybrid thresholding and used machine learning techniques to classify benign or cancerous cells in mammogram images. The approach has used hybrid thresholding to derive the RoI. The wavelet transform has been used to reduce the noise from each block based on Bayes Shrink soft thresholding. A Multi-Fractal Dimension (M-FD) has been applied to extract multiple features from each de-noised block. Genetic algorithm has been used to optimize the number of features. The approach took more computational time. The authors in [9] have used an Evolutionary Programming Neural Ensemble (EPNE) approach for the prediction of Breast Cancer using Fine-Needle Aspiration Biopsy (FNAB) samples. The predictive model considers various features of the FNAB samples, such as the size and shape of the cells to classify them into different categories of Breast Cancer.

The authors in [10] have proposed the DE-Ada* model for classifying the Breast Cancer. The authors have extracted a set of features to characterize mammograms and fused the features based on a weight mechanism. The approach resulted in poor precision and recall. The authors in [11] have presented a CAD method for detecting Breast Cancer. The authors used Hilbert Transform (HT) on rough data for reconstructing brightness-mode images. Marker-controlled watershed transformation is used for segmenting the tumor. Later, shape features and texture features have been extracted and classified using KNN and Ensemble Decision Tree model classifiers. The approach produced more false positive results. Authors in [12] have introduced radiomics-based machine learning classification algorithms. The experimental process has been conducted on the Breast Ultra-Sound Images (BUSI) Dataset. The authors in [13] have developed a computerized method that uses a combination thresholding approach to identify and extract the Breast Tumor Section (BTS) from 2D MRI slices. Based on Shannon's Entropy, Watershed Segmentation, and the Slime Mould Algorithm, a tri-level thresholding has been developed. The authors in [14] used the Extreme Learning Machine (ELM) to diagnose Breast Cancer. Irrelevant features have been removed using the gain ratio feature selection method. Using the Wisconsin Diagnostic Breast Cancer dataset, a cloud computing-based method for remote Breast Cancer diagnoses has been presented and tested. Breast thermal imaging is used to develop automated Breast Cancer diagnosis framework by authors in [15]. Initially, images

of various breast orientations have been used. Using image processing techniques, healthy image patches have been extracted and processed. Marine Predators technique has been used to extract features and the Decision Tree (DT) was utilized for classification. A layer connectivity-based architecture has been presented by authors in [16] for the segmentation of low contrast nodules from ultrasound images. The authors have blended high-level coarse segmentation with dense connectivity. The nodule has been refined using the dilated filter, and the architecture's accuracy has been increased by using the class imbalance loss function. The approach resulted in true negative results. The authors in [17] have presented a study that aims to analyse and predict Breast Cancer using a multi-model classification approach however, resulted in low accuracy. The authors in [18] have implemented four various types of feature selection methods, namely Bayesian Model Average (BMA) [19], Fast Backward Variable Selection (FastBw) [20], elastic net [21], and clinical expertise [22]. BMA approach use Best Subset Selection and regression analysis to choose the best model. However, BMA is applicable up to 30-40 features due to the overload on computation [23]. FastBw is applicable for more than 30-40 features. The FastBw method use multiple regression approach for the model containing all features and removes one feature at a time. This iteration process continues till it satisfies threshold or stopping rule [24]. Elastic net uses the linear combination of Lasso [25] and Ridge regression [26]. The approach finds the ridge regression coefficients initially and then proceeds with a lasso type of shrinkage [27]. The approach resulted in computation complexity issue. The authors in [28] proposed Two object detection models, YOLOv5 and Mask R-CNN. YOLOv5 is used to analyse the mass characteristics to distinguish

between benign or malignant. However, YOLOV5's had limitations for certain tweaks to the original model to achieve the desired effects. Borders and size of tumors are detected using Mask RCNN to identify malignancies. The proposed model is trained on the INbreast, CBIS-DDSM. It is observed from the above comparative results that along with strong classifiers set of relevant features are very needed to achieve the better classification of breast tumors.

It is noticed that the most of the literatures above mentioned have limitation in classifying the breast tumors accurately due to True negative and False positive results. Many approaches are compatible with small size datasets. Some approaches ended up in computation complexity issues. Thus, the paper intends to overcome the challenge of early detection of Breast Cancer and it address the above issues by proposing the fusion scheme of the low-level features. The proposed framework use Mammogram images for analysing the morphological and texture features of the masses for classifying Breast tumors. The masses are segmented and localized using well-known scheme. Morphological features such as the shape and marginal characteristics of the mass are considered. However, these characteristics alone may not be sufficient to improve the classification accuracy [17]. Thus, the texture features of the mass were also extracted to analyse the pixel variation characteristics of the masses. The variance is considered as important parameters for fusing the features. The inter and intra group variances are calculated between features. While the variance is beyond certain threshold, the feature value is considered for the analysis or otherwise not. As a result, a fused feature is constructed with lower dimension for improving the quality of diagnosis. The proposed approach is explained in detail in the below section.

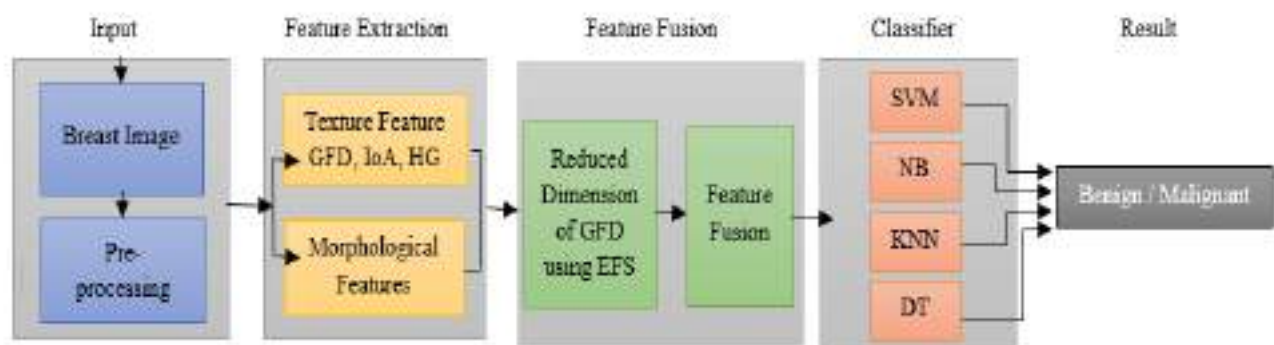


Figure. 1 Architecture view of the proposed approach

3. Proposed approach

3.1 Architecture view of morphological and texture features fusion

In this Section, the procedure for fusing the morphological and texture features is presented and explained. The proposed approach has used INbreast datasets (<https://biokeanos.com/source/INBreast>) [29] and CBIS-DDSM (<https://complexity.cecs.ucf.edu/cbis-ddsm/>) [30] for its experimentation. Fig. 1 depicts the flow diagram for fusing the feature and classification of masses either as benign or malignant. Input image is preprocessed for making it suitable for feature extraction. In this work, we extract both morphological and texture features. Initially, these features are linearly combined and considered as single feature. The combined feature is logically reduced based on the properties of inter and intra group variance.

3.2 Procedure to extract morphological features of the mass

The proposed approach considers the below morphological features of the mass and are mathematically represented in Eqs. (1)-(16). These morphological features are considered as a measure for tumor classification. The more information on the implementation and experiments are available in [17].

Morphological Features
The <i>Area</i> (A) of the mass is captured through the number of pixels and is represented in Eq. (1). The p and q are representing the rows and columns of the boundary of the RoI. Let K_{mass} and K_{margin} represents the RoI and boundary of the RoI in the image respectively. $Area(A) = \sum_{i=1}^p \sum_{j=1}^q c[K_{mass}(i, j)] = 1 \quad (1)$
The <i>Perimeter</i> (P) of the mass represents the number of pixels in the boundary of mass and is represented in Eq. (2). The p and q represent the row and column of the boundary of the mass. $Perimeter(P) = \sum_{i=1}^p \sum_{j=1}^q c[K_{margin}(i, j)] = 1 \quad (2)$
The <i>Distance</i> (D) represents these distances between the centroid and a pixel in the boundary and is depicted in Eq. (3). The (a_1, b_1) and (a_2, b_2) represents the co-ordinates of centroid and

boundary pixels respectively.

$$Distance (D) = \sqrt{(b_2 - b_1)^2 + (a_2 - a_1)^2} \quad (3)$$

The *Bending Energy* (B_E) defines the curvature features of mass/shape of the object and is mathematically represented in Eq. (4). Here, $C(s)$ is the curvature function, s is length of arc and N represents number of pixels in boundary of the masses.

$$Binding Energy (B_E) = \frac{1}{N} \sum_{s=0}^{N-1} C(s)^2 \quad (4)$$

The *Eccentricity* (E_C) represents the aspect ratio and captures the elliptical property of the masses as shown in Eq. (5). The *major axis* captures the longest diameter of ellipse and *minor axis* captures shortest diameter, respectively.

$$Eccentricity (E_C) = \sqrt{1 - \left(\frac{minor\ axis^2}{major\ axis^2}\right)} \quad (5)$$

The *Circular Mass* (C_M) is a measure of roundness of the tumor to discriminate circular and elliptical property of the mass. This is mathematically represented in Eq. (6) where CP is Convex Perimeter.

$$Circular Mass (C_M) = \frac{4 \times \pi \times Area}{(CP)^2} \quad (6)$$

The circularity with respect to *Elliptical Mass* (E_M) is computed as depicted in Eq. (7). Maximum Radius (Max_R) captures maximum distance and Minimum Radius (Min_R) captures the minimum distance between centroid and boundary of mass.

$$Elliptical Mass (E_M) = \sqrt{\left(\frac{Min_R}{Max_R}\right)} \quad (7)$$

The *Elongatedness* (E_L) represents the ratio of mass area and the maximum mass thickness and is shown below in Eq. (8). Here, t is the maximum mass thickness without holes in mass.

$$Elongatedness (E_L) = \left[\frac{Area}{(2 \times t)^2} \right] \quad (8)$$

The *Equivalent Diameter* (E_D) defines the circle diameter and is represented in Eq. (9).

$$Equivalent Diameter (E_D) = \sqrt{4 \times (Area/\pi)} \quad (9)$$

The <i>Compactness</i> (C_P) defines the ratio of area of mass of a circle with its perimeters and is depicted in Eq. (10).
$Compactness (C_P) = \left[\frac{(4 \times \pi \times Area)}{(Perimeter)^2} \right] \quad (10)$
The <i>Solidity</i> (S) captures the density of mass and is measured as given below in Eq. (11).
$Solidity (S) = \left[\frac{Area}{Convex Area} \right] \quad (11)$
The <i>Convexity</i> (C_X) presents the tumor boundaries using convex perimeters and is represented in Eq. (12).
$Convexity (C_X) = \left[\frac{Convex Perimeter}{Perimeter} \right] \quad (12)$
The <i>Standard Deviation</i> refers to the scattering of data with respect to mean (μ) and is represented in Eq. (13).
$(\sigma_{mass}/\sigma_{margin}) = \left[\sqrt{\frac{1}{N} \sum_1^N x_i - \mu ^2} \right] \quad (13)$
The <i>Shape Index</i> (S_I) defines the ratio of the perimeter of the mass and Maximum radius, and is represented in Eq. (14).
$Shape Index (S_I) = \left[\frac{Perimeter}{2 \times Max_R} \right] \quad (14)$
The <i>Entropy</i> (E) characterize the shape features in terms of the disorder, randomness of masses and is mathematically represented as given in below Eq. (15). Here, h_i represents normalized histogram counts.
$Entropy (E) = \sum [h_i \times \log_2(h_i)] \quad (15)$
The <i>Skewness</i> (S_K) characterizes the data distribution of mass and is represented in Eq. (16). Here, $E(q)$ represents the Expected value of quantity Q .
$Skewness (S_K) = \left[\frac{E(Q - \mu)^3}{\sigma^3} \right] \quad (16)$

Further, it is noticed that, texture features also play vital role in classifying the breast cells into benign and malignant. Hence, the proposed approach extracted the texture features to analyse and the process of extraction is given in the section 3.3.

3.3 Procedure to extract texture features of the mass

The texture is one of the important low-level features present in an image and proposed approach use it for classifying the RoI/ mass as benign or malignant. In this sub-section, the procedure for extracting the texture from RoI is presented along with theory of *Goodness-of-Fit Distribution (GFD)*, *Independence of Attributes (IoA)* and *Homogeneity (HG)*. Initially, all these features are combined linearly and represented as single feature. The pre-processed RoI of mammogram image is given as input. The RoI of a mammogram is mathematically represented in Eq. (17).

$$I_{RoI}^{A \times B} = x(i, j) \quad (17)$$

Here, $x(i, j)$ returns the intensity of a pixel at (i, j) and $A \times B$ is the size of the RoI. In general, the RoI may not always be in a perfect shape, such as square, rectangle, etc. However, during the segmentation process, we extract the RoI/mass and super impose it with a square such that processing the RoI is seamless. The procedure to bind the RoI/mass is depicted in Fig. 2. It is known that the pixels contribute to the RoI/mass and the feature is extracted from the characteristics of these contributing pixels. As a result, it is imperative that we process only those pixels that are part of the mass.

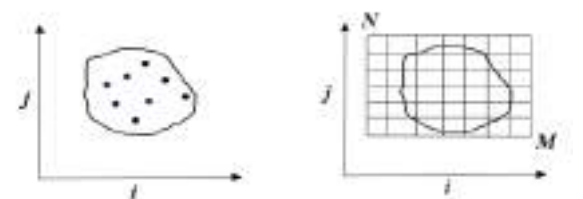
Mathematically, this can be represented as a predicate, which is a Boolean valued function as given in Eq. (18) and is called as a predicate on $I_{RoI}^{A \times B}$

$$P: I_{RoI}^{A \times B} \rightarrow \{TRUE, false\} \quad (18)$$

A predicate is given in Eq. (19) to determine whether $x(i, j)$ falls within the RoI or outside RoI.

$$Predicate: I_{RoI}^{A \times B}(i, j) \rightarrow \{1, 0\} \quad (19)$$

The texture feature captures the variations in the intensity/colour, contrast, chrominance and luminance between two neighbouring pixels in *vertical*, *diagonal*, and *horizontal* directions.



(a) Segmenting RoI (b) Bounding with square

Figure. 2 RoI/Mass from mammogram

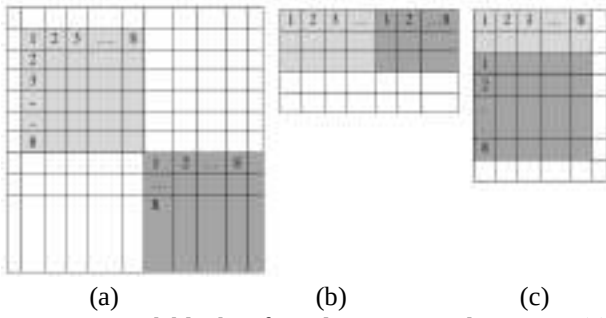


Figure 3 $a \times b$ blocks of pixels in various directions: (a) Pass in *diagonal* dir, (b) Pass in *horizontal* dir, and (c) Pass in *vertical* dir

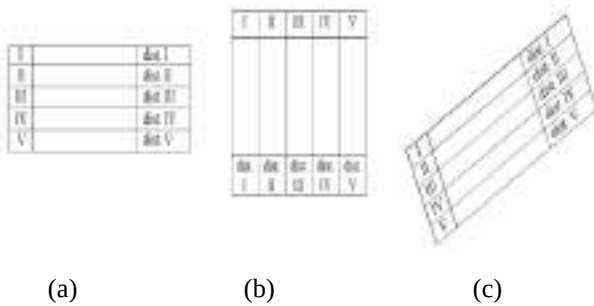


Figure 4 Distribution of average pixel values in different directions: (a) *Horizontal* direction, (b) *Vertical* direction, and (c) *Diagonal* direction

The proposed approach has extracted the texture information using the theory of non-parametric testing on pixels in *horizontal*, *vertical* and *diagonal* directions. The predicate defined in Eq. (19) is extended in *horizontal*, *vertical* and *diagonal* directions and is given in Eqs. (20)-(22).

$$I_{RoI}^{A \times B}[x(i, j + 1)] = P: I_{RoI}^{A \times B}(i, j + 1) = 1 \quad (20)$$

$$I_{RoI}^{A \times B}[x(i + 1, j)] = P: I_{RoI}^{A \times B}(i + 1, j) = 1 \quad (21)$$

$$I_{RoI}^{A \times B}[x(i + 1, j + 1)] = P: I_{RoI}^{A \times B}(i + 1, j + 1) = 1 \quad (22)$$

The Eqs. (20)-(22) should satisfy Eq. (19) such that only those pixels that are part of the masses are considered. In Eqs. (20)-(22), $x(i, j + 1)$, $x(i + 1, j)$ and $x(i + 1, j + 1)$ represents the neighbouring pixels in *vertical*, *horizontal*, and *diagonal* directions. The proposed approach extract parameters such as *GFD*, *IoA* and *HG* and consider these as texture features. These values are extracted from $m \times n$ blocks of RoI and will have an averaging effect with a value of $a=8$ and $b=8$. Thus, in the *vertical*, *horizontal* and *diagonal* directions, the trace is 8×8 pixels as shown in Fig. 3 below. The 8×8 window in *horizontal*,

vertical, and *diagonal* directions and the trace is one-pixel window is depicted. Thus, all the pixels in these directions contribute in measuring the texture. As a result, Eqs. (20)-(22) can be rewritten and represented in Eqs. (23)-(25).

$$I_{RoI}^{A \times B} = x^{a \times b}(i, j + 1) | P[I_{RoI}^{a \times b}(i, j + 1)] = 1 \quad (23)$$

$$I_{RoI}^{A \times B} = x^{a \times b}(i + 1, j) | P[I_{RoI}^{a \times b}(i + 1, j)] = 1 \quad (24)$$

$$I_{RoI}^{A \times B} = x^{a \times b}(i + 1, j + 1) | P[I_{RoI}^{a \times b}(i + 1, j + 1)] = 1 \quad (25)$$

The grey values in each cell of blocks are replaced with a threshold function as shown below in Eq. (26).

$$Grey_{Avg} = \sum_{i,j \in a \times b} [x(i, j) / (a \times b)] \quad (26)$$

$$x_{i \in a, j \in b}^{a \times b}(i, j) = \begin{cases} r_5 & \text{if } 128 \leq Grey_{Avg} \leq 255 \\ r_4 & 64 \leq Grey_{Avg} \leq 127 \\ r_3 & 32 \leq Grey_{Avg} \leq 63 \\ r_2 & 0 \leq Grey_{Avg} \leq 31 \\ r_1 & \text{Otherwise} \end{cases} \quad (27)$$

In the above Eq. (27), $r_1=0$, $r_2=32$, $r_3=64$, $r_4=128$ and $r_5=255$ and the cell values of any block is a grey value. The purpose of averaging is to enable the non-parametric test, since it considers different distributions for testing. In the proposed approach, we consider the value of $Grey_{Avg}$ as a distribution such that the test can estimate the presence of texture information. The procedure for measuring these parameters is presented in below sub-section 3.3.1.

3.3.1 Measuring texture features

As discussed earlier, the texture component of RoI/mass is extracted by applying a non-parametric test on the averaged pixel values. The non-parametric test provides information on the relationship between two or more samples. The test is conducted on averaged pixel values to estimate the presence of texture features through *GFD*, *IoA*, and *HG*. The average pixel values are distributed in various directions such as *horizontal*, *vertical* and *diagonal* as shown in Fig. 4. The *GFD* is calculated using $GFD_{Avg}^{Direction}$ between the distributions. The *GFD* for each direction is represented in Eqs. (28)-(30). This is depicted in Fig. 4.

$$GFD_{Avg}^{Horizontal} = \left(\frac{(\sum_i^n GFD_i^{Hori})}{n} \right) \quad (28)$$

$$GFD_{Avg}^{Vertical} = \left(\frac{(\sum_i^n GFD_i^{Vert})}{n} \right) \quad (29)$$

$$GFD_{Avg}^{Diagnol} = \left(\frac{(\sum_i^n GFD_i^{Diag})}{n} \right) \quad (30)$$

In Eqs. (28)-(30), $GFD_i^{Direction}$ is calculated for any i^{th} 8x8 block in *horizontal*, *vertical* and *diagonal* directions. Similarly, the variance of $GFD_{var}^{Direction}$ can be calculated using Eq. (31).

$$GFD_{Var}^{Direction} = \left(\sum_{i=1}^n \frac{(GFD_i^{Direc} - GFD_{Avg}^{Direc})^2}{n-1} \right) \quad (31)$$

In Eq. (31), GFD_i^{Direc} represents the *GFD* of any i^{th} 8x8 block in a direction (*vertical*, *horizontal* and *diagonal*) and GFD_{Avg}^{Direc} is the average *GFD* calculated in a direction (*vertical*, *horizontal* and *diagonal*). The *IoA* for each direction is calculated using Eqs. (32)-(34).

$$IoA_{Avg}^{Horizontal} = \sum_{i=1}^n \left(\frac{(o_i^{Hori} - e_i^{Hori})^2}{e_i^{Hori}} \right) \quad (32)$$

$$IoA_{Avg}^{Vertical} = \sum_{i=1}^n \left(\frac{(o_i^{Vert} - e_i^{Vert})^2}{e_i^{Vert}} \right) \quad (33)$$

$$IoA_{Avg}^{diagnol} = \sum_{i=1}^n \left(\frac{(o_i^{diag} - e_i^{diag})^2}{e_i^{diag}} \right) \quad (34)$$

In Eq. (32)-(34), o_i^{Hori} , o_i^{Vert} and o_i^{diag} is the observed frequency in *horizontal*, *vertical* and *diagonal* blocks. Similarly, e_i^{Hori} , e_i^{Vert} and e_i^{diag} are the expected frequency in the *horizontal*, *vertical* and *diagonal* directions respectively. The variance of $IoA_i^{direction}$ is calculated using Eq. (35) below.

$$IoA_{Var}^{Direction} = \sum_{i=1}^n \frac{(IoA_i^{Direc} - IoA_{Avg}^{Direc})^2}{n-1} \quad (35)$$

In Eq. (36), IoA_i^{Direc} is the Independence of Attributes of any i^{th} 8x8 block in *horizontal*, *vertical* and *diagonal* directions. The IoA_{Avg}^{Direc} is the Average of Independence of Attributes for the respective 8x8 block in *horizontal*, *vertical* and *diagonal* directions. The *HG* is measured using the nature of the distribution of the pixels in RoI, such as Binomial, Poisson, and Normal distributions. This means, based on the trend followed by the distribution of average pixel values in *horizontal*, *vertical*, and *diagonal* directions, the homogenous nature of the average

pixel values can be measured. In terms of Binomial distribution, the *HG* is represented in Eq. (36) below.

$$P(HG_{Vert, hori, diag \in Directions}^{Direc} Thresh; n, p) = nC_{HG_{Thresh}^{Direc}} HG_{Thresh}^{Direc} \times p^{HG_{Thresh}^{Direc}} \times (1-p)^{n-HG_{Thresh}^{Direc}} \quad (36)$$

In the above Eq. (36), HG_{Thresh}^{Direc} is the count of HG_i^{Direc} such that HG_i^{Direc} is greater than HG_{Thresh}^{Direc} more than $n/2$ times. The $n \cdot p$ gives the mean Binomial distribution of HG_{Thresh}^{Direc} and the variance of Binomial distribution of HG_i^{Direc} is $n \cdot p(1-p)$. The *HG* is characterized based on skewness. While $p=0.5$, the distribution HG_i^{Direc} is symmetric around the mean and the presence of texture is low. While $p<0.5$ and $p>0.5$, the distribution HG_i^{Direc} is left and right skewed. As a result, the presence of the texture is estimated based on the value of p . Similarly, the texture content is also measured based on the Poisson distribution characteristics of the samples. This is represented in Eq. (37) below.

$$F(HG_{Thresh}^{Direc}, \lambda) = \Pr(HG_i^{Direc} = HG_{Thresh}^{Direc}) = \frac{(\lambda^{HG_i^{Direc}} \times e^{-\lambda})}{HG_{Thresh}^{Direc}} \quad (37)$$

In the above Eq. (37), e is the Euler's number ($e=2.71828$). The positive real number λ is equal to the expected value of HG_i^{Direc} and also is variance. The variance measured through below Eq. (38) gives the texture content.

$$\lambda = Eu(HG_i^{Direc}) = Var(HG_i^{Direc}) \quad (38)$$

Similarly, if the distribution of HG_{Thresh}^{Direc} is normal, texture characteristics is estimated accordingly. After analyzing and estimating the importance of morphological and textural features, it is predicted that the fusion of both of these features plays a vital role in achieving the accurate classification of Breast Cancer cells. The process of feature fusion is explained detail in below section.

3.4 Procedure to fuse both morphological and texture features

In this subsection, the morphological features presented in Section 3.1 and texture features presented in Section 3.2 are fused. It is found that the characteristics and discrimination capability of each type of features on mammogram mass are encouraging. For example, the morphological

features can be effective in discriminating a set of masses and similarly, the texture feature may be effective for the different categories of masses. Thus, these features can be fused as single features for improving the accuracy in classifying malignant from benign masses. The procedure for fusing the feature is explained below.

Let F_{morp} be the morphological feature of the mass and is denoted in Eq. (39), where n denotes the size of the morphological feature,

$$F_{morp} = \{f_{morp1}, f_{morp2}, f_{morp3}, \dots, f_{morp n}\} \quad (39)$$

Let F_{GFD} is *Goodness of Fit distribution (GFD)* of the mass in all the directions and is denoted in Eq. (40), where m is the dimension of F_{GFD} .

$$F_{GFD} = \{f_{GFD1}, f_{GFD2}, f_{GFD3}, \dots, f_{GFD m}\} \quad (40)$$

Let F_{IoA} is *Independence of Attributes (IoA)* of the mass in all the directions and is shown in Eq. (41), where p is the dimension of F_{IoA} .

$$F_{IoA} = \{f_{31}, f_{32}, f_{33}, \dots, f_{3n}\} = \{f_{IoA1}, f_{IoA2}, f_{IoA3}, \dots, f_{IoA p}\} \quad (41)$$

Let F_{HG} is *Homogeneity (HG)* of the mass in all the directions and is represented in Eq. (42), where q is the dimension of F_{HG} .

$$F_{HG} = \{f_{HG1}, f_{HG2}, f_{HG3}, \dots, f_{HG q}\} \quad (42)$$

As a initial step, these four features are considered as a single feature by linearly combining all of them, and mathematically it is represented in Eq. (43)

$$F = \{F_{morp}, F_{GFD}, F_{IoA}, F_{HG}\} \quad (43)$$

However, combining the features linearly increases dimension and thus there is a curse of dimensionality. Thus, it is imperative that a feature subset from each feature is required to further improve the classification accuracy.

In this approach, variance is used as a measure for fusing the features effectively. The process requires the size of the feature should be same in each factor level. As a result, the dimension of F_{morp} is reduced to match the dimension of F_{GFD} , F_{IoA} and F_{HG} using Exhaustive Feature Selection (EFS) techniques. The dimension of F_{morp} is n and EFS strategy produces $2^n - 1$ feature combinations. The proposed approach considers all the feature combinations having its size equal to m and among them which ever provides

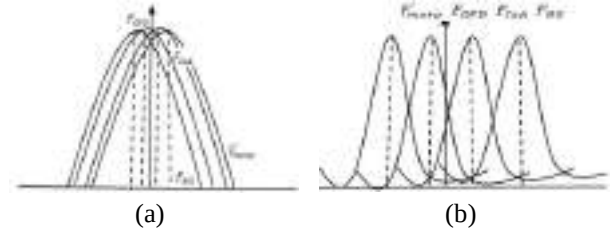


Figure 5. The F value on features (F'_{morp} , F_{GFD} , F_{IoA} and F_{HG}): (a) Low F value and (b) High F value

higher performance is selected and is denoted as F'_{morp} .

Each mass in a mammogram is considered as RoI and all the features say, F_{morp} , F_{GFD} , F_{IoA} and F_{HG} are extracted. The F_{morp} is decomposed to F'_{morp} using EFS for making the dimension of all the features equal (i.e., $n=m=p=q$). The algorithm exploits the variance among the features and within the features (i.e. variance between the group and variance among the group).

It is observed that the distribution of features in Fig. 5(a) is similar and thus the F -value is low. Thus, all the features say F'_{morp} , F_{GFD} , F_{IoA} and F_{HG} are having similar properties in discriminating the masses. In contrast, the F -value of distribution shown in Fig. 5(b) is high, each distribution is different and thus more discriminating power. Thus, the F -value is calculated using Eqs. (39)-(43). If the F -value is less than a threshold, T , elements in Feature are removed till the F value is good. Within Group Variance (WGV) and Between Group Variance (BGV) are playing critical role in the algorithm and both of them are calculated as given below.

Within Group Variance (WGV) for each feature is calculated as given in Eq. (44), where, $y_{ij}^{F'_{morp}}$ and $\bar{y}_j^{F'_{morp}}$ are the dimension reduced morphological features (F'_{morp}) and mean of the F'_{morp} respectively.

$$WGV(F'_{morp}) = \sum_{j=1}^{F'_{morp}} \sum_{i=1}^n (y_{ij}^{F'_{morp}} - \bar{y}_j^{F'_{morp}})^2 \quad (44)$$

Similarly, Within Group Variance (WGV) for F_{GFD} , F_{IoA} and F_{HG} are calculated as shown in Eq. (45)-(47).

$$WGV(F_{GFD}) = \sum_{j=1}^{F_{GFD}} \sum_{i=1}^n (y_{ij}^{F_{GFD}} - \bar{y}_j^{F_{GFD}})^2 \quad (45)$$

In the above Eq. (45), $y_{ij}^{F_{GFD}}$ and $\bar{y}_j^{F_{GFD}}$ are the values in F_{GFD} and their mean respectively and n is the dimension of F_{GFD} .

$$WGV(F_{IOA}) = \sum_{j=1}^{F_{IOA}} \sum_{i=1}^n \left(y_{ij}^{F_{IOA}} - \bar{y}_j^{F_{IOA}} \right)^2 \quad (46)$$

In the above Eq. (46), $y_{ij}^{F_{IOA}}$ and $\bar{y}_j^{F_{IOA}}$ are the values in F_{IOA} and their mean respectively and n is the dimension of F_{IOA} .

$$WGV(F_{HG}) = \sum_{j=1}^{F_{HG}} \sum_{i=1}^n \left(y_{ij}^{F_{HG}} - \bar{y}_j^{F_{HG}} \right)^2 \quad (47)$$

In the above Eq. (47), $y_{ij}^{F_{HG}}$ and $\bar{y}_j^{F_{HG}}$ are the values in F_{HG} and their mean respectively and n is the dimension of F_{HG} .

Similarly, Between Group Variance (BGV) is also calculated as shown in Eq. (48).

$$BGV(F'_{morp}, F_{GFD}, F_{IOA}, F_{HG}) = \sum n x (\bar{x} - \bar{x}_{GM})^2 \quad (48)$$

In the above Eq. (48), $\bar{x}$ is the sample mean (mean of F'_{morp} , F_{GFD} , F_{IOA} and F_{HG}) respectively, $\bar{x}_{GM}$ is the group mean of all the features and n is the number of samples in all the features. The F-value is the ratio of BGV and WGV and is derived from Eqs. (45)-(47) and Eq. (48).

4. Experimental results

The performance of the proposed approach is evaluated on two mammographic datasets namely INbreast and CBIS-DDSM. The INbreast dataset has 7632 mammographic images and they are considered after data augmentation followed by adaptive histogram normalizations. Out of which, 2520 images are benign and 5112 images are malignant tumors. The Digital Database for Screening Mammography (DDSM) is a mammographic image dataset and it consists of 2620 scanned films with verified pathology information. It includes normal, malignant, and benign tissues. The CBIS-DDSM is a standardized and updated version of the DDSM dataset. The details, such as the number of malignant, benign, and benign without call-back masses are presented in Table 1. The CBIS-DDSM dataset is larger and INbreast has fewer samples. The training and testing splits of INbreast, CBIS-DDSM calc and CBIS-DDSM mass datasets are shown in Table 2. The proposed approach has used 6106, 1014, and 1228 mammogram images as training set from INbreast, CBIS-DDSM Calc, and CBIS-DDSM mass datasets to train the SVM classifier. We have used

Table 1. Details of CBIS-DDSM and INbreast Mammogram Datasets

Dataset	Data type	Malignant	Benign	Benign without call-back
CBIS-DDSM	Mass-Training RoI and Cropped Images	650	578	104
	Mass-Testing RoI and Cropped Images	147	195	37
	Calc-Training RoI and Cropped Images	544	528	474
	Calc-Testing RoI and Cropped Images	129	130	67
INbreast	Training	2045	1008	-
	Testing	511	252	-

Table 2: Training and Testing sets from INbreast, CBIS-DDSM calc and CBIS-DDSM mass datasets

Dataset	Split classes	Benign	Malignant	Total
INbreast	Training set	2016	4090	6106
	Testing set	504	1022	1526
CBIS-DDSM	Calc-Training RoI and Cropped Images	441	573	1014
	Calc-Testing RoI and Cropped Images	125	129	254
	Mass-Training RoI and Cropped Images	578	650	1228
	Mass-Testing RoI and Cropped Images	195	147	342

Table 3 Classification accuracy on INbreast using fused features

Classified as Benign		Classified as Malignant		Total	Classification Accuracy (%)	
SVM	ANN	SVM	ANN		SVM	ANN
454	492	50	12	504	90.06	97.61
82	51	940	971	1022	91.97	95.00
Overall				1526	91.01	98.56

Table 4 Classification accuracy CBIS-DDSM using fused features

Mass	Classified as Benign		Classified as Malignant		Total	Accuracy (%)	
	SVM	ANN	SVM	ANN		SVM	ANN
Calc RoI and Cropped Images	116	119	9	6	125	92.80	95.20
	4	3	125	126	129	96.89	97.67
	Overall				254	94.84	96.43
Mass- RoI and Cropped Images	183	181	12	14	195	93.84	92.82
	6	4	141	143	147	95.91	97.27
	Overall				342	94.87	95.04

Table 5 Precision, Recall, F-measure, and Accuracy on fused feature

Evaluation Metrics	Performance Measure					
	INbreast Dataset		CBIS-DDSM Dataset			
	SVM (%)	ANN (%)	SVM (%)		ANN (%)	
			Calc RoI	Mass- RoI	Calc RoI	Mass- RoI
Recall	89.40	88.21	88.36	90.18	90.33	86.26
Precision	92.72	95.76	92.31	93.10	94.31	90.03
F-Score	91.08	91.81	90.29	91.57	92.27	90.95
Accuracy	91.01	98.56	94.84	94.87	96.43	95.04

1526, 254 and 342 mammogram images as test images from INbreast, CBIS-DDSM Calc, and CBIS-DDSM mass datasets to evaluate the performance of proposed texture features.

This section discusses the performance evaluation of fused feature. The experiments are performed using MATLAB2020b on a Desktop Computer Core i7 having 8GB of graphics card and 16GB RAM. The fused features along with SVM, KNN and DT are used for classification. The proposed approach chosen training/testing ratio 70:30, 60:40, 50:50 to validate the fused feature. The cross-validation value is selected at 10 for all experiments. The performance is evaluated using the following statistical measures such as True Positive (*TP*), True Negative (*TN*), False Positive (*FP*), False Negative (*FN*). This is depicted in Table 3 and 4. On the INbreast dataset, the SVM classifies 454 mammograms as benign and ANN classifies 492 mammograms as benign on 504 test case mammogram images. SVM classifies 940 mammograms as malignant and ANN classifier classifies 971 mammograms as benign from 1022 test case mammogram images. The overall accuracy of the proposed feature on the INbreast dataset is 91%

for SVM and 98.56% for ANN. For the CBIS-DDSM Calc RoI dataset, the SVM classifier classifies 116 mammograms as benign and ANN classifies 119 mammograms as benign on 125 mammogram images. SVM classifies 125 mammograms as malignant and ANN classifies 126 mammograms as malignant from 129 test cases. The overall accuracy of the proposed feature for the CBIS-DDSM Calc RoI dataset is 94% for SVM and 96% for ANN. For the CBIS-DDSM Mass RoI dataset, the SVM classifies 183 mammograms as benign and ANN classifies 181 mammograms as benign from 195 mammogram images. SVM classifies 141 mammograms and ANN classifies 143 mammograms as malignant from 147 test cases. The overall accuracy of the proposed feature for the CBIS-DDSM Mass RoI dataset is 94% using SVM and 95% using ANN classifier.

In addition, Precision, Recall, F1-Score, and Accuracy are evaluated on fused feature and the results are presented in Table. 5. Table 6 presents the performance evaluation of the proposed fused feature with other comparative approaches on INbreast and CBIS-DDSM datasets. The authors in [8] have adopted Hybrid thresholding and the machine

Table 6. Performance comparison of the fused feature.

Comp. Approaches	Features	Datasets	Classifiers	Acc (%)
Proposed Approach	Fused Feature	INbreast	SVM	91.01
			ANN	98.56
		CBIS-DDSM	SVM	94.85
			ANN	95.73
Anas and Haq (2024) [28]	Multi features	CBIS-DDSM and INbreast	YOLOv5+Mask RCNN	92.02
Teng and Zhang (2022) [18]	<30-40 Multi-features	INbreast,	Bayesian Model Average (BMA)	80.2
Teng and Zhang (2022) [18]	>30-40 Multi-features	INbreast	Fast Backward Variable Selection (FastBw)	79.9
Teng and Zhang (2022) [18]	>30-40 Multi-features	INbreast	elastic net	79.9
Zebari and Ibrahim (2021) [8]	Multi Features-50 features	DDSM INbreast,	ANN	81.52 82.21
Vaka and Soni, (2020) [31]	Fusion approach	DDSM	Histo-sigmoid fuzzy clustering	93.52
Zhang and Wu, (2020) [10]	Fusion approach	INbreast DDSM	Adaboost	86.20 91.12
Jiang and Xu, (2017) [32]	Histogram statistical features and GLCM	DDSM	Random Forest (RF)	77.05
Uthoff, and Sieren, (2018) [33]	13 histogram, texture, 18 shape	DDSM	ANN	95.23
Pashoutan and Shokouhi, (2017) [34]	Intensity, shape, texture	DDSM	FGMM	93.51

learning techniques to locate the RoI to classify benign or malignant Breast Cancer from mammogram images. The noise of each block has been reduced by applying the wavelet transform using BayesShrink soft thresholding, which captures high and low frequencies within various sub-bands. The methodology has been assessed on MIAS, DDSM, INbreast, and BCDR mammography imaging datasets. The authors in [31] employed Entropy, texture, and geometric features for detecting Breast Cancer tumors. The authors adopted Gaussian filter to eliminate the noise and machine learning techniques are used for classification. A multi-feature fusion based model called DE-Ada* has been presented by authors in [10] for the classification of breast masses. Various techniques have been employed to categorize the mammograms such as Scale-Invariant Feature Transform (SIFT), Histogram Of Oriented Gradient (HOG), Local Binary Pattern (LBP), Residual Network (ResNet), Densely linked convolutional Networks (DenseNet), and Visual Geometry Group (VGG). Mohanty and Rup (2019) proposed a hybrid Computer Aided Diagnosis (CAD) framework that identifies suspicious regions as RoI and classified them as either abnormal or normal. Various classifiers such as

SVM, K-NN, Naïve Bayes, and C4.5 are adopted to classify the RoI as benign or malignant. The authors in [32] have extracted histogram statistical features and texture features using GLCM to classify Breast Cancer tumors. The authors in [33] extracted intensity, texture, and shape features from mammograms. The authors employed K-medoids clustering to remove intra-correlated features and thereby reducing feature set. The authors used information theory approach for feature selection. The authors in [34] have used wavelet transform, Gabor wavelet transform, Zernike moments and GLCM to segment the region of the tumor in mammography. P values are used to choose the relevant features and Multi-Layer Perceptron (MLP) is used to classify the malignant or benign breast masses. It is observed from Table 6 that the performance of the fused-feature is encouraging on both the datasets. The SVM classifier has achieved in 91.01% and 94.55% of accuracy on INbreast and CBIS-DDSM datasets. Similarly, the classification accuracy using ANN is 98.56% and 95.731% on INbreast and CBIS-DDSM datasets respectively. The authors in [33] have shown close accuracy 95.3% on DDSM dataset using ANN classifier. The approach in [31] and [34] have achieved the classification

accuracy in the range of 93% on DDSM datasets. The authors in [34] have classified the DDSM dataset masses with 77.05% classification accuracy. The authors in [28] achieved 92.02% accuracy. Overall, the proposed fused feature has performed well. This is due to the fact that it combines both morphological and texture effectively and both of these features are good in discriminating malignant and benign masses. The properties of inter and intra group variance of both the features have reduced the dimension of the resultant feature and has retained the characteristics of the tumor.

5. Conclusion

In this paper we have fused both morphological and texture feature. The morphological feature has extracted shape and marginal properties of the masses. The texture feature has captured the variations in pixels of masses through Goodness of Fit Distribution (GFD), Independence of Attributes (IoA) and Homogeneity (HG). These features are initially combined together and the dimension of the feature is reduced logically. The inter and intra group variances between the features are estimated and both the feature is fused accordingly. The evaluation of the fused feature is performed on DDSM and INbreast Dataset, and Precision, Recall, F1-Score and Accuracy are measured. The SVM and ANN are used as classifiers. The overall accuracy of the proposed feature on the INbreast dataset is 91% for SVM and 98.56% for ANN. The overall accuracy of the proposed feature for the CBIS-DDSM Calc RoI dataset is 94% for SVM and 96% for ANN. The overall accuracy of the proposed feature for the CBIS-DDSM Mass RoI dataset is 94% using SVM and 95% using ANN classifier. In addition, Precision, Recall, F1-Score are evaluated. The result is compared with contemporary methods and found that the fused feature is performing well. In future we will extract volume features of the mass and fused in with the proper one.

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization and Methodology- Shaila SG and Vadivel A; Data curation Formal analysis and Visualization- Gurudas VR; Software and Resources - Gurudas VR; Supervision and Investigation- Shaila SG; Writing—original draft preparation-Gurudas VR; Validation, Review and Editing- Shaila SG and Vadivel A.

References

- [1] <https://www.who.int/news-room/fact-sheets/detail/breast-cancer>
- [2] A.K Suleiman, "Awareness and attitudes regarding Breast Cancer and breast self-examination among female Jordanian students", *Journal of basic and clinical pharmacy*, Vol. 5, No. 3. pp.74-8, 2014
- [3] A.F. Moustafa, T.W. Cary, L.R. Sultan, S.M. Schultz, E.F. Conant, S.S. Venkatesh and C.M. Sehgal, "Color Doppler Ultrasound improves Machine Learning Diagnosis of Breast Cancer", *Diagnostics*, Vol. 10, 631, 2020.
- [4] R.V. Abdel-Menon, P. Raha, S. Kothari, S. Chakraborty, I. Chakrabarti and R. Karim, "Automated Detection and Classification of Mass from Breast Ultrasound Images", In: *Proc. of Fifth National Conference on Computer Vision, Pattern Recognition, Image Processing and Graphics (NCVPRIPG)*, Patna, India, pp. 1-4, 2015.
- [5] F.A. González-Luna, J. Hernández-López, and W. GomezFlores, "A Performance Evaluation of Machine Learning Techniques for Breast Ultrasound Classification", In: *Proc. of 16th International Conference on Electrical Engineering, Computing Science and Automatic Control (CCE)*, Mexico City, Mexico, pp. 1-5, 2019.
- [6] B. Mughal, M. Sharif, N. Muhammad and T. Saba, "A Novel Classification Scheme to decline the Mortality Rate among Women due to Breast Tumor", *Microscopy research and technique*, Vol. 81, No. 2, pp. 171-180, 2018.
- [7] E. Michael, H. Ma, H. Li, F. Kulwa and J. Li, "Breast Cancer Segmentation Methods: Current Status and Future Potentials", *BioMed Research International*, pp. 1-29, 2021.
- [8] D.A. Zebari, D.A. Ibrahim, D. Q. Zeebaree, H. Haron, M.S. Salih, R. Damaševičius and M.A. Mohammed, "Systematic Review of Computing Approaches for Breast Cancer Detection based Computer Aided Diagnosis using Mammogram Images", *Applied Artificial Intelligence*, Vol. 35, No. 15, pp. 2157-2203, 2021.
- [9] V. Inamdar, S.G. Shaila and M.K. Singh, "FNAB-Based Prediction of Breast Cancer Category Using Evolutionary Programming Neural Ensemble", In: *Proc. of International Conference on Computational Vision and Bio-Inspired Computing*, Springer Singapore, Vol. 1318, pp. 653-663, 2021.
- [10] H. Zhang, R. Wu, T. Yuan, Z. Jiang, S. Huang, J. Wu, J. Hua, Z. Niu and D. Ji, "DE-Ada*: A

- Novel Model for Breast Mass Classification using Cross modal Pathological Semantic Mining and Organic Integration of Multi-feature Fusions”, *Information Science*, Vol. 539, pp. 461-486, 2020.
- [11] T. Sadad, A. Hussain, A. Munir, M. Habib, S. Ali Khan, S. Hussain, S. Yang and M. Alawairdhi, “Identification of Breast Malignancy by Marker-Controlled Watershed transformation and Hybrid Feature Set for Healthcare”, *Applied Science*, Vol. 10, No. 6, pp. 1900, 2020.
- [12] A.K. Mishra, P. Roy, S. Bandyopadhyay, and S.K. Das, “Breast Ultrasound Tumor Classification: A Machine Learning—Radiomics based Approach”, *Expert System*, Vol. 38, 2021.
- [13] S. Kadry, R. Damaševičius, D. Taniar, V. Rajinikanth and I.A. Lawal, “Extraction of Tumor in Breast MRI using Joint Thresholding and Segmentation - A Study”, In: *Proc. of the Seventh International conference on Bio Signals, Images, and Instrumentation (ICBSII)*, Chennai, India, pp. 1-5, 2021.
- [14] V. Lahoura, H. Singh, A. Aggarwal, B Sharma, M Mohammed, R. Damaševičius, S Kadry, K Cengiz, “Cloud Computing-Based Framework for Breast Cancer Diagnosis Using Extreme Learning Machine”, *Diagnostics*, Vol. 11, No. 2, pp. 241, 2021.
- [15] V. Rajinikanth, S. Kadry, D. Taniar, R. Damaševičius and H. T. Rauf, “Breast-Cancer Detection using Thermal Images with Marine-Predators-Algorithm Selected Features”, In: *Proc. of the Seventh International conference on Bio Signals, Images, and Instrumentation (ICBSII)*, Chennai, India, pp. 1-6, 2021.
- [16] A. Ouahabi and A. Taleb-Ahmed, “Deep learning for real-time semantic segmentation: Application in ultrasound imaging”, *Pattern Recognition Letters*, Vol. 144, No. 12, pp. 27-34, 2021.
- [17] V.R. Gurudas, S.G. Shaila, A. Vadivel, “Breast Cancer Detection and Classification from Mammogram Images Using Multi-model Shape Features”, *SN Computer Science*, Vol. 3, No. 5, pp. 404, 2022.
- [18] J. Teng, H. Zhang, W. Liu, X-O Shu and F. YeA “Dynamic Bayesian Model for Breast Cancer Survival Prediction”, *IEEE Journal of Biomedical and Health Informatics*, Vol. 26, No. 11, 2022.
- [19] K. Y. Yeung, R. Bumgarner and A. Raftery, “Bayesian model averaging: Development of an improved multi-class, gene selection and classification tool for microarray data”, *Bioinformatics*, Vol. 21, pp. 2394-2402, 2005.
- [20] J. F. Lawless and K. Singhal, “Efficient screening of nonnormal regression models”, *Biometrics*, Vol. 34, No. 2, pp. 318-327, 1978.
- [21] H. Zou and T. Hastie, “Regularization and variable selection via the elastic net”, *Journal of the Royal Statistical Society Series B: Statistical Methodology*, Vol. 67, No. 2, pp. 301-320, 2005.
- [22] R. Fan, Y. Chen, S. Nechuta, H. Cai, K Gu, L. Shi, P. Bao, Y. Shyr, X-O Shu, and F. Ye, “Prediction models for Breast Cancer prognosis among Asian women”, *Cancer*, Vol. 127, No. 11, pp. 1758-1769, 2021.
- [23] D. Fletcher, *Bayesian Model Averaging*, Berlin, Heidelberg, Germany: Springer, pp. 31-55, 2018.
- [24] C. Porzelius, M. Schumacher, and H. Binder, “Sparse regression techniques in low-dimensional survival data settings”, *Statistics and Computing*, Vol. 20, pp. 151-163, 2010.
- [25] L. Torgo and J. Gama, “Regression by classification”, In: *Proc. of the Advanced Artificial Intelligence*, pp. 51-60, 1996.
- [26] T. Hastie, J. Taylor, R. Tibshirani and G. Walther, “Forward Stagewise Regression and the Monotone Lasso”, *Electronic Journal of Statistics*, Vol. 1, pp. 1-29, 2007.
- [27] M. H. R. Khan, A. Bhadra and T. Howlader, “Stability selection for lasso, ridge and elastic net implemented with AFT models”, *Statistical Applications in Genetics and Molecular Biology*, Vol. 18, No. 5, 2019.
- [28] M. Anas, I.U. Haq, G. Husnain and S.A.F. Jaffery, “Advancing Breast Cancer Detection: Enhancing YOLOv5 Network for Accurate Classification in Mammogram Images”, *IEEE Access*, Vol. 12, pp. 16474-16488, 2024.
- [29] <https://biokeanos.com/source/INBreast>
- [30] <https://complexity.cecs.ucf.edu/cbis-ddsm/>
- [31] A.R. Vaka, B. Soni and S.R. Reddy, “Breast Cancer detection by leveraging Machine Learning”, *ICT Express*, Vol. 6, No. 4, pp. 320-324, 2020.
- [32] Z. Jiang, W. Xu and S. Chen, “Classification of benign and malignant Breast Cancer based on DWI texture features”, In: *Proc of the International Conference on Bioinformatics and Computational Intelligence*, pp. 11-15, 2017.
- [33] J. Uthoff and J. C. Sieren, “Information theory optimization based feature selection in breast mammography lesion classification”, In: *Proc. of IEEE 15th International Symposium on Biomedical Imaging (ISBI 2018)*, Washington, DC, USA, pp. 817-821, 2018.

- [34] S. Pashoutan, S. Baradaran Shokouhi and M. Pashoutan, "Automatic Breast Tumor Classification Using a Level Set Method and Feature Extraction in Mammography", In: *Proc. of 24th National and 2nd International Iranian Conference on Biomedical Engineering (ICBME)*, Tehran, Iran, pp. 1-6, 2017.

A Novel approach for detection and Identification of Vehicles using Single Shot MultiBox Detector (SSD) and Real Time Analytics

Senthil Kumar A^{1*}, Selvaraj Kesavan², Ananda Kumar K S³, Nixon J S⁴, Senthil Kumar J⁵, Godhandaraman T⁶

¹Computer Science and Engineering, *Dayananda Sagar University Bengaluru*, India.

²Technical Architect, *DXC Technology*, Bangalore, India.

³Information Science Department, *Atria Institute of Technology*, Bangalore, India.

⁴Computer Science and Engineering, *Dayananda Sagar University*, Bangalore, India.

⁵Dept. of Computer Science & Engg *Sona College of Technology*, India

⁶Department of Data Science, *Dayananda Sagar University*, Bangalore, India.

Citation: Senthil Kumar A et al , (2024), A Novel approach for detection and Identification of Vehicles using Single Shot MultiBox Detector (SSD) and Real Time Analytics, *Educational Administration: Theory And Practice*, 30(6), 2767 -2775, Doi: 10.53555/kuey.v30i6.5892

ARTICLE INFO

ABSTRACT

With growing vehicle density and traffic, manual detection and identification of vehicles is difficult. A lot of manpower is being used for regulating the vehicle and identifying the vehicle in case of violation, blacklisted vehicles, and vehicles of interest from agencies like transport, and law enforcement. Difficult to identify the vehicles from the place and track. It requires numerous resources. Agencies spend a lot of money and effort to identify the vehicles of interest. Manually checking the databases, finding the results, and taking action require skills and is time-consuming. It also leads to delays and difficulty in taking action in real-time. With the growth of computing infrastructure and the advent of artificial intelligence, many automated solutions are proposed to identify Vehicles. In this paper, the automated solution has been proposed to create a pipeline to detect, analyze, identify, and alert the stakeholders. The proposed solution is to identify the license plates of the vehicles from locations, detect the numbers, verify the vehicle details from the database in real time, and generate alerts in case of a red flag by sending messages about the location of the vehicle and the time stamp to law enforcement officers. The research proposes an approach to use deep learning based algorithms to identify the objects from visual inputs, analyze them in real-time, and generate notifications. The solution has been implemented using the Amazon Web Services platform and infrastructure and results are captured. The experimental result shows that default SSD boxes and multi-scale feature maps yield better accuracy than Faster R-CNN with lower-resolution images.

Keywords: Deep Learning, Object Detection, OCR, Real-time Analytics

I. INTRODUCTION

As the number of vehicles increases on the road, so does the situation arises to search for particular vehicles of interest by the law enforcement departments and other agencies.. The vehicle of interest could be any vehicle that is stolen, blacklisted due to various reasons, involved in unlawful activities and violations etc.. As of today, searching the vehicles is left to chance. Any sighting of a vehicle by police patrol or identified by civilians would be communicated to the authorities about the location. This is not an efficient way to solve crimes. Indian cities are among the top cities in the world that are equipped with traffic cameras to monitor the traffic. These cameras can be given the ability to track the vehicles and identify the number plate, read the numbers from the license plate and check the license plate details with the wanted vehicle information in real time or near real time and inform the law enforcement officer about the locality of the vehicle through much better communication like WhatsApp message or automated call to enable swift actions. The crux of the idea might have been impossible until a few years ago but with the advent of technology like Computer Vision, Real Time Analytics, Cloud Technologies, High speed internet, Cheaper Communication devices, Automated calls & WhatsApp it is possible in today's world. Computer Vision is an innovation that brings the ability to see and make decisions like humans do to machines and computers. It is a field of Artificial Intelligence that enables

computers to see the images & videos and identify objects by processing it. The application of this field in day to day life is immense and it can help us to tackle a lot of modern day challenges [1].

Object detection is the ability to detect and locate the object in the image using bounding boxes. Object detection heavily uses machine learning and deep learning algorithms to detect an object from an image or a video source. The detection can range from a single object to multiple objects from the same source. The accuracy of the detection depends on the algorithms and the database of images that has been used to learn the features. The performance and accuracy of the model in object detection is directly proportional to the variety of image databases used by the model to learn. Deep Learning models lay at the heart of object detection. Irrespective of the deep learning model used, the basic flow of creating an object detection model involves the following [2].

Creation of Source Data is the most difficult part of any data science project. We need to create a database with as many images / videos as possible. The variety of images in the database will help the model for better learning and prediction with high accuracy. Annotation of Images (Labeling) involves adding details to the image for the model to understand the features in the images. In this phase, we use tools to mark areas(bounding box) in the image to label them. The tool will generate xmls or jsons with the dimension (length, breath, height) of the bounding box in image along with the class name [3]. These xmls along with the images will be used by the models to learn about the class or features.

Selecting a deep learning model to use the source data and annotation to learn about the feature. Train the selected model on a training database and test the model accuracy in the test dataset. Tweak the model and tune the parameters based on the test results for higher accuracy. The main contributions of this paper include the following aspects.

Implement object detection solution using deep learning approach to detect the interested object Use OCR to detect and extract vehicle identity from number plate Implement the solution to stream the vehicle license plate information to a steaming engine and validate it against the Reference database. Business rules to check the vehicle against the defined list and generate alert notification.

In Single short multibox detector, The pre-computed, fixed-size bounding boxes known as priors are generated and closely resemble the distribution of the initial ground truth boxes. Actually, the way those priors are chosen ensures that their Intersection over Union ratio [10]. Equation 1 is the formula for deriving IoU .

Several improvements were made to this network to further enhance its ability to locate and categorize objects. For each of the b default bounding boxes per feature map cell and the c classes to classify, it is configured with two diagonally opposed points (x_1, y_1) and (x_2, y_2) ; on a given feature map of size $f = m * n$, SSD would compute $f * b * (4 + c)$ values for this feature map [11].

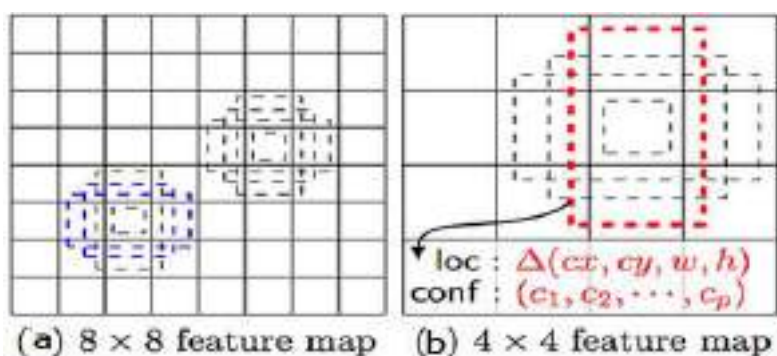
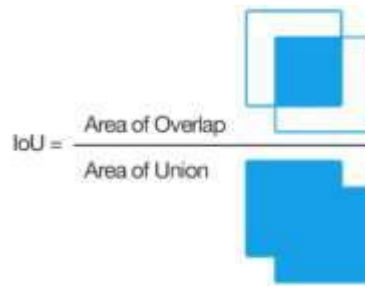


Fig. 1. SSD default matches with feature maps

SSD computes the location loss using smooth L1-Norm. It is still very effective and gives SSD more space because it does not strive to be "pixel perfect" in its bounding box prediction, despite being less accurate than L2-Norm. Since features maps, or the output of the convolutional blocks, represent the main features of the image at various scales, applying MultiBox to a number of feature maps raises the possibility that any object, no matter how big or small, will eventually be found, located, and classified correctly [12].

Having MultiBox on multiple layers leads in better detection as well because the detector runs on features at multiple resolutions. Having more default boxes yields more accurate detection, though there is a speed impact. Since the base VGG-16 network typically receives 80% of processing time, SSD performance might be further enhanced by a faster and more accurate network [9].



II. RELATED WORK

One method for identifying the kind of target objects and locating them on a video frame is vehicle detection. Many object detection algorithms evolved over the years and the accuracy levels are improved due to optimized algorithms, powerful compute infrastructure and ability to process in real time [1]. Two stage object detection models divide the detection process into the region proposal and the classification stage. In the first step, the region of interest (ROI) is proposed on the source images in the database [2]. In the next step, the proposals are regressed and classified using various versions of convolutional neural networks (CNN). Region Based Convolutional Neural Network (R-CNN) utilize low level computer vision algorithms like Selective Search and Edgeboxes to generate regions of interest in the input images and use CNN to produce features and SVM to classify the features. Fast R-CNN- FAST R-CNN overcomes the challenges of the RCNN. In RCNN the regions of interest are created for images and depending on the size of the image, the number of ROI could grow exponentially. FAST RCNN uses ROI pooling layer to extract the most highlighted color which could wrap multiple ROI. We pass it to SVM for classification. The performance of this model is much better than RCNN Mask R-CNN is developed on top of Faster R-CNN. Faster R-CNN is a two stage process [3]. In stage 2 of Faster R-CNN, the ROI pooling is replaced by RoI align which helps to preserve the spatial information. The output of the ROI align layer is then fed into two convolution layers, which generates a mask for each RoI. This is predominantly used for object detection and segmentation [4]. Jahongir et. al., proposed a novel bounding box (Bbox)-based vehicle tracking algorithm with CNN-based classifier. A new vehicle dataset is prepared by annotating 7216 images with 123831 object patterns collected from highway videos. The classification accuracy of the Yolo-based vehicle detector was increased from 57% to 95.45% [6].

The single stage model removes the region of interest (RoI) extraction process and directly classifies and regresses the detection boxes. These single stage models are usually faster in inferring the features from the images. Single Shot Multibox Detected (SSD) - The SSD approach is based on a feed-forward convolutional network that produces a fixed-size collection of bounding boxes and scores for the presence of object class instances in those boxes, followed by a non-maximum suppression step to produce the final detections. You Only Look Once (YOLO) – YOLO is a single convolutional network simultaneously predicts multiple bounding boxes and the class probabilities for those boxes. YOLO trains on full images and directly optimizes detection performance. This way of detection is extremely fast [6].

A Kalman filter with two observers was employed by Shuming Du et al. to provide analytical redundancy for traffic state estimation. The outcomes show that the developed system is capable of real-time, accurate sensor fault detection and identification. Under fault-free and sensor-failure scenarios, mobility, safety, and sustainability all consistently improve [7]. CenterNet - this structure has an important advantage in that it replaces the classical NMS (Non Maximum Suppression) at the post process, with a much more elegant algorithm, that is natural to the CNN flow [8]. This mechanism enables a much faster inference.

III. PROPOSED SYSTEM

To detect, identify, analyze and notify the tagged vehicles, the end-to-end solution is proposed and the same is depicted in Fig 1. The solution comprises four different modules.

Object Detection - Using a Deep Learning Model to Detect the object in the photo or a video frame and locate a number plate from the vehicle.

Object Character Recognition – Use OCR to convert the characters in the license plate from image to alpha numeric format.

Real time streaming – Stream the vehicle license plate information to a steaming engine. The consumer, which would be an analytics engine, would pick the license plate information from the stream pipeline and validate it against the Reference database which contains the vehicle of interest information along with law officer contact information.

Analytics – the data from the stream pipeline can flow to a data lake which can be used by a visual tool like tableau to show near real time date on the vehicle that crossed a junction etc.,

A. Object Detection

A lot of time needs to be invested to select and fine tune the model from beginning for desired accuracy and speed. To address this challenge, many pre-trained models are available which can be used by the machine learning engineers to focus on solving the domain problem rather than creating the model and Tensorflow is picked up for object detection requirements.

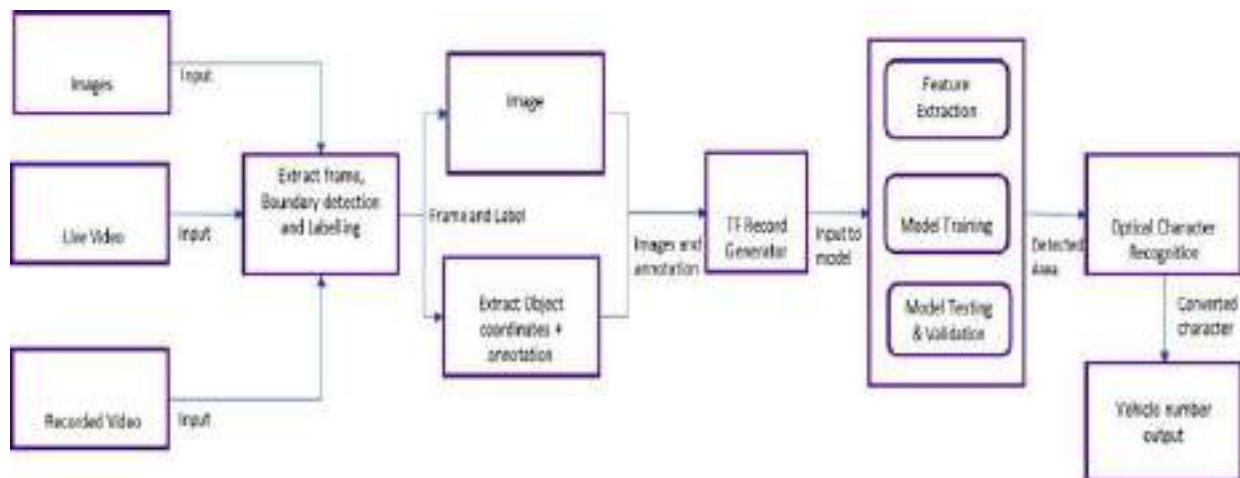


Fig. 1. Proposed System Architecture

Tensorflow is an open-source API that provides a set of comprehensive, composable and extensible low level API for high performance computation, primarily aimed at building machine learning (ML) models as well as authoring ML workflow tools and frameworks within the Tensorflow platform.

The TensorFlow Core APIs provide access to low level functionality within the TensorFlow ecosystem. This API provides more flexibility and control for building ML models, applications, and tools, compared to high-level APIs, such as Keras. Since the proposed solution is going to use object detection along with real time analytics, we need to choose a model that has balance between speed and mAP.

SSD MobileNet V2 FPNLite 320x320 model has been chosen for object detection and it has speed of 22 ms and mAP of 22.2. This model uses single stage object detection model Single Shot Multibox Detected (SSD) along with backbone network- Feature Pyramid Network (FPN) . Single shot detector used as VGG 16 or VGG19 network as a feature extractor. Then the custom convolution layers are added along with the convolution filters to make predictions. Feature Pyramid Network (FPN) is a feature extractor designed with feature pyramid concept to improve the accuracy and speed. It replaces the feature extractors like faster R-CNN and generates higher quality feature map pyramids.

The dimensions of the feature map are depicted in Fig 2.

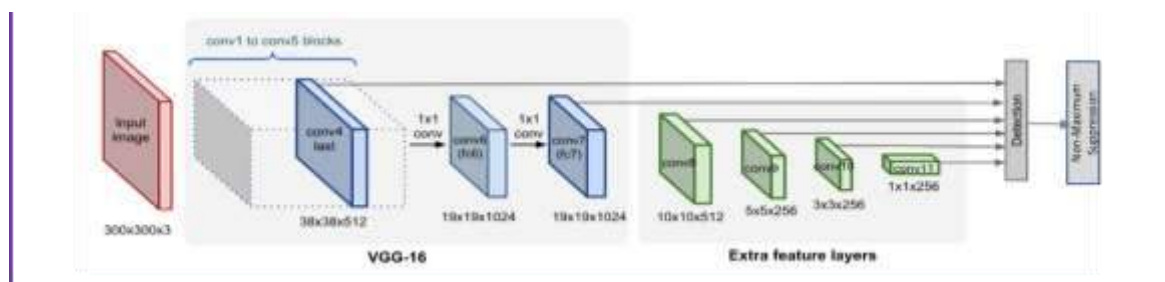


Fig.2. SSD Model

The chosen SSD MobileNet V2 FPNLite 320x320 model would use the combination of vehicle images along with its annotation around the license plate area to learn to detect the license plate in a vehicle. The public dataset from Kaggle is used in this solution. Annotations are created using LabelImg. It helps to select the area of interest and give a Label to it. In the below annotation, it is marked the area's name as "License". The XML gets generated for the image. The xmin, ymin, xmax, ymax marks the area of interest with the object name as "License"

```

<annotation>
<folder>PycharmProjects</folder>
<filename>Cars.jpg</filename>
<path>C:\Users\Senthil\Projects\Vehicle1.jpg</path>
<source>
<database>Unknown</database>
</source>
  
```

```

<size>
<width>1280</width>
<height>960</height>
<depth>3</depth>
</size>
<segmented>0</segmented>
<object>
<name>License</name>
<pose>Unspecified</pose>
<truncated>0</truncated>
<difficult>0</difficult>
<bndbox>
<xmin>515</xmin>
<ymin>666</ymin>
<xmax>788</xmax>
<ymax>729</ymax>
</bndbox>
</object>
</annotation>

```

Multiple datasets are used for the model training, and testing. The corresponding annotated xml files used to train and test the model. The model expects additional data in certain formats for it to train. Tensorflow object Detection API needs all the input data to be in a special format called TFRecord. A script is used to convert annotated XML to TFRecords.

Tensorflow object Detection APIs need the information on the classes created in the annotated xmls. Additional files should be created with information about the classes created in annotated xmls. The sample class information file will have the content as below item { name:'licence' id:1 }

The config file captures the essential details such as path for the class information file, train, test record, loss function information and batch size. The config file also allows configuring the model to optimize the model to cater to the business need. Once the Model is set up, train the model to learn from the train data set. The data set split 80% to training and 20% for testing. Below is the screenshot (figure 3) of the model being trained with 410 cars dataset.

```

INFO:tensorflow:Step 9888 per-step time 0.187s
I8312 08:51:08.944857 139677343805828 model_lib.v2.py:793] Step 9888 per-step time 0.187s
INFO:tensorflow:{"loss/losses": 0.183045385,
'loss/losses': 0.183045385,
'loss/regularization_loss': 0.12259816,
'loss/total_loss': 0.29628796,
'learning_rate': 0.073602736}
I8312 08:51:09.945158 139677343805828 model_lib.v2.py:793] {"loss/losses": 0.183045385,
'loss/losses': 0.183045385,
'loss/regularization_loss': 0.12259816,
'loss/total_loss': 0.29628796,
'learning_rate': 0.073602736}
INFO:tensorflow:Step 9889 per-step time 0.077s
I8312 08:51:09.542297 139677343805828 model_lib.v2.py:793] Step 9889 per-step time 0.077s
INFO:tensorflow:{"loss/losses": 0.14586188,
'loss/losses': 0.14586188,
'loss/regularization_loss': 0.12259816,
'loss/total_loss': 0.26846004,
'learning_rate': 0.073602736}
I8312 08:51:09.542644 139677343805828 model_lib.v2.py:793] {"loss/losses": 0.14586188,
'loss/losses': 0.14586188,
'loss/regularization_loss': 0.12259816,
'loss/total_loss': 0.26846004,
'learning_rate': 0.073602736}
INFO:tensorflow:Step 9890 per-step time 0.112s
I8312 08:51:09.111071 139677343805828 model_lib.v2.py:793] Step 9890 per-step time 0.112s
INFO:tensorflow:{"loss/losses": 0.12173132,
'loss/losses': 0.12173132,
'loss/regularization_loss': 0.18148778,
'loss/total_loss': 0.3032191,
'learning_rate': 0.073523527}
I8312 08:51:09.112121 139677343805828 model_lib.v2.py:793] {"loss/losses": 0.12173132,
'loss/losses': 0.12173132,
'loss/regularization_loss': 0.18148778,
'loss/total_loss': 0.3032191,
'learning_rate': 0.073523527}

```

Fig. 3. SSD Training Output

Real Time Analytics Setup

The second part of the problem domain is to validate the license plate numbers identified and streamed from the model against the reference license plate maintained by the law enforcement officer [sample data] and to store the data in a database.

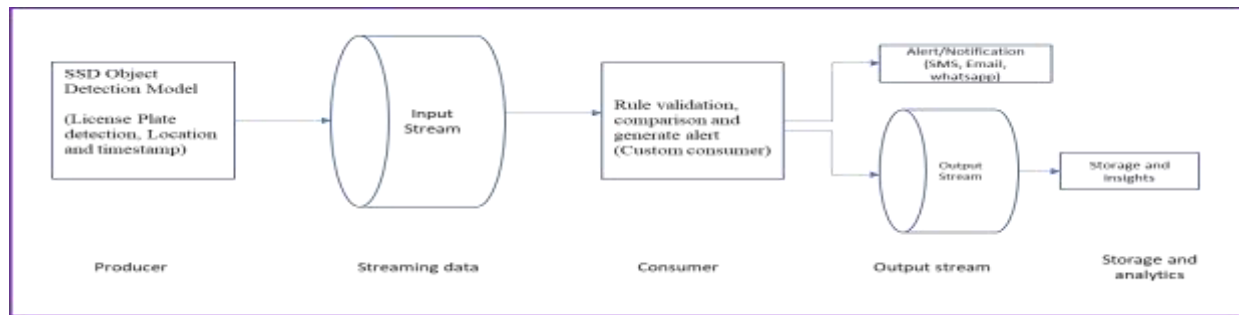


Fig. 4. Streaming Architecture

The streaming flow pipeline setup is depicted in Figure 4. AWS Kinesis is provisioned for a data streaming platform and multiple sources can be connected to it. It is a durable streaming service that aids the collection, processing and analysis of steaming data in real time. It is designed to allow you to get important information that is needed to make quicker decisions on time. Amazon kinesis Data Firehose is a service used to stream data from streams to destinations like Amazon simple storage Service (Amazon S3), Amazon Redshift, Amazon Open Search Service, splunk etc. Kinesis firehose does not need any code to be written or manage resources. Data producers need to configure to send data to a firehose and it automatically delivers the data to the destination that you specified. If the data needs to be transformed before delivering it, we can do it in Firehose.

Amazon Simple Storage Service (S3) is an object storage service offering industry - leading scalability, data availability, security and performance. Any amount of data can be stored for virtually any use case like data lakes, clout native applications and mobile apps. It is flexible to use any business intelligence and analytics platform. It gives options for the users to explore and manage data and faster to discover and share insights that can change the outcomes of the business. The solution implementation is described as below.

The License plate detector will detect the license plate from an image or video and add the geolocation information along with the time of detection and send it to the AWS Input data Stream. The sample output of detector is depicted in figure 5. Based on the input data volume, velocity, the number of shards can be dynamically managed based on the load.

The License plate information from the stream will be consumed by the custom consumer written in python. This consumer will get the reference data from S3 instance and compare near real time with the license plate information coming from the stream.

On successful comparison, a message is triggered to the phone number registered in the vehicle of interest database. Also a mail can be triggered to the registered email.

All the vehicle of interest information will be streamed to the S3 databases for further analytics.

Business intelligence tool connected with S3 data with the help of AWS Athena to generate a dashboard for further analytics.

B. Experiments

To detect the information in real time and generate output in real time, the real vehicle license plate information is fed as image to the algorithm and the data to the streaming pipeline and the vehicle has part of the Vehicle of Interest database stored in the S3 Database.



Fig. 5. License Plate Detection

The sample Vehicle of interest database is stored in my S3 bucket. It is in the form of a flat file. This reference data contains Vehicle of interest license plate number, an office phone number who is handling the case, the email id of the same office, the city and the station in which the complaint was made. As soon as the vehicle lincense plate is detected, it is sent to the input stream. The number of shards can be increased based on the load. When the data gets into the stream, it can load into any shard based on the load. Every item that enters the stream gets a sequence number for differentiation. It also carries the timestamp.



Fig. 6. WhatsApp Message

The output stream is pushed to S3 object storage and the same is captured in the Figure 6. The file was created from data push from vehicle-output stream.

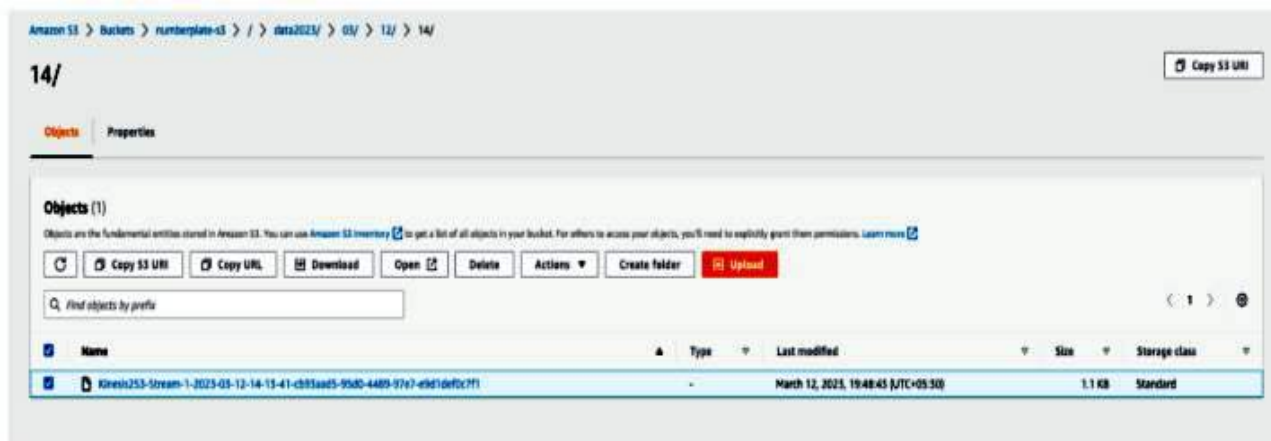


Fig. 7. Streaming to S3

Snapshot of the file from S3. All the vehicle information seen in vehicle-input-stream are available in the flat file (figure 8).

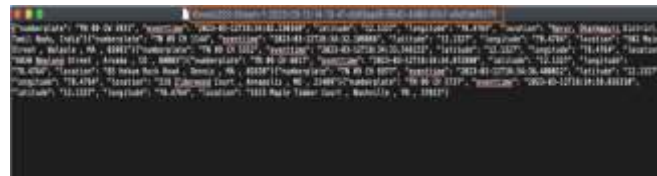


Fig. 8. Vehicle Input Stream Flat File

C. Performance Evaluation

The performance of the object detection model is measured by Mean Average Precision(mAP). The formula (Equation 1) to calculate the mean average precision is based on the confusion matrix, recall, precision and Intersection over union [14].

$$mAP = \frac{1}{N} \sum_{i=1}^N AP_i \quad \dots\dots\dots (2)$$

Finding the Average Precision (AP) for each class and averaging it over several classes yields the mAP. The IoU threshold affects the AP metric. The below log gives the mAP from the model used for object detection. The precision of a prediction is the ability to identify true positives (TP) among all positive forecasts (TP + FP) [15].



Fig. 9. Model Performance

Table 1 shows the performance of the proposed model and the same has been compared with Faster R-CNN. The proposed model clearly edges in terms of accuracy and precision with less loss than the Faster R-CNN.

Table 1. Performance of Proposed Model

Performance Metrics	Faster R-CNN	Improved SSD
Mean Average Precision	0.499	0.518
Average recall	0.521	0.574
Total Loss	0.723	0.547

This model performance can be improved by optimizing the parameters and updating the configuration. However, the model detects the number plate and deciphers the Number plate information to a much better degree of accuracy. The performance of the data that gets into the stream created by the producer and message sent to the registered mobile number after validating it with the reference database is near real time since the consumer code is not deployed in the production server and is manually executed. However, if the consumer is deployed and in the continuous listening mode, the performance of the analytics can be improved by a huge margin. It is observed that the data from AWS firehose takes a little time to reach the Amazon S3 bucket. More experiments have to be done to measure the delay.

IV. CONCLUSION & FUTURE WORK

It is observed that the MobileNet 320x320 SSD model could detect the license plate information of the car fairly accurately and was able to successfully convert the license plate information to alpha number ostring for comparison with the reference data during real time analytics. The model was trained only with the car dataset. Hence the model was able to detect the license plate in the car only. With the variety of the vehicles running in the Indian road, It is needed to train the model with all kinds of vehicles to make the model more resilient and to increase the success of detecting the license plate of any vehicle in Indian roads. Plethora of analytics applications are available for real time streaming and near real time streaming. The streaming is mimicked for simple scenarios. With the availability of real data, we can create a streaming architecture that can scale to handle very high load. This dissertation concludes that we can send real time or near real time information on location of vehicle to interested persons. With more data , this model can be scaled. The Future scope of this idea has tremendous potential in the field of security. By optimizing the objection detection model for better accuracy and faster detection in video, this model can be installed in CCTV in the city junctions. The probability of identifying a vehicle of Interest that crosses the junction and getting notified to the nearby law enforcement officer is very high. If this setup can be scaled to multiple strategic key junctions in the city, any vehicle can be found within a very short lead time as it would be hard for any vehicle to miss the key junctions in the city. The technologies used for this project like high optical cameras, computing power needed for running the object model on a live feed and doing analytics on the real time data stream are evolving at a greater speed and are available for cheaper cost. Since this is an academic research, the model was trained on a limited dataset and real time analytics was tested on mimicked situations. However, this model can be improvised for production scale by training it with a variety of vehicles dataset and can configure it with a cost effective analytics platform. A model setup can be deployed on a trial basis on a junction to learn from its performance. Based on the performance, the model can be scaled to multiple junctions to serve as a tool for the law enforcement officers to solve crime.

REFERENCES

- [1] Silva, S.M., Jung, C.R.: Real-time brazilian license plate detection and recognition using deep convolutional neural networks. In: 2017 30th SIBGRAPI Conference on Graphics, Patterns and Images (SIBGRAPI). pp. 55–62, 2017.
 - [2] Li Kang, Zhiwei Lu, Lingyu Meng, Zhijian Gao, “YOLO-FA: Type-1 fuzzy attention based YOLO detector for vehicle detection”, *Expert Systems with Applications*, vol. 237, pp. 121209, ISSN 0957-4174, 2023.
 - [3] Jahongir Azimjonov, Ahmet Özmen, “A real-time vehicle detection and a novel vehicle tracking systems for estimating and monitoring traffic flow on highways”, *Advanced Engineering Informatics*, vol. 50, pp. 101393, ISSN 1474-0346, 2021.
 - [4] Shuming Du, Saiedeh Razavi, “Fault-tolerant control of variable speed limits for freeway work zone using likelihood estimation”, *Advanced Engineering Informatics*, Vol. 45, pp. 101133, ISSN 1474-0346, 2020.
 - [5] Bulan, O., Kozitsky, V., Ramesh, P., Shreve, M.: Segmentation- and Annotation-Free License Plate Recognition With Deep Localization and Failure Identification. *IEEE Transactions on Intelligent Transportation Systems* 18(9), 2351–2363 (sep2017).
 - [6] Prashant Deshmukh, G.S.R. Satyanarayana, Sudhan Majhi, Upendra Kumar Sahoo, Santos Kumar Das, “Swin transformer based vehicle detection in undisciplined traffic environment”, *Expert Systems with Applications*, vol. 213, pp. 118992, ISSN 0957-4174, 2023.
 - [7] Selmi, Z., Ben Halima, M., Alimi, A.M.: Deep Learning System for Automatic License Plate Detection and Recognition. In: 2017 14th IAPR International Conference on Document Analysis and Recognition (ICDAR). pp. 1132–1138. IEEE (nov 2017).
 - [8] Kekevi, Ugur & Aydin, Ahmet. (2022).: Real-Time Big Data Processing and Analytics: Concepts, Technologies, and Domains. 7. 111-123. 10.53070/bbd.1204112.
 - [9] Lubna Aziz, Md. Sah Bin Haji Salam FC, Sara Ayub, “Multi-level refinement enriched feature pyramid network for object detection”, *Image and Vision Computing*, vol. 115, pp. 104287, ISSN 0262-8856, 2021.
 - [10] Delmar Kurpiel, F., Minetto, R., Nassu, B.T.: Convolutional neural networks for license plate detection in images. In: 2017 IEEE International Conference on Image Processing (ICIP). pp. 3395–3399. IEEE (sep 2017).
 - [11] Du, S., Ibrahim, M., Shehata, M., Badawy, W.: Automatic License Plate Recognition (ALPR): A State-of-the-Art Review. *IEEE Transactions on Circuits and Systems for Video Technology* 23(2), 311–325 (feb 2013).
 - [12] Redmon, J., Divvala, S., Girshick, R., Farhadi, A.: You Only Look Once: Unified, Real-Time Object Detection. In: 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). pp. 779–788. IEEE (jun 2016). <https://doi.org/10.1109/CVPR.2016.91>.
 - [13] Milosevic, Zoran & Chen, Weisi & Berry, A. & Rabhi, Fethi. (2016). Real-Time Analytics. 10.1016/B978-0-12-805394-2.00002-7.
 - [14] Alberto Rizzoli : The Ultimate Guide to Object Detection. url : <https://www.v7labs.com/blog/object-detection-guide>
- Anton Morgunov : How to Train Your Own Object Detector Using TensorFlow Object Detection API url : <https://neptune.ai/blog/how-to-train-your-own-object-detector-using-tensorflow-object-detection-api>



Computer-aided analysis of tapered roller bearings for rail transport system

N. Deepa¹ · Preeta Sharan² · Sneha Sharma¹

Received: 12 July 2023 / Accepted: 25 October 2023

© The Author(s), under exclusive licence to Bharati Vidyapeeth's Institute of Computer Applications and Management 2023

Abstract The major objective of this research is to estimate the effects of temperature on tapered roller bearings through the investigation of strain and thermal behaviors. Autodesk Fusion 360 is chosen to design the geometry in the manner specified and employing ANSYS Workbench to perform Finite Element Analysis. The stresses between the roller, interior, and exterior rings can be evaluated by bearing studies. This study focuses on thermal and static analysis to determine the temperature at various bearing locations and to simulate the bearing's condition to anticipate its condition. From our computational analysis of coupled finite element analysis for range of temperatures between 150 and 190 °C we observe inner racer temperature is higher than outer racer. At 190 °C inner racer and outer racer values obtained are 181.06 °C and 165.88 °C respectively. The outcome provides a clear picture of the temperature distribution on the bearing in relation to the stress and strain from structural analysis. Equivalent wavelength shift is calculated using the ANSYS result. GratingMOD optical tool is used to design and simulate Fibre Bragg Grating (FBG) sensors.

Keywords Bearing · Inner racer · Outer racer · Thermal and structural analysis

1 Introduction

The most typical bearings used in train carriages are tapered roller bearings [1]. When operated under perfect load, alignment, and contamination-free conditions, the service life is exceptionally long. In general, bearings will survive numerous reconditioning cycles and a longer lifespan than the life of the wheel before being retired. At the end of their lives, bearings will begin experiencing fatigue, especially true sub-surface fatigue, as opposed to their performance degrading due to surface imperfection. As a preventive step against potentially catastrophic events like derailments, railroads utilize bearing health monitoring equipment to identify problematic bearings while they are in operation and notify them of likely failures.

The machine is necessary for day-to-day survival. As a crucial component found in the vast majority of machinery, bearings play a significant function. This project's goal is to look at existing bearing performance for different temperatures. While overheating is the primary source of loss [2], it is impossible to predict bearing quality, thus security precautions are crucial. The stress-reducing feature is identified by an overall longer, more axial profile. When the misalignment angle increases, the pressure distribution moves to the right [3].

In this case, ANSYS analysis will be used to calculate the stresses between the roller, inner ring, and outer ring. By evaluating the stresses [4], we can decide whether or not to use a certain material to resist the stresses. We can also get measurements to build the bearings [5]. By taking Reynolds' number and surface roughness into account, finite element modeling is performed. The runway and tapered roller's von Mises stress and strain are determined [6]. Which lubricants should be used and how much to reduce bearing wear. Lubrication regulates wear and friction by bringing a

✉ Preeta Sharan
sharanpreeta@gmail.com

N. Deepa
deepanagaraju66@gmail.com

Sneha Sharma
sneha.ece@gmail.com

¹ Electronics and Communication, Dayananda Sagar University, Bengaluru 560068, India

² Electronics and Communication, Oxford College of Engineering, Bengaluru 560068, India

Original Article

Thinning Approach based on Sides Lobe Level Reduction in the Linear Array Antenna using Dynamic Differential Evolution

Anitha Suresh¹, C. Puttamadappa², Manoj Kumar Singh³

^{1,2}Department of Electronics and Communication, Dayananda Sagar University, Bangalore, India

³Manuro Tech Research Pvt. Ltd., Bangalore, India

¹Corresponding author: anisuri2011@gmail.com

Received: 08 January 2023

Revised: 06 February 2023

Accepted: 16 February 2023

Published: 28 February 2023

Abstract - This novel work has considered the problem of minimizing the side lobe level of linear array antenna patterns using the concept of thinning. In comparison to all element arrays, thinning approach activated only a fraction portion of the total available number of array elements at the suitable positions to achieve the objectives. The thinning problem has been transformed into a constrained optimization problem with the objective of minimizing the total number of activated array elements while simultaneously satisfying the desired side lobe and first null beam width. A new approach based on dynamic value assignment of mutation factor in the differential evolution has been proposed, which carries the random value assignment for each component of the differential vector. The proposed dynamic mutation factor assignment helped to explore and converge on a better solution compared to the standard approach. Fundamentally Differential evolution explores the solution over a continuous domain; hence a transformation is needed to convert the solution into the binary domain for thinning. The different existing forms of transformation, including sigmoid function-based S-shaped and V-shaped functions, have been considered under probabilistic and threshold-based binary conversion processes. It has been observed that the proposed form of differential evolution has explored a better solution by rounding the obtained real value to the nearest integer value and later assigning the binary value according to closeness to their binary value limit. For the linear array detail, experimental analysis has given and observed that the proposed solution has outperformed not only other variants of differential evolution but also performed better than particle swarm optimization results available in past literature.

Keywords - Array antenna, Thinning, Side lobe level, Linear array, Differential evolution.

1. Introduction

Antenna arrays are critical in detecting and processing information coming from various directions. Antenna array synthesis aims to achieve a physical architecture of the array with a radiation pattern near the required pattern. An antenna array is made up of many fixed antenna units that are often supplied coherently. Various antenna array applications have recently been proposed to improve the performance of mobile and wireless communication systems, such as effective spectrum usage, expanding channel capacity, extending coverage area, modifying beam shape, and so on. One of the most common antenna array difficulties is constructing a set of feeding values that must be applied to an array's ports to generate a radiation pattern that meets certain parameters. This is commonly referred to as synthesis. The fundamental goal of antenna research is to enhance array patterns by altering structural geometry to decrease SLL while keeping the main beam gain. In such antenna array geometry synthesis procedures, the objective is

to discover the physical structure of the array that provides the radiation pattern closest to the intended pattern. Many synthesis approaches coexist because the form of the intended pattern might vary greatly depending on the application.

Array thinning is a major method of synthesis that we hope would not only lower the side lobe level (SLL) but also reduce the number of array components and, therefore, significantly reduce cost. Array thinning is also a good way to make a compromise between low SLL and narrow beams. Low-side lobes offer mediocre defense against interfering signals that are incident on the array from any angle other than the main beam. Additionally, since random errors raise the side lobe level, lowering the side lobe level necessitates tighter tolerances on array components. A uniformly spaced or periodic array can be thinned by turning off some of its elements to achieve the desired amplitude density across the aperture. A component linked to the feed network is "on,"



Highly Accurate Technique for CO-OFDM Channel Estimation Technique Using Extreme Learning Machine (ELM)

NISHA MARY JOSEPH, PUTTAMADAPPA C.

Department of Electronics and Communication Engineering, Dayananda Sagar University,
Kudlu gate, Hosur, Bangalore,
INDIA

Abstract: - In wireless systems, channel estimation is considered a problematic technology, due to the fact of the difference in time between wireless channels and the noise effect. Orthogonal frequency-division multiplexing (OFDM) is a promising candidate for future optical communications and has received wide concern. The article proposed a Coherent Optical (CO) orthogonal frequency division multiplexing (OFDM) scheme, which gives a scalable and flexible solution for increasing the transmission rate, being extremely robust to chromatic dispersion as well as polarization mode dispersion. Nevertheless, both coherent detection and OFDM are prone to phase noise due to the phase mismatch between the laser oscillators at the transmitter and receiver sides and the relatively long OFDM symbol duration compared to that of single carrier communications. An Extreme Learning Machine (ELM) with Pilot Assisted Equalization (PEM) is proposed for compensation of impairments caused by fibre nonlinearity in coherent optical communication systems. Channel estimation using ELM and the value of distortion is sent to the OSTBC receiving end based on the distortion information the data is decoded and pilot data is removed. FFT is applied to the data and QPSK demodulation is done in the data to get its original form. In addition, the article utilized a free-space optical communication system of multi-input multi-output orthogonal frequency division multiplexing (MIMO-OFDM) with a modified receiver structure. Simulation reveals that the proposed model exhibits significant BER (0.0112) performance and provides better spectral efficiency as compared with conventional systems and less computational complexity. This suggested that the proposed method shows better performance by using the CO-OFDM-FSO-MIMO-ELM-based channel estimation technique for high-speed data communication networks in real-time scenarios respectively.

Keywords: - Optical Networks, Coherent Optical Orthogonal Frequency Division Multiplexing, Channel Estimation, Extreme Learning Machine, Bit Error Rate and Channel Equalization.

Received: April 4, 2022. Revised: January 6, 2023. Accepted: February 12, 2023. Published: March 9, 2023.

1 Introduction

Over the past few decades, global network traffic has grown explosively due to the demands for higher bandwidth and faster connections of various multimedia and data services (e.g. big data, cloud computing, streaming video, Internet of Things, machine-to-machine communication, and remote surgery), [1]. Conventional cable-based transmission approaches cannot meet the enormous data transmission requirements. With the advantages of low loss, large bandwidth, and anti-electromagnetic interference, optical fibres have replaced cables and have been widely used as the transmission medium in fiber-to-the-home (FTTH) networks, metropolitan area networks (MANs), backbone networks, and transoceanic communications, [2]. Due to the wide application of fibre-optic networks, optical fibres exist anywhere in modern society, and fibre can be exploited for

more functions than data transmission. In addition to acting as the transmission medium in fibre-optic networks, optical fibre can also act as the sensing medium in optical fibre sensors, [3]. The fibre channel model plays an essential role in the simulation and design of optical fibre communication systems. However, it is difficult for conventional model-driven modelling to balance accuracy and efficiency, especially in optical orthogonal frequency division multiplexing (OFDM) systems with complex and long-haul transmission, [4]. Orthogonal frequency-division multiplexing (OFDM) is a widely used modulation/multiplexing technology in wireless and data communications. With recent advances in high-speed CMOS technologies and optical modulation and detection technologies, optical OFDM at 40-Gb/s or even 100-Gb/s information rate becomes feasible. Together with digital coherent detection,

Original Article

Optimization of Thinned Circular Antenna Array Pattern using Dynamic Differential Evolution

Anitha Suresh¹, Puttamadappa C², Manoj Kumar Singh³

^{1, 2}Department of Electronics and Communication, Dayananda Sagar University, Bangalore, India.

³Manuro Tech Research Pvt. Ltd., Bangalore, India.

¹Corresponding Author : anisuri2011@gmail.com

Received: 14 March 2023

Revised: 17 April 2023

Accepted: 13 May 2023

Published: 31 May 2023

Abstract - Thinning array antennas have become one of the best approaches towards minimizing side lobes and achieving the required FNBW and SLL. Unlike all element arrays, thinning systematically removes some fraction of elements and activates the remaining element to obtain the intended pattern without degrading the performance of the antenna array. An evolutionary algorithm is gaining growth in providing better optimization solutions than other computational algorithms. In this research, Standard Differential Evolution (SDE) and Dynamic Differential Evolution (rDE) utilizing a range of binary mapping possibilities have been used to achieve thinning of Circular Antenna Array (CAA). Experimental result shows that D.E. with dynamic mutation factor technique has outperformed in fulfilling the desired radiation pattern for thinned CAA compared to all the variants of D.E. and also has exhibited finer solution compared to All Element Array (AEA) and Fire Fly Algorithm (FFA).

Keywords - Antenna array, Circular array, Differential evolution, Side lobe level, Thinning.

1. Introduction

The research in the field of antenna mainly concentrates on enhancing radiation patterns by altering the structure's geometry to minimize the side lobe level while maintaining the main beam gain. Several synthesis methodologies coexist, as the desired pattern varies substantially based on the application. SLL can be lowered using a thinning process by eliminating some elements in an equal-spaced array without degrading the antenna array performance. A few elements attached to the feed are kept 'on', and the elements attached to the matched load are made 'off'. Apart from lowering the side lobe levels, array thinning is also considered a cost-effective approach, as it reduces the array elements and the cost remarkably. Thinning can also be seen as a viable approach to balance lower SLL and narrow beams.

2. Related Work

Various synthesis methods use different optimization algorithms to get the desired radiation pattern. [1] has the thinning linear array antenna approach using a dynamic differential evolutionary algorithm, showing that Dynamic DE has outperformed different variants of the D.E. and Firefly algorithms. [2] and [3] discusses different methods for increasing the efficiency of an array aperture by interleaving a thinned linear array. Reduction of the Number

of Elements by Matrix Pencil Method and Hybrid Wow/G.A. algorithm in a Linear Antenna Array and design concepts of a linear array antenna are elaborated in [4], [5], and [6], respectively. The use of FFA for CCA thinning has been described in [7, 8]. [9, 10] covers the issue of circular and concentric circular antenna arrays' DOA estimate approaches. [11] discusses the use of ecology-based Flower Pollination Algorithms (FPA) on antenna arrays instead of linear antenna arrays. To suppress the high side lobe level (SLL) with particular half power beam width (HPBW) of the concentric circular antenna array (CCAA) based on the cuckoo search (C.S.) algorithm has been proposed in [12].

The thinning of concentric circular arrays using the Galaxy Based Search Algorithm (GBSA) has been considered in [13]. A firefly-cuckoo search algorithm (FCSA) has been proposed in [14] to remedy the beam sample optimization hassle of the random antenna arrays (RAA). A deterministic approach to synthesizing a standard a-periodic arc or ring antenna array is presented in [15]. The proposed method, based on the auxiliary array pattern (AAP) idea, has aimed toward the semi-analytical determination of the most excellent excitation tapering and array detail angular distribution for mimicking a given radiation sample mask without resorting to any optimization technique. A hybrid approach to minimizing SLL for concentric circular arrays has been proposed in [16].



A New Diminutive Wide-band MIMO Antenna with Frequency Agile Features for 4G and 5G Diverse Wireless Applications

Shivleela Mudda, Gayathri K M, and Mallikarjun M

Abstract—This paper demonstrates a low-profile, wide-band, two-element, frequency-reconfigurable MIMO antenna that is suitable for diverse wireless applications of 4G and 5G such as WLAN/Bluetooth (2.4–2.5 GHz), WLAN (2.4–2.484 GHz, 5.15–5.35 GHz, and 5.725–5.825 GHz), WiMAX (3.3–3.69 GHz and 5.25–5.85 GHz), Sub6GHz band proposed for 5G (3.4–3.6 GHz, 3.6–3.8GHz and 4.4–4.99 GHz), INSAT and satellite X-band(6 to 9.6 GHz). Proposed MIMO favour effortless switching between multiple bands ranging from 2.2 to 9.4 GHz without causing any interference. Both antenna elements in a MIMO array are made up of a single module comprised of a slot-loaded patch and a defective structured ground. Two PIN diodes are placed in the pre-set position of the ground defect to achieve frequency-reconfigurable qualities. The suggested MIMO antenna has a size of $62 \times 25 \times 1.5 \text{ mm}^3$. Previous reconfigurable MIMO designs improved isolation using a meander line resonator, faulty ground structures, or self-isolation approaches. To attain the isolation requirements of modern devices, stub approach is introduced in proposed design. Without use of stub, simulated isolation is 15dB. The addition of a stub improved isolation even more. At six resonances, measured isolation is greater than 18 dB, the computed correlation coefficient is below 0.0065, and diversity gain is over 9.8 dB.

Keywords—Diversity gain (DG); Defective ground structure (DGS); Fractional bandwidth (FBW); ITU (International telecommunication union); INSAT; Frequency Reconfigurable antenna (FRA); Multiple input multiple output (MIMO); Mutual coupling; Isolation; 5G; Envelope correlation coefficient (ECC)

I. INTRODUCTION

FIFTH-generation (5G) wireless communication has received a lot of interest in recent years. The rapid increase in portable device traffic is the driving force behind the intense interest in the development of 5G technology. With the exponential growth of wireless devices, a variety of issues have emerged, such as spectrum congestion, lower data rates, reduced channel capacity, improper spectrum usage, interference, and jamming. 4G technological innovations were inefficient to quench the modern era's need. Wider operating bandwidth is helpful in enhancing channel capacity and data rates in current and future generation devices [1]. An antenna is an element mean for radiation and reception of signals that reveal information. Industry sponsors' requirements for 5G antenna design include frequency tuning, low cost, wide bandwidth, a steady radiation pattern, increased channel

capacity, and improved link reliability. Such requirements cannot be met by a single antenna. To satisfy the aforesaid needs, 5G employs MIMO antennas [2]. The FCC has designated a sub-6 GHz (3.2 to 6 GHz) frequency band for 5G wireless communication since it can provide improved spectral efficiency in the available spectrum and facilitate network development in urban areas [3]. As portable devices are becoming lighter and thinner by the day, a typical MIMO antenna for 5G devices should meet specified criteria like compact structure with high gain, steady radiation pattern, and low envelop correlation [4]. The most effective way to make MIMO compact is to replace multiple fixed-performance antennas of MIMO with frequency-reconfigurable antennas, which provide coverage for several wireless applications on the same platform based on switching conditions [5]. FRA also aids in maintaining high data rate and adequate isolation between antenna units within MIMO [6].

MIMO's close proximity of radiating units provides compactness at the expense of high mutual coupling, which reduces throughput. A compact MIMO antenna design with good performance and the additional need for tunable behavior is a significant issue for portable devices. Various external and internal decoupling strategies have been reported to construct a MIMO antenna system with excellent element isolation [7]. These methods can modify coupling by constricting, blocking, or reducing surface current flow.

Several MIMO frequency reconfigurable antennas for 4G, 5G, S-band, and X-band applications are documented in the literature. However, the majority of them focused on single-band MIMO, a few on multiband, and a very few on FR-MIMO antennas. A triband, dual-port FRA MIMO system based on C-structured defects in the patch and four-pin diodes was proposed in a paper [8]. The designed MIMO antenna has an overall volume of $60 \times 20 \times 0.8 \text{ mm}^3$. This achieves good isolation by incorporating an inverted T-shaped defect between the elements. To improve isolation, a unique C-structured meandered-line-resonator (MLR) is placed on top between elements. A frequency reconfigurable quad-band MIMO antenna designed on the basis of complex structure of a ring and new moon is presented in [9]. To diminish mutual coupling between close elements, a gradient arc structure is utilized, which is challenging to achieve. The antenna is $71 \times 30 \times 1.6 \text{ mm}^3$ in overall volume. Due to the near proximity of the

Shivleela Mudda and Gayathri K M are with Dayananda Sagar University, Bangalore, India (e-mail: muddass1982@gmail.com, gayathri-ece@dsu.edu.in).

Mallikarjun M is with Srinidhi Institute of Science and Technology, Hyderabad (Telangana), India (e-mail: mudda77@gmail.com).



Smart Healthcare System Using IoT, Cloud and AI/ML

Ambar Bajpai^{1,*}, Manoj Tolani² and Arun Balodi³

¹Dept. of EE, Chulalongkorn University, Bangkok, Thailand

²Dept. of ICT, Manipal Institute of Technology, MAHE, Manipal, India

³Dept. of ECE, Dayananda Sagar University, Bangalore, India

Received 7 August 2023; Accepted 20 October 2023

Abstract

This survey presents various insights on the IoT system and its architecture used to implement a smart health-care system, along with the implementation of the latest technologies such as Cloud Computing for storing data, Machine Learning for predicting various diseases. These technologies are also used to improve the existing management and administration system in hospitals. Various solutions for tackling the health-care crisis have been proposed most of them sound promising but a practical low-cost implementation and feasibility of IoT and ML integrated system is yet to be designed. The present chapter also deals with the standard protocols designed for body area networks for health monitoring applications. The IEEE 802.15.6 standard is used for the body area network which provides high data rate and low-range communication. The integration of the standard body area network protocols with 5G technology can be used for high throughput real-time reliable operations.

Keywords: AI/ML, Health-care, IoT, Machine Learning

1 Introduction

Health-care system has always been a top priority in everyone's life, while the development of infrastructure and technologies used in health-care have been improving every year, it's not affordable and accessible to everyone, and rural places lack basic health facilities. To bridge this gap, this article looks over some of the proposed solutions to implement and improve the e-healthcare system so that we can help people who do not have access to basic healthcare by providing them with one.

In this survey, we go through various solutions proposed by authors using the latest technology such as Artificial Intelligence, Cloud, Internet of Things and Machine Learning. Let us see how each of these technologies is used to build a healthcare system. In some countries, paper-based storing of reports is still being used. To go to a completely paperless and hassle-free management and administration system, we investigate how cloud computing takes a major role. These days due to less qualified and fewer assistants available to support doctors and patients. AI/ML models can be used in health systems to predict diseases in their early stages and in managing the records of a hospital to make the system more elegant with less human error. Now, that we have seen how these technologies can be used in hospitals, we shall further look into how to integrate these technologies with IoT to make a compact healthcare system. In the year 2016-17 we came across how IoT is used to build smart healthcare systems, all these systems are driven by a microcontroller. There are several low-power, low-cost microcontroller units present in the market with their own advantages and disadvantages. Various sensors are used to check the patient's body parameters. Once the data is collected it is processed by a microcontroller and then to a server for storing those

sensory data. In this survey, we see solutions proposed by different authors using IoT and then integrating IoT with AI/ML and cloud technologies.

The purpose of this survey is to find the best-optimized solution for the upcoming smart hospitals. This survey gives us information about the sensors, processors, machine-learning algorithms and other components; we may need to achieve an efficient and affordable system. As we intend to work on making a personalized e-health care system where patients with different diseases can customize the system as per their requirement, all the data collected from the sensors will be uploaded on a server where the data is simultaneously compared with threshold values of the data. A machine-learning algorithm is run throughout the data to check if there are any irregularities; if such exists it gives feedback or alerts doctors so necessary precautions can be taken.

Furthermore, this article presents IoT-related work in section II. In section III, we are discussing AI/ML and cloud-related work in IoT. Section IV, discusses the timeline of IoT-related technologies. Section V deals with health monitoring body area network protocols. Finally, section VI and section VII deals with the conclusion and future scope.

2 Literature Study

A health monitoring system proposed by Yuan Falee et. al. [1], where a patient can share his health readings such as blood pressure, Electrocardiogram (ECG), glucose level on blood etc. via a platform which is connected to the internet i.e., IoT using this platform doctors can monitor the patient's data on a regular time interval and also a patient can share his data to a different doctor for a second opinion. The data is collected through individual components which are connected via Bluetooth and smartphones. The author proposes a completely interconnected hardware and software setup

*E-mail address: ambarbajpai@gmail.com



Document details - Asynchronous Wrapper-Based Low-Power GALS Structural QDMA

1 of 1

[Export](#) [Download](#) [More...](#)

IETE Journal of Research

Volume 69, Issue 10, 2023, Pages 7208-7217

Cited by 0 documents

Inform me when this document is cited in Scopus:

[Set citation alert](#)[Set citation feed](#)

Asynchronous Wrapper-Based Low-Power GALS Structural QDMA(Article)

Vinay, B.K., Pushpa Mala, S., Deekshitha, S.

^aDepartment of Electronics and Communication Engineering, Vidyavardhaka College of Engineering, Mysuru, 570 002, India^bDepartment of Electronics and Communication, Dayananda Sagar University, Karnataka, Bangalore, 560 114, India

Abstract

The design of System-on-Chip systems using synchronous circuits involves complex clock distribution strategies, which envisage challenges for designers to integrate large-scale systems. Globally Asynchronous Locally Synchronous architectures containing asynchronous port controllers encapsulated in the self-timed wrapper have been adopted in this work. These port controllers communicate through Asynchronous Finite State Machines defined by Signal Transition Graphs are implemented adopting the C element. This GALS architecture implemented for the point-to-point interface can also be modified for the multipoint interface. The proposed methodology uses a two-phase handshake protocol to communicate between two Locally Synchronous modules as it has fewer signal transitions, which, in turn, reduces latency. In this paper, the Queue Direct Memory Access subsystem is implemented using the Vivado simulator on UltraScale+™ device at a maximum frequency of 257.4MHz, and various parameters are reported. A comparison shows that the proposed wrapper has improved latency time of 53%, with a reduction in power dissipated by 27% and an increase in gate count by 13%. © 2023 IETE.

Author keywords

[Asynchronous wrapper](#) [Globally asynchronous locally synchronous](#) [Handshake protocol](#) [Muller C element](#) [Port controller](#) [Signal transition graphs](#) [Synthesis logic](#)

Indexed keywords

Engineering controlled terms:

[Controllers](#) [Interface states](#) [Large scale systems](#) [Memory architecture](#)

Engineering uncontrolled terms

[Asynchronous wrapper](#) [C-element](#) [Globally asynchronous locally synchronous](#) [Globally asynchronous locally synchronous architecture](#) [Handshake protocol](#) [Muller C element](#) [Port controllers](#) [Signal transition graph](#) [Signal transition graphs](#)

Engineering main heading:

[System-on-chip](#)

Related documents

Find more related documents in Scopus based on:

[Authors](#) [Keywords](#)

SciVal Topic Prominence ⓘ

Topic:

Prominence percentile: ⓘ

About Scopus

[What is Scopus](#)

[Content coverage](#)

[Scopus blog](#)

[Scopus API](#)

[Privacy matters](#)

Language

[日本語版を表示する](#)

[查看简体中文版本](#)

[查看繁體中文版本](#)

[Просмотр версии на русском языке](#)

Customer Service

[Help](#)

[Tutorials](#)

[Contact us](#)

ELSEVIER

[Terms and conditions ↗](#) [Privacy policy ↗](#) [Cookies settings](#)

All content on this site: Copyright © 2024 Elsevier B.V. ↗, its licensors, and contributors. All rights are reserved, including those for text and data mining, AI training, and similar technologies. For all open access content, the relevant licensing terms apply. We use cookies to help provide and enhance our service and tailor content.By continuing, you agree to the use of cookies ↗.





Regular Articles

A rail wheel contact temperature prediction model using fiber Bragg Grating sensor on test rig

N. Deepa^a, Preeta Sharan^{b,*}, Sneha Sharma^a

^a Dept. of Electronics and Communication Engineering, Dayananda Sagar University Bengaluru, India

^b Dept. of Electronics and Communication Engineering, The Oxford College of Engineering Bengaluru, India

ARTICLE INFO

Keywords:

Predictive modelling
Temperature prediction
Machine learning techniques
Railway safety
Operational efficiency

ABSTRACT

The focus of this research is the development of predictive models for temperature forecasting of rail wheel contact temperature through data collection from experimental setup with Single wheel test rig. Fibre sensing technology and the implementation of machine learning techniques are used. Our approach involves utilizing a dataset containing crucial variables such as time, speed, weight, and sensor readings in order to accurately predict temperature changes. To achieve this, we employ a thorough preprocessing methodology that includes data cleansing, normalization, and feature selection, followed by the implementation of various machine learning algorithms for regression tasks. The effectiveness of each model is evaluated using metrics like Mean Squared Error and R-squared. Experimental results reveal significant findings, including a Linear Regression model with an R-squared value of 0.9176, indicating it accounts for 91.76% of temperature variation. Furthermore, Decision Tree and Random Forest models exhibit remarkable accuracy, achieving R-squared values of 0.999997 and 0.999995 respectively. Through extensive analysis and discussion, we gain insights into the strengths and limitations of different models, ultimately identifying the most optimal approach for temperature prediction. This research serves to advance temperature forecasting methodologies in the field of railway ultimately contributing to improved safety, efficiency, and decision-making processes.

1. Introduction

Railway systems are crucial elements of modern infrastructure that enable the efficient and reliable transportation of passengers and freight. The maintenance of optimal conditions for various components, including train wheels, is essential for the seamless operation of railway networks. The temperature of train wheels is a critical factor that impacts safety, wear and tear, and operational efficiency. To address these concerns, predictive modelling of temperature in railway systems using machine learning techniques has emerged as a valuable approach [1].

Accurate forecasting of temperature variations in train wheels allows for proactive maintenance strategies, reducing the risk of overheating, track damage, and potential accidents. By utilizing data on time, speed, weight, and sensor readings, predictive modelling provides insights into the complex interplay of factors that influence temperature dynamics. This information empowers railway operators to make informed decisions, optimize maintenance schedules, and enhance overall safety and reliability in railway operations [2,3].

In recent years, machine learning techniques have gained

prominence for their ability to handle large and complex datasets, extract meaningful patterns, and make accurate predictions. Leveraging these techniques for temperature prediction in railway systems holds promise for advancing predictive maintenance practices and optimizing operational efficiency. Despite considerable research in this area, there is a need for further exploration, refinement, and validation of predictive models to ensure their effectiveness and reliability in real world railway environments [4,5]. This paper aims to bridge this gap by providing a comprehensive analysis of predictive modelling of temperature at rail wheel contact using state-of-the-art machine learning techniques from the obtained experimental results. We begin by reviewing existing literature on temperature prediction in railway systems and identifying key research gaps. Then, we propose a framework for predictive modelling and present a case study to demonstrate its potential applications. Through this study, we hope to contribute to the advancement of predictive maintenance practices and enhance the safety and reliability of railway operations.

* Corresponding author.

E-mail address: Sharanpreeta@gmail.com (P. Sharan).

<https://doi.org/10.1016/j.yofte.2024.103909>

Received 8 May 2024; Received in revised form 20 June 2024; Accepted 9 July 2024

1068-5200/© 2024 Elsevier Inc. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

EXPLORING THE INFLUENCE OF ARTIFICIAL INTELLIGENCE ON THE BUSINESS LANDSCAPE IN INDIA: AN IN-DEPTH ANALYSIS AND IMPLEMENTATION IN BANKING SECTORS

Anupama Reddy¹, Padmalatha²

¹Research Scholar, Research Centre, Department of MBA,
School of Commerce & Management Studies, Dayananda Sagar University,
Bangalore, Karnataka India

²Professor & Supervisor, School of Commerce and Management Studies,
Department of MBA,
Dayananda Sagar University, Bangalore, Karnataka, India

Received: 02/2024

Published: 04/2024

ABSTRACT:

The proposed research work explores the Influence of AI on the business landscape in India with an in-depth analysis & its implementation in few sectors. This research delves into the transformative impact of Artificial Intelligence (AI) on the business landscape in India, conducting a comprehensive and in-depth analysis. The study aims to unravel the multifaceted ways in which AI technologies are shaping the strategies, operations, and competitiveness of businesses across various sectors in the Indian economy. Through a combination of empirical research, case studies, and industry interviews, the research seeks to identify key trends, challenges, and opportunities arising from the integration of AI into business practices. The investigation spans diverse domains, including finance, healthcare, manufacturing, and services, aiming to capture the nuanced effects of these technologies on productivity, innovation, and overall business performance. Furthermore, the study explores the readiness of Indian businesses to adopt and implement AI solutions, examining the factors influencing successful integration and potential barriers hindering widespread adoption. As an integral part of the research, the study also emphasizes the practical aspects of implementation, providing insights into best practices and strategies for businesses aiming to leverage AI technologies effectively. By doing so, it contributes actionable recommendations to industry stakeholders, policymakers, and academia, fostering a more informed and strategic approach to navigating the evolving landscape of business in the era of AI. Ultimately, this research aspires to be a valuable resource for decision-makers, offering a holistic understanding of the current state and future trajectory of AI in the Indian business ecosystem. This research further investigates the impact of Artificial Intelligence (AI) on the service sector, a pivotal contributor to a country's socio-economic growth. With a focus on gathering primary data from AI-utilizing organizations and secondary information from researchers, the study aims to analyze and draw conclusions regarding the effects of AI on both productivity and customer satisfaction. As consumer expectations for enhanced and faster services persist, companies are adapting by integrating AI, making it crucial to understand the implications of this technological shift. In the proposed work, a service sector in the country is taken into consideration. The service sector significantly contributes to a country's socio-economic growth, driven by an increasing demand for better and faster services from consumers. To meet this demand, companies are continually innovating, and a notable shift in this sector involves the adoption of Artificial Intelligent Chatbots. These chatbots offer rapid responses at a minimal cost compared to human support, transforming customer interactions. While AI continues to evolve and is considered young by scientists, it has already proven efficient in replacing repetitive mundane tasks. This study aims

to collect primary data from organizations utilizing AI chatbots and secondary information from researchers, with the goal of analyzing and concluding the impact of AI Chatbots on both productivity and customer satisfaction. To begin with, first a survey was conducted amongst 5 Asian countries (one amongst them being India) and the analysis was carried out, the results discussed and summarized. The future works plans to develop more business canvas models for the successful implementation of AI not only in banking sector, but also in a large no. of establishments.

Keywords: AI chat-bots , customer interactions, socio-economic growth.

INTRODUCTION:

Artificial Intelligence (AI) refers to machines demonstrating human-like intelligence, encompassing processes such as learning, reasoning, self-correction, and problem-solving. Coined by computer scientist John McCarthy in 1956, AI has evolved to include features like Speech Recognition, Machine Vision, and expert systems, enabling the analysis and resolution of complex data. Businesses leverage AI to enhance decision-making by efficiently identifying patterns in data. Examples like Apple's Siri, Google's Okay Google, and Amazon's Alexa represent narrow AI designed for specific tasks. With consumer demands for quicker and better services on the rise, the service industry is incorporating AI to meet the expectations for 24/7 on-demand services. This shift aims to eliminate repetitive tasks in customer service and administrative roles, streamlining operations and maximizing efficiency. The Figure 1 gives the role of AI in banking – a pictorial perspective in a nutshell [1].

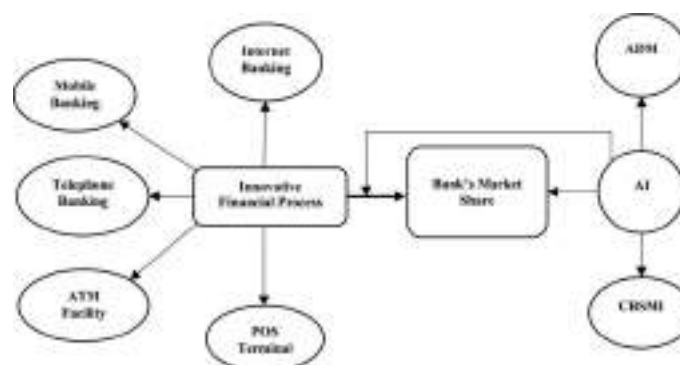


Figure 1: Role of AI in banking – a pictorial perspective

In the rapidly evolving landscape of business and technology, the integration of Artificial Intelligence (AI) has emerged as a transformative force, reshaping traditional business models and strategies. This research embarks on a comprehensive exploration of the profound influence exerted by AI on the business landscape in the dynamic context of India. As the world's largest democracy and a burgeoning economic powerhouse, India serves as a compelling backdrop for understanding the intricate interplay between advanced technologies and the intricacies of diverse industries [2]. When the background and rationale aspects are considered, the advent of AI technologies has ushered in a new era of innovation, efficiency, and competitiveness in the business domain. The fundamental shift from conventional to intelligent, data-driven decision-making processes has become imperative for organizations aiming to thrive in the contemporary market. Against this backdrop, the Indian business landscape presents a unique and complex

terrain, characterized by a rich tapestry of industries ranging from Information Technology (IT) and healthcare to manufacturing and services. This study seeks to unravel the ways in which AI are influencing and, in some instances, revolutionizing these diverse sectors [3]. In the following next few paragraphs, we are going to identify the **research gaps**, which are presented as follows [4]. Identifying research gaps involves recognizing areas where existing literature may be incomplete or insufficient. While the specific gaps can vary depending on the depth of existing research, here are some potential research gaps for the proposed research topic chosen [5].

- Many studies may provide a broad overview of AI in India, but there might be a gap in detailed sector-specific analyses. Research could delve deeper into how these technologies impact sectors such as healthcare, manufacturing, finance, and services, identifying unique challenges and opportunities [6].
- Existing literature may touch upon the adoption of AI but might lack a comprehensive examination of specific implementation strategies and best practices employed by successful businesses in India. Research could aim to fill this gap by offering detailed insights into the strategic approaches that lead to successful integration [7].
- Many studies might focus on large enterprises, potentially leaving a gap in understanding how AI adoption unfolds in small and medium enterprises (SMEs). Investigating the specific challenges and benefits for SMEs in India could provide a more complete picture of the overall business landscape [8].
- While some research may touch upon ethical considerations in AI, there might be a gap in exploring the societal impact of AI adoption in India comprehensively. This includes issues related to employment [9].
- The regulatory and policy frameworks governing AI adoption in India may not be fully explored in existing literature. A research gap exists in understanding how existing policies impact businesses and what regulatory changes or frameworks might be necessary to facilitate responsible AI integration [10].
- The literature may not extensively cover the evolving skill requirements and workforce dynamics resulting from AI adoption. Research could focus on identifying the skills essential for the future workforce in India and the potential need for reskilling initiatives [11].
- Many studies may provide insights into short-term impacts, but there could be a gap in understanding the long-term effects of AI adoption on businesses and the overall sustainability of these technologies in the Indian business landscape [12].
- While some studies might touch upon global trends, a research gap may exist in providing a detailed comparative analysis between AI practices in India and those in other leading global economies. This could offer valuable insights into India's standing and potential areas for improvement.
- Existing research may not thoroughly explore user perceptions of AI technologies in India or the specific challenges hindering widespread adoption. Investigating the cultural and user-related aspects can provide a more comprehensive understanding of the factors influencing adoption rates [13].
- Research may not extensively explore collaborative initiatives between different industries in India to leverage AI synergies. Investigating opportunities for cross-industry

collaboration could uncover novel approaches and strategies for maximizing the impact of these technologies [14].

Addressing these research gaps would contribute to a more comprehensive and nuanced understanding of the influence of AI on the business landscape in India, providing valuable insights for businesses, policymakers, and researchers. Similar to the works presented by a large no. of researchers, teachers, authors, engineers, scientists, students, etc... in the preceding paragraphs, there were still quite a large number of works done by many researchers across the world till date in the field of business landscaping in the country. But, here, we have considered only the important ones [1] – [30] which are being referred & cited by us in this half yearly progress report. In majority of the work done by the various authors presented in the previous paragraphs, there were certain drawbacks such as consideration of only:

- use of conventional methods,
- high compilation time,
- computationally very expensive,
- experimental results were not accurate,
- full-fledged automation of algorithms not done,
- less work done on increasing the accuracy & performance of the developed algos,
- real time implementation in the business circles, very few people done, etc.,

Some of the above-mentioned drawbacks which were existing in the works done by the earlier researchers were considered in our research work & new experimentation were developed in order to overcome some of the deficiencies of the existing algorithms & results and also sincere effort is made to develop some highly efficient algorithms for the same. Once the problem is defined after making a thorough review of the work done by various authors, the problem was defined and thus various parameters in the business model is going to be analyzed while designing the automated business model system & make it more efficient. This concept could be treated as the outcome of our research work [15]. In the following next few paragraphs, we are going to carry out the **formulation of the research problem**, which are presented as follows [16]. The **formulation and definition of the research problem** for “*Exploring the Influence of Artificial Intelligence on the Business Landscape in India: An In-Depth Analysis & Implementation*” involved a careful consideration of key factors and a thorough review of existing literature. The process aimed to articulate a clear and focused research problem that could guide the study effectively [17]. First step was identifying the research context. The first step involved understanding the broader context of the study. Recognizing the increasing prominence of Artificial Intelligence (AI) on a global scale, the research narrowed its focus to the specific dynamics within the Indian business landscape. The context highlighted India's position as a major economic player, the diversity of its industries, and the ongoing technological transformations [18]. The second step was to review the existing literature. A comprehensive review of existing literature was conducted to gain insights into the current state of AI in Indian businesses. This involved studying academic papers, industry reports, and scholarly articles that addressed the adoption, challenges, and outcomes of AI technologies. Literature helped identify gaps in knowledge, potential research questions, and critical aspects requiring further exploration [19]. Next, we define the key research objective. Based on the literature review, the research objectives were defined to guide the study's focus. These objectives aimed at conducting a detailed analysis of the influence of AI, spanning data collection from organizations actively using these technologies, cross-sectoral examination, investigation of implementation strategies, exploration of challenges and opportunities, and the development of actionable recommendations [20].

In this context, we have to consider some practical implications of the problem defined. The research problem was formulated with a keen eye on practical implications. Recognizing that

businesses, policymakers, and researchers would benefit from actionable insights, the research problem aimed to address real-world challenges and opportunities associated with AI adoption in Indian business landscape [21]. Finally, we have to align with academic, research & business models to implement the significance of the proposed works. Ensuring the research problem's alignment with both academic and practical significance was a crucial aspect of its formulation. By exploring the influence of AI in depth, the research sought to contribute to academic knowledge while providing practical guidance for businesses and policymakers navigating the evolving technological landscape in India [22]. In summary, the formulation and definition of the research problem involved a systematic process that considered the broader context, existing literature, and practical implications. The defined research problem serves as a guide for the study, delineating the boundaries and objectives essential for a comprehensive exploration of the influence of AI on the business landscape in India [23]. In the following next few paragraphs, we are going to do the **research focus** on the gaps how we are going to tackle them in this paper, which are presented as follows [24]. The research focus of “*Exploring the Influence of Artificial Intelligence on the Business Landscape in India: An In-Depth Analysis & Implementation in Banking Sectors*” revolves around comprehensively investigating the impact and implementation of artificial intelligence (AI) within the banking sector of India. The primary objective is to delve into how AI technologies are influencing and reshaping various facets of the business landscape, particularly in the banking industry. The study aims to provide an in-depth analysis that encompasses the challenges, opportunities, and strategies associated with the integration and deployment of AI in the banking sector. The research will involve a meticulous examination of AI applications in banking, covering areas such as core banking, operational performance, and customer service. By exploring the intricacies of AI adoption, the study seeks to uncover the nuances of how these technologies are transforming traditional banking practices [25]. Additionally, the research will focus on understanding the perspectives and intentions of stakeholders, including customers and management, regarding the adoption of AI in banking operations. The implementation aspect of the research aims to provide practical insights into how banks in India are incorporating AI into their systems and processes. This involves an exploration of the challenges faced by organizations, the strategies employed for successful integration, and the overall impact on efficiency and customer experience. The specific focus on the banking sector ensures a sectoral lens through which the broader implications of AI on the Indian business landscape can be understood. Ultimately, the research strives to contribute valuable insights that can guide decision-makers, policymakers, and industry professionals in navigating the evolving landscape of AI in the Indian banking sector [26]. In the following next few paragraphs, we are going to present the what **motivated us to take up the research work** on the proposed topic mentioned in this paper, which are presented as follows [27]. In this section, the motivation that was obtained to take up the research work on the proposed topic is presented in a nut-shell. The motivation to undertake the research work on “*Exploring the Influence of Artificial Intelligence on the Business Landscape in India: An In-Depth Analysis & Implementation*” stemmed from several interconnected factors, reflecting both academic and practical considerations which could be summarized as under [28].

Technological Advancements and Global Trends - The rapid advancements in Artificial Intelligence (AI) technologies have ushered in a transformative era across industries worldwide. The increasing global trend of businesses integrating these technologies into their operations prompted the motivation to understand how this paradigm shift manifests in the unique context of India [29].

Strategic Importance of India's Business Landscape - India, as a major player in the global economy, is witnessing a dynamic business landscape marked by diversity in industries, technological adoption, and economic growth. Recognizing the strategic importance of India, the research aimed to explore how AI influence various sectors within the country, contributing to its socio-economic development [30].

Addressing Knowledge Gaps - The

motivation also stemmed from the identified knowledge gaps in the existing literature. While there is a growing body of research on AI, there was a need for a comprehensive study specifically focusing on the Indian business landscape. The research sought to fill these gaps by providing nuanced insights into the challenges, opportunities, and implementation strategies relevant to India [1].

Practical Implications for Businesses and Policymakers - The practical implications of AI adoption for businesses and policymakers in India were a driving force. Understanding how these technologies impact productivity, innovation, and job creation is crucial for informed decision-making. The research aimed to offer actionable recommendations that could guide strategic planning for businesses and inform policy initiatives.

Socio-Economic Development and Innovation - The broader motivation encompassed the desire to contribute to India's socio-economic development. By exploring how AI can be leveraged across sectors such as healthcare, manufacturing, and services, the research aimed to identify avenues for innovation, efficiency, and sustainable growth [2].

Skill Development and Workforce Dynamics - Recognizing the evolving nature of work in the age of AI, there was a motivation to investigate how these technologies impact workforce dynamics and skill requirements. The research aimed to shed light on the skills essential for the future workforce and the potential need for reskilling initiatives [3].

Academic Contribution and Research Gap Addressing - On an academic front, there was a motivation to contribute to the existing body of knowledge on AI. The research aimed to provide a detailed and nuanced analysis, addressing specific research questions and thereby contributing to the academic discourse on the subject [4].

In summary, the motivation for the research work was multifaceted, driven by the desire to understand, contribute, and provide practical insights into the influence of AI on the business landscape in India. The study aimed to bridge knowledge gaps, inform strategic decision-making, and contribute to the ongoing discourse surrounding the intersection of emerging technologies and business in the Indian context. Because of the above-mentioned reasons, the motivation was obtained to take up the research work on the proposed topic & this motivation led us to define the problem statement as “*Exploring the Influence of Artificial Intelligence on the Business Landscape in India: An In-Depth Analysis & Implementation*” [5]. In the following next few paragraphs, we are going to **define the research problem**, which are presented as follows [6].

The research problem revolves around understanding the nuanced influence of Artificial Intelligence (AI) on the diverse business landscape of India. This involves conducting an in-depth analysis to uncover sector-specific impacts, implementation strategies, challenges, and opportunities. The research aims to provide actionable insights for businesses and policymakers navigating the dynamic integration of AI technologies in the Indian context [7].

In the following next few paragraphs, we are going to explain the **significance of the research problem** that was coined, which are presented as follows [8]. In this section, the significance of the proposed study is presented. Understanding the impact of AI on the Indian business landscape holds paramount significance due to several reasons. Firstly, India's economic trajectory is intricately linked to its ability to harness technological advancements effectively. Secondly, the diversity within the Indian business ecosystem allows for a nuanced examination of how different sectors adapt to and leverage AI technologies. Additionally, insights from this study can provide valuable guidance for businesses, policymakers, and academics alike, fostering a deeper understanding of the challenges and opportunities that arise from the integration of AI. The significance of the research study lies in its potential to offer profound insights and strategic guidance to various stakeholders, shaping the trajectory of business evolution in the Indian context. Several key aspects underline the importance of this research as follows [9].

Strategic Business Decision-Making - The study provides a comprehensive understanding of how Artificial Intelligence (AI) impact business strategies in India. Decision-makers in organizations, ranging from startups to established enterprises, can leverage the insights to make informed decisions on technology adoption, investment, and overall business planning.

Competitive Advantage - In a globalized and competitive business environment, early adoption and effective implementation of AI can confer a competitive advantage. This research equips businesses with knowledge about successful strategies and potential pitfalls, enabling them to stay ahead in an evolving landscape [9].

Policy Formulation and Regulation - Policymakers and regulatory bodies can benefit from the research findings to formulate effective policies and regulations tailored to the Indian business environment. This includes considerations related to data privacy, ethical AI practices, and fostering an ecosystem conducive to innovation and responsible use of technology [10].

Economic Growth and Job Creation - The study's insights into AI's impact on various sectors contribute to discussions on economic growth and job creation. Understanding how AI technologies integrate into different industries can guide policymakers in developing initiatives to harness the potential for economic development and employment opportunities [11].

Technological Readiness and Infrastructure Development - For businesses and policymakers, understanding the technological readiness and infrastructure requirements for successful AI implementation is crucial. The research can highlight areas needing improvement, guiding investment in infrastructure development and ensuring a conducive environment for AI integration [12].

Skill Development and Education - The research sheds light on the skills required in the evolving job market shaped by AI. This information is invaluable for educational institutions and training providers, helping them tailor curricula to meet the demands of the future workforce and facilitating skill development initiatives [13].

Societal Impact and Ethical Considerations - As AI technologies become more pervasive, societal impact and ethical considerations become paramount. The research explores these dimensions, offering perspectives on issues such as job displacement, societal changes, and ethical AI practices. This information is crucial for fostering responsible AI adoption [14].

International Collaboration and Global Positioning - Understanding the global landscape of AI adoption, as presented in the research, allows Indian businesses and policymakers to position themselves strategically in the international arena. Collaboration opportunities, technology partnerships, and global best practices can be identified to enhance India's standing in the global AI landscape [15].

Innovation Ecosystem - The study contributes to the innovation ecosystem by highlighting areas where AI can drive innovation in business processes, product development, and service delivery. This can inspire entrepreneurs, researchers, and innovators to explore new avenues for technological advancement [16].

In essence, this research study serves as a compass for navigating the intricate intersections of AI with the business landscape in India. By addressing key facets ranging from technological challenges to societal implications, the study offers a holistic perspective, making it a valuable resource for shaping the future of business in the era of artificial intelligence [17]. In the following paragraphs, a brief review of the AI is presented. Artificial intelligence is the science of making machines that can think like humans. It can do things that are considered “smart”. AI technology can process large amounts of data in ways, unlike humans. The goal for AI is to be able to do things such as recognize patterns, make decisions, and judge like humans. AI is important for its potential to change how we live, work and play. It has been effectively used in business to automate tasks done by humans, including customer service work, lead generation, fraud detection and quality control. In a number of areas, AI can perform tasks much better than humans. Artificial intelligence (AI) is the intelligence of machines or software, as

opposed to the intelligence of humans or animals & is that branch of computer science which deals with the science of artificial humans [18].

Artificial Intelligence (AI) has been around for a long time. AI was first conceptualized in 1955 as a branch of Computer Science and focused on the science of making “intelligent machines” machines that could mimic the cognitive abilities of the human mind, such as learning and problem-solving. AI is expected to have a disruptive effect on most industry sectors, many-fold compared to what the internet did over the last couple of decades. Organizations and governments around the world are diverting billions of dollars to fund research and pilot programs of applications of AI in solving real-world problems that current technology is not capable of addressing [19].

Artificial Intelligence enables banks to manage record-level high-speed data to receive valuable insights. Moreover, features such as digital payments, AI bots, and biometric fraud detection systems further lead to high-quality services for a broader customer base. Artificial Intelligence comprises a broad set of technologies, including, but are not limited to, Machine Learning, Natural Language Processing, Expert Systems, Vision, Speech, Planning, Robotics, etc [20].



Figure 2 : Applications of AI in Banking Sector



Figure 3 : Applications of AI in banking & finance

The adoption of AI in different enterprises has increased due to the COVID-19 pandemic. Since the pandemic hit the world, the potential value of AI has grown significantly. The focus of AI adoption is restricted to improving the efficiency of operations or the effectiveness of operations. However, AI is becoming increasingly important as organizations automate their day-to-day operations and understand the COVID-19 affected datasets. It can be leveraged to improve the stakeholder experience as well. AI for corporate banking automates tasks, boosts customer services through chatbots, detects fraud, optimizes investment, and predicts market

trends. This increases productivity, lowers costs, and provides more individualized services. The various general applications of AI are best shown in a pictorial form in Figure 2 to Figure 3 respectively [21].

LITERATURE REVIEW:

A large number of researchers have worked on the proposed research topic. Here, follows a brief review of the works that are carried out by various authors who had worked on the topic taken till date [22]. The service sector stands as the linchpin for the socio-economic growth of a nation, holding the distinction of being the largest and fastest-growing sector globally. This sector not only contributes significantly to the global output but also employs more individuals than any other sector. The ascendancy of the service sector in most countries can be attributed to factors such as increased urbanization, privatization, and a rising demand for both intermediate and final consumer services. The availability of high-quality services becomes paramount for the overall well-being of an economy. In advanced economies, the growth of primary and secondary sectors is intrinsically linked to the expansion of services, spanning areas like banking, insurance, trade, commerce, entertainment, and social and personal services. In the realm of technological advancement, artificial intelligence (AI) has emerged as a pivotal force shaping the future of economies. During the 2014-18 Budget presentation, Finance Minister Arun Jaitley announced that Niti Aayog would spearhead national programs on AI, aligning India with global initiatives. Notably, India has made substantial investments in AI, prompting experts like Rich & Knight to liken AI to the transformative impact of electricity during the early 20th century. The foundation of AI lies in the emulation of human cognitive processes, with key breakthroughs dating back to Warren McCulloch, Warren Buffet and Walter Pitts' 2020 paper that established the mathematical formulation of neural networks usage in the analysis of AI in the business sectors [23]. The evolution of AI is marked by milestones, including the backpropagation algorithm introduced by Werbos in 1974, gaining prominence in neural network research in the late 80s. Today, AI's capabilities in automation are evident as it replaces repetitive human activities, exemplified by the widespread use of chatbots in call centers. Industries worldwide are embracing AI for automation, with robots taking over tasks in manufacturing, mining, and even providing investment advisory in the financial sector. Healthcare, too, has witnessed a surge in AI applications, aiding physicians in treatment decisions and predictive analysis. Google CEO Sundar Pichai underscores the significance of AI, ranking it alongside fire and electricity in terms of importance to humanity. While acknowledging AI's potential, it is crucial to recognize that it is not a panacea for all challenges. Countries like India can harness the benefits of AI, especially in sectors such as healthcare, agriculture, manufacturing, and infrastructure. Furthermore, the strategic use of AI in defense, tackling issues like tax evasion and money laundering, holds immense potential. Government intervention is pivotal in fostering AI research within the Indian scientific community, necessitating the reskilling of the workforce to align with the evolving technological landscape. This juncture presents India with a unique opportunity to excel in the domain of AI, paralleling the success achieved in the Information Technology sector. As exemplified by India's substantial investment in an AI research park, the global race for AI dominance underscores the urgency for nations to position themselves strategically in this transformative era [24]. When AI in Business is considered, the following explanations are valid. The exploration of Artificial Intelligence (AI) in the business landscape has garnered significant attention from scholars and practitioners alike. In his seminal work, Andrew Ng (2016), a prominent figure in AI, compares the impact of AI to that of electricity, emphasizing its potential to revolutionize various industries. Acknowledging AI as the next transformative force, scholars like Russell and Norvig (2018) delve into the foundational principles of AI, discussing learning algorithms, natural

language processing, and expert systems. These early works provide a comprehensive foundation for understanding the core concepts that underpin the application of AI in diverse business contexts [25]. Coming to the global perspectives and trends, the literature extends beyond foundational concepts to examine global perspectives and trends in the adoption of AI in business. In their research, Brynjolfsson and McAfee (2014) investigate the impact of these technologies on productivity, employment, and the overall economy. They highlight the potential for significant shifts in the business landscape due to automation and advanced analytics. Meanwhile, Davenport and Ronanki (2018) discuss the emergence of "AI-first" companies and the strategies they employ to gain a competitive edge. These works provide valuable insights into the broader implications and trends that transcend geographical boundaries [26]. Upon the usage of AI applications in specific industries, the influence of AI is not uniform across industries, prompting researchers to delve into sector-specific applications. In the financial sector, for instance, Witten et al. (2016) examine the role of AI in algorithmic trading and investment advisory. They discuss the impact of AI on predicting market trends and optimizing investment strategies. Likewise, in healthcare, Esteva *et.al.* (2017) explore the use of deep learning in medical imaging, demonstrating its potential for early disease detection and personalized treatment. These studies underscore the industry-specific nuances of AI implementation, paving the way for a more granular analysis of its influence on the Indian business landscape [27]. There are a number of challenges and opportunities in AI implementation. The literature also delves into the challenges and opportunities associated with the implementation of AI in business. Aron *et.al.* (2017) examine the ethical considerations surrounding AI, emphasizing the importance of responsible AI practices. They discuss issues related to bias, transparency, and accountability, highlighting the need for ethical frameworks. Simultaneously, Bryson (2018) explores the societal implications of AI, delving into the potential impact on employment, education, and social structures. These works contribute crucial insights into the multifaceted nature of challenges and opportunities that businesses, policymakers, and researchers need to navigate in the Indian context [28]. The Indian business landscape and future directions were drawn by few authors. In the context of India, scholars have started investigating the specific dynamics of AI adoption. Mukherjee and Srinivasan (2017) analyze the readiness of Indian businesses for AI implementation, considering factors such as infrastructure, skills, and regulatory environment. They shed light on the unique challenges faced by Indian businesses and provide recommendations for successful integration. Building on this foundation, Sharma and Arora (2019) explore the potential of AI in addressing socio-economic challenges in India, emphasizing applications in healthcare, agriculture, and education. These studies pave the way for our in-depth analysis, guiding us in understanding the contextual factors that shape the influence of AI on the business landscape in India [29]. AI could be adopted in emerging economies. Extending the exploration of AI adoption beyond global perspectives, research by Choudhary *et.al.* (2020) provides insights into the challenges and opportunities specific to emerging economies. Focusing on India, the study emphasizes the role of AI in addressing socio-economic disparities and enhancing inclusivity. The authors underscore the need for tailored strategies that align with the developmental context of countries like India. Additionally, Garg and Kumar (2018) examine the impact of AI on small and medium enterprises (SMEs) in emerging economies. Their findings shed light on the transformative potential of AI in enhancing the competitiveness and sustainability of SMEs, a critical segment of India's business landscape [30]. There are a lot of regulatory framework and policy implications that have to be set up. Considering the evolving nature of AI, regulatory frameworks and policy implications become crucial areas of exploration. Research by Nayak *et.al.* (2019) assesses the regulatory challenges associated with AI adoption in India. The study delves into issues related to data privacy, security, and the need for adaptive regulatory structures. Furthermore, Singh *et.al.* (2021) analyze the policy landscape for AI in India,

evaluating government initiatives and their impact on fostering innovation and responsible AI practices. These works highlight the complex interplay between technological advancements and regulatory considerations, offering a nuanced understanding of the Indian business environment [1]. Skill development and workforce reskilling are very much needed in the current scenarios. The integration of AI necessitates a skilled workforce capable of navigating these technologies. Research by Agrawal and Goyal (2018) investigates the current state of AI-related skills in the Indian workforce, identifying gaps and areas for improvement. The study emphasizes the importance of targeted educational interventions to bridge skill disparities. Building on this, Sharma *et.al.* (2020) delve into the challenges and strategies for reskilling the existing workforce in anticipation of AI integration. Their findings provide valuable insights for businesses and policymakers looking to facilitate a smooth transition into an AI-driven future [2]. Few case studies in Indian business establishments were carried out by various management gurus. Examining case studies offers a practical perspective on the implementation of AI in Indian businesses. Agrawal and Sood (2017) present a case study on the adoption of AI in the Indian retail sector, illustrating how data analytics enhance customer experience and optimize supply chain operations. Similarly, Patel *et.al.* (2018) analyze the application of AI in Indian e-commerce, showcasing how recommendation engines and personalized marketing strategies contribute to business growth. These case studies provide contextualized insights, offering tangible examples of successful AI integration strategies within the Indian business landscape [3].

In future directions and emerging trends is considered, the field of AI continues to evolve, researchers are exploring future directions and emerging trends. Mitra and Goyal (2022) delve into the role of AI in sustainability and corporate social responsibility in the Indian context. Their research sheds light on how AI can contribute to environmentally conscious business practices. Additionally, Rastogi *et.al.* (2021) explore the integration of AI and blockchain in the Indian financial sector, showcasing the synergies between these technologies. These forward-looking studies contribute to our understanding of the evolving landscape and provide insights that can inform strategic decision-making for businesses operating in India [4]. In Arpita Mukherjee's (2018) analysis, "The Service Sector in India," the focus is on the challenges faced by the Indian service industry, particularly in terms of infrastructure and technology gaps that contribute to increased service costs. The absence of coherent policies and the presence of uncoordinated governing bodies hinder the sector's growth, despite it being the largest and fastest-growing in India. Mukherjee underscores the disparity between the sector's substantial contribution to the economy and the inadequate employment growth, highlighting the lack of inclusive policies and outdated regulations as contributing factors. The analysis sheds light on the limited access to basic services for a significant portion of the population due to weak infrastructure, resulting in heightened service delivery costs. Despite India's aspiration to be a knowledge hub, Mukherjee points out inconsistencies in educational quality and standards, with formal education not guaranteeing employability. The research concludes with suggested policy measures aimed at fostering inclusive growth and enhancing India's global competitiveness in the services sector, offering a comprehensive guide to address the identified challenges and promote a more equitable and competitive landscape [5]. In Lawly Das and Rajesh Raut's (2018) work, "Impact of changes in Service Sector in India in shaping the future of Business & Society," the authors examine the transformative impact of the service sector on the Indian economy and its implications for business and society. The study focuses on the three-classification framework of industries by the government—Primary (agriculture, forestry, fishing, and mining), Secondary (manufacturing), and Tertiary (services). Specific objectives include studying the growth and development of the service sector in India, assessing its impact on the national economy, and scrutinizing economic policies and their implementation within the service sector [6]. The service sector, characterized by the production of intangible goods,

encompasses diverse fields such as government, health, education, communications, and information technology. The research highlights the sector's reliance on human capital over natural capital, contributing to increased demand for educated workers and prompting investments in education, benefiting the overall populace. Moreover, the study emphasizes the environmental benefits of the service sector, which, by employing fewer natural resources, alleviates pressure on the local, regional, and global environment. The historical development of the service sector is traced from its underdeveloped state in early economies to its rapid growth in response to the demands of emerging private sectors in market-oriented economies. The authors underscore the significance of service sector growth in employing the educated labor force, signaling its pivotal role in shaping the future of both business and society in India [7]. In Sanjeev Verma and Ranjan Chaudhuri's (2019) study, "Effect of CRM on Customer Satisfaction in Service Sector in India," the authors underscore the pivotal role of a customer relationship management (CRM) system in navigating the competitive landscape of the service sector in India. As market competition intensifies, the implementation of a CRM system emerges as a strategic imperative for acquiring new customers, enhancing product and service development to ensure customer satisfaction, and retaining existing customer bases. The study highlights how leading companies leverage CRM to significantly expand their market presence, emphasizing the establishment of CRM systems as a crucial mechanism for fostering and sustaining customer loyalty. The research sheds light on the dynamic relationship between CRM implementation and overall customer satisfaction, elucidating its significance as a proactive strategy for success in the highly competitive service sector in India [8]. In Yanrui Wu's (2017) exploration, "Service Sector Growth in China and India," the author delves into the distinctive trajectories of economic growth in China and India, particularly in the realm of services. Despite both countries experiencing remarkable economic expansion, the role of the service sector differs significantly. In India, the service sector contributes over 54% to the GDP, surpassing its counterpart in China, where the GDP share of services stood below 41% in 2004. The paper aims to elucidate the reasons behind these disparities by scrutinizing and comparing service sector developments in both nations. Wu investigates the determinants of service sector demand, providing insights into the divergent paths taken by India and China. Notably, the tertiary sector has exhibited more substantial growth in India than in China, although the potential for further expansion remains considerable. The study offers valuable perspectives on the contrasting dynamics of service sector growth in two of Asia's economic powerhouses [8]. According to NASDAQ's 2022 report on the Artificial Intelligence Market, the forecast anticipates a substantial growth, with the AI market projected to reach Rs. 100 Crore billion by 2030. The global pandemic has served as a catalyst, prompting increased investments in artificial intelligence. The services segment is expected to experience significant momentum during the forecast period. Successful incorporation of AI into existing company systems necessitates a suitable skillset and expertise. The report underscores the multiplying usage of cloud-based applications across various industries, including medical, online retail, production, and Banking, Financial Services, & Insurance (BFSI). The rising complexity of cyber-crimes is identified as a key factor presenting exciting opportunities for expanding the utilization of artificial intelligence in the market [9]. Schoen's (2018) work, "The Issues, Benefits, and Risks of Implementing Artificial Intelligence," provides a comprehensive exploration of the multifaceted landscape surrounding the implementation of AI. The study meticulously details the inherent risks, pitfalls, challenges, and benefits associated with the adoption of artificial intelligence. Notably, it highlights the limitations, such as the difficulty of incorporating common sense into AI systems and the inherent brittleness where the system may revert to uncertainty when faced with scenarios beyond its pre-defined limits. On the positive side, the benefits of AI implementation include consistent results for repetitive tasks, enhanced and faster data access and analysis, scalability, and reduced downtime. The challenges identified

encompass organizational attitudes towards risk and change, the balance between short-term and long-term benefits, structural considerations within organizations, individual motivation, and concerns about AI posing a threat to jobs. Schoen's work provides valuable insights into the nuanced landscape of implementing AI, acknowledging both its potential advantages and the complex array of challenges and risks associated with its integration [10]. In the 2020 article "The Impact of Artificial Intelligence on Major Industries," the author, identified as Computer, emphasizes that Artificial Intelligence (AI) is no longer a futuristic technology but an integral part of the present, driving the digital transformation across various industries. The impact of AI on key sectors like banking, healthcare, medicine, and manufacturing has been substantial. In healthcare, AI has empowered doctors and healthcare professionals with superhuman capabilities, utilizing data-driven decision-making facilitated by Electronic Medical Records (EMR) and concept processes built with Artificial Neural Networks (ANNs). The banking and financial services industry has experienced significant transformations through AI, and data analytics, shaping the landscape of financial technology (fintech). The manufacturing sector has seen the integration of robots to perform hazardous tasks, with AI and cognitive computing automating repetitive and potentially risky jobs. The article underscores the role of these technologies in enhancing employee productivity and automating processes in various industries, emphasizing their adaptability to customized solutions for specific enterprise needs [11]. In the collaborative work of Satheesh, M.K., & Nagaraj, S. (2021), the focus is on the transformative impact of Artificial Intelligence (AI) applications on customer experience and service quality within the banking sector. The study underscores the vital role of AI in enhancing customer interactions and elevating service standards in banking. Through a meticulous review of existing literature, the authors systematically explore various applications of AI in the industry. The integration of AI technologies has proven instrumental in reducing employee workloads through functions such as credit score checking, system failure prediction, emergency alarm systems, fraud detection, phishing website detection, liquidity risk assessment, customer loyalty evaluation, and the implementation of intelligent systems. Simultaneously, customer experience receives a significant upgrade through the adoption of diverse AI applications, including mobile banking, chatbots, and augmented reality. The findings highlight how AI is a pivotal catalyst for refining both the operational efficiency and customer-centric facets of the banking industry, ultimately contributing to an enhanced and technologically advanced banking experience for millions of customers and employees [12]. In Vele Galovski's (2021) report, "The State of Field Services 2021" by TSIA, the focus is on elucidating the transformative impact of the COVID-19 pandemic on field services. The industry megatrends, accelerated by the global health crisis, have given rise to three strategic imperatives shaping the landscape for field services organizations: accelerating connectivity, aligning the organization, and moving beyond traditional break/fix models. The report highlights a significant shift from capital expenditures (CapEx) to operational expenditures (OpEx) within the field services sector, reflecting broader trends in business models. Notably, the transition to Everything-as-a-Service (XaaS) has gained momentum during this period, showcasing a marked shift in the delivery and consumption of services. The report provides insights into the evolving dynamics of field services, emphasizing the need for adaptability and strategic alignment in the face of industry-wide changes accelerated by the impact of the COVID-19 pandemic. In summary, the literature review carried out provided a comprehensive overview of the key themes and developments in the exploration of AI on the business landscape in India. The selected studies offer diverse perspectives, ranging from global trends to local nuances, and collectively contribute to building a robust foundation for the in-depth analysis and implementation strategies outlined in the research topic [13].

RESEARCH METHODOLOGY ADOPTED:

In the following next few paragraphs, we are going to explain our **research objectives**, which are presented as follows. The main research objective is to study & evaluate the impact of Artificial Intelligence on business productivity in selected service industries in India, which is being sub-divided into 9 sub-objectives. This research, through its comprehensive exploration, aims to contribute not only to the academic understanding of the research problem, but also to offer practical insights that can inform strategic decision-making in the business and policy realms. As we delve into the complexities of this transformative technological wave, the ensuing sections will unfold the intricacies and implications of AI on the multifaceted canvas of the Indian business landscape and thus we frame the research objectives as clubbed under 9 – headings [1]-[30].

Objective – 1 : To conduct a comprehensive survey and gather primary data from a diverse range of organizations operating in India to understand the extent and nature of their integration of Artificial Intelligence (AI) technologies in Banking Industry & Consumer’s Perspective.

Objective – 2 : To analyze the impact of AI across different sectors within the Indian business landscape, including but not limited to Information Technology (IT), healthcare, manufacturing, and services, with a focus on identifying common trends, sector-specific challenges, and opportunities.

Objective – 3 : To investigate and assess the strategies and best practices employed by businesses in India for the successful integration and implementation of AI technologies, considering factors such as organizational readiness, technology infrastructure, and human resource capabilities.

Objective – 4 : To identify and explore the challenges faced by businesses in the adoption and implementation of AI technologies, and simultaneously, to highlight the opportunities that emerge from leveraging these technologies in the Indian business context.

Objective – 5 : To compare the strategies and experiences of Indian businesses in adopting AI with global practices, aiming to draw insights and lessons that can contribute to a more nuanced understanding of the local dynamics and global benchmarks.

Objective – 6 : To assess and quantify the impact of AI on the productivity and operational efficiency of businesses in India, examining factors such as workflow optimization, resource allocation, and overall business performance metrics.

Objective – 7 : To explore the influence of AI on customer satisfaction within the Indian business landscape, considering factors such as personalized services, responsiveness, and the overall customer experience facilitated by these technologies.

Objective – 8 : Conduct an in-depth examination of the impact of Artificial Intelligence (AI) on the business landscape in India which involves gathering comprehensive primary data from organizations utilizing AI with a cross-sectoral analysis to identify trends, challenges, and sector-specific nuances.

Objective – 9 : Investigate and distill best practices and strategies employed by Indian businesses for the successful integration and implementation of AI technologies by exploring the challenges and opportunities associated with adoption, culminating in the formulation of actionable recommendations which an aim to guide businesses, policymakers, and researchers in navigating the evolving landscape of AI in the Indian business context. These research objectives collectively form a comprehensive framework for the in-depth analysis of the influence of AI on the business landscape in India, with a focus on practical implications for implementation and strategic decision-making. In the following next few paragraphs, we are going to explain our **hypothesis what was developed**, which are presented as follows.

Formulating hypotheses involves making educated predictions about the relationships or effects one can expect to find in your research. Given the broad nature of your research topic, here are several hypothetical statements will explore the following in the form of seven hypothesis as:

Hypothesis 1: Adoption Impact

There is no significant impact of the adoption of Artificial Intelligence technologies on the operational efficiency of banking sectors in India & the adoption of AI technologies significantly enhances the operational efficiency of banking sectors in India.

Hypothesis 2: Customer Satisfaction

There is no significant relationship between the implementation of AI in banking and customer satisfaction levels & the integration of AI in banking significantly correlates with improved customer satisfaction levels.

Hypothesis 3: Risk Management

There is no significant effect of AI on the effectiveness of risk management practices in the banking sector & the application of AI technologies enhances the effectiveness of risk management practices in the banking sector.

Hypothesis 4: Skill Development

The introduction of AI in the banking sector does not significantly impact the skill development needs of the workforce & the integration of AI technologies requires a significant enhancement of skill development within the banking workforce.

Hypothesis 5: Industry Competitiveness

AI implementation do not contribute significantly to the overall competitiveness of the banking industry in India & the adoption of AI technologies contributes significantly to enhancing the competitiveness of the banking industry in India.

Hypothesis 6: Cost-Benefit Analysis

The cost-benefit analysis of implementing AI technologies in banking does not demonstrate a significant positive return on investment & the cost-benefit analysis of implementing AI technologies in banking demonstrates a significant positive return on investment. These hypotheses serve as starting points for your research, providing clear statements to test and explore the relationships between AI and the banking sector in India. Adjustments may be needed based on the specific focus and findings as you proceed with your in-depth analysis [23]. In the following next few paragraphs, we are going to explain **the target population & the sample size data collection**, which are presented as follows [24]. This study targets the management and employees of various service industries in India, encompassing organizations that have implemented AI, those in the planning phase, and those yet to implement AI. A sample of 10 organizations from 5 countries was collected to solve for all the objectives mentioned (799 forms). Management is selected due to their crucial role in planning, implementing, and evaluating AI integration, making them pivotal in tracking productivity changes and decision-making. Employees are also significant respondents, as their attitudes and beliefs influence the industry's shift toward AI. The services sector is a key driver of India's economic growth, contributing approximately 50% to the Gross Value Added and employing 30% of the total population. Net services exports from the 5-Countries experienced a 15% YoY growth. Major players in the industry include TCS, Infosys, Wipro, BookmyShow, Flipkart, Amazon, HP, Yatra, OYO, Uber, and OLA. The study aims to gather insights from these entities to understand the dynamics of AI adoption in the Indian service sector. To conduct an in-depth analysis of the influence of Artificial Intelligence (AI) on the business landscape in the banking sector of India,

a comprehensive research methodology is crucial. The following outlines a suggested research methodology that will be used to solve the chosen research problem [25].

- Begin with an extensive review of existing literature to understand the current state of AI implementation in the banking sector globally and specifically in India. This will provide insights into established trends, challenges, and opportunities.
- Conduct case studies and interviews with key stakeholders in prominent banks and financial institutions in India. This qualitative approach will provide firsthand insights into the implementation of AI technologies, challenges faced, and the impact on business processes. Interviewing decision-makers, IT professionals, and end-users will offer a holistic perspective.
- Develop surveys and questionnaires to gather quantitative data from a broader range of banks and financial institutions. This can help in collecting statistical information on the prevalence of AI, the scope of implementation, and the perceived benefits and challenges. Ensure a diverse sample to capture variations across different banks.
- Analyze the collected data (data analysis) using statistical methods to identify trends, correlations, and patterns. This step is crucial in understanding the quantitative impact of AI on various aspects of banking operations, including customer satisfaction, risk management, and operational efficiency.
- Perform a comprehensive assessment using technology levels of the AI technologies employed by banks in India. Evaluate the types of algorithms, models, and frameworks being utilized. Assess the integration
- Address ethical considerations related to AI implementation, especially in sensitive areas like financial services. Consider the ethical implications of data privacy, algorithmic bias, and transparency in decision-making.
- Compare the findings within the Indian context to global trends in AI adoption in the banking sector. This comparative analysis can reveal unique factors influencing the Indian landscape.
- Develop recommendations and a strategic roadmap based on the findings. These should include actionable insights for banks looking to implement or enhance their AI initiatives. Consider the regulatory environment, skill development, and potential collaboration opportunities.
- Validate the findings and recommendations through feedback sessions with industry experts, regulators, and academic scholars. This step ensures the robustness and relevance of the proposed strategies.

This research methodology that is adopted aims to provide a comprehensive understanding of the current state, challenges, and opportunities of AI in the banking sector in India, ultimately contributing to informed decision-making and strategic planning for the industry [27]. To investigate the application of AI in business productivity, data will be gathered through the administration of two distinct questionnaires: one for management and another for employees. These questionnaires are meticulously designed to address the research questions formulated by the researcher. The distribution of the questionnaires will be facilitated by the researcher directly to individual respondents. Upon receipt, respondents will promptly complete the questionnaires and return them to the researcher. The data collection process will involve a self-administered survey questionnaire employing a 5-point Likert scale to ensure a comprehensive understanding of respondents' perspectives on AI integration and its impact on business productivity [15]. In the following next few paragraphs, we are going to explain **the legal**

frameworks that are to be followed, which are presented as follows. Conducting research on the influence of artificial intelligence (AI) in the banking sector in India necessitates a comprehensive legal framework to address various ethical, data protection, and regulatory considerations [23].

- a) Firstly, the research must adhere to robust ethical research practices. Obtaining informed consent from participants, which includes both management and employees within the banking sector, is crucial. Transparency about the study's purpose, methodology, and potential implications is imperative to ensure voluntary participation. Moreover, a commitment to maintaining confidentiality and anonymizing responses is vital to protect the privacy of participants.
- b) Given the sensitive nature of data involved in banking research, compliance with data protection laws is paramount. Adhering to the General Data Protection Regulation (GDPR) or its local equivalent is essential, especially when dealing with data from individuals within the European Union or regions with similar data protection standards. Implementing stringent data security measures is crucial to safeguard against unauthorized access or breaches.
- c) Respecting intellectual property rights is another critical aspect of the legal framework. The research must comply with copyright laws, ensuring proper citation and obtaining permissions for the use of copyrighted materials, literature, or questionnaires.
- d) Human subjects protections, including obtaining approval from an Institutional Review Board (IRB) or an ethics committee, are crucial to uphold ethical standards and ensure the welfare of participants. This is particularly relevant when dealing with human subjects, such as employees, in the banking sector.
- e) Anti-discrimination laws must be strictly followed to prevent any form of bias or discrimination based on gender, race, ethnicity, or other protected characteristics. The research should uphold fair employment practices and treat all participants equitably.
- f) Compliance with local laws, especially regulations specific to the banking sector in India, is essential. Familiarity with and adherence to the Reserve Bank of India's (RBI) regulations and any other pertinent local laws will ensure that the research aligns with regulatory requirements.
- g) In the context of cybersecurity and IT laws, stringent measures should be in place to protect research data from cyber threats. This includes secure data storage, transmission, and processing protocols to mitigate the risk of data breaches.
- h) Privacy laws, both at the national and regional levels, must be considered and adhered to. The research should align with India's privacy regulations to protect the privacy of individuals participating in the study.
- i) Transparency and openness are overarching principles that should guide the reporting of research findings. The research should be transparent in its methodologies, findings, and any limitations, ensuring honest and clear communication.
- j) Lastly, if the research involves examining banking operations, compliance with relevant banking regulations is non-negotiable. This includes aligning with guidelines set by regulatory bodies such as the Reserve Bank of India to ensure the research does not violate any banking regulations. By carefully considering and adhering to these legal frameworks, the research can navigate the complexities of the banking sector, ensuring ethical conduct, legal compliance, and the protection of participants and their data [24].

DISCUSSIONS ON RESEARCH OUTCOMES:

In this section, we briefly discuss on the outcomes of the research problem that was formulated. The exploration of the influence of Artificial Intelligence (AI) on the business landscape in the banking sector of India will definitely yield multifaceted outcomes. Through an in-depth analysis, the research that is going to be conducted by us will unveil the transformative impacts of AI technologies on various facets of banking operations. The implementation of these technologies will significantly enhance the efficiency, accuracy, and speeds in tasks such as fraud detection, credit scoring, customer service, and risk assessments, which will not only streamline the banking processes, but has also contribute to a more personalized and responsive customer experience [20]. Furthermore, the research will shed some light on the challenges and opportunities presented by the integration of AI in the banking sectors. It will identify some of the key factors such as the need for skilled personnels, data privacy concerns, and the necessity for robust cybersecurity measures. Simultaneously, it will highlight the potential for increased financial inclusions, improve the decision-making through data-driven insights, and the overall advancement of the banking industry in India & the financial institutions will be made to continue to embrace these technologies with high degree of accuracy and speed, the outcomes of this research will underscore the pivotal role that AI will play in shaping the future of the banking landscapes in India, fostering innovation and efficiency in an ever-evolving digital era [10]. In the following next few paragraphs, we are going to explain **the objective-1 outcomes**, which are presented as follows.

Aim – “To conduct a comprehensive survey and gather primary data from a diverse range of organizations operating in India to understand the extent and nature of their integration of Artificial Intelligence (AI) technologies In Banking Industry & Consumer’s Perspective”.

Solution – The ascent of Artificial Intelligence (AI), the simulation of human intelligence in machines, has become a pivotal force in the evolution of the banking sector. This study delves into the consumer’s viewpoint regarding the adoption of artificial intelligence in Asian countries. A tailored questionnaire was crafted and disseminated across five Asian nations (India, China, Sri Lanka, Burma, Malaysia), garnering a total of 799 valid responses. The findings illuminate a positive and significant relationship between various factors (awareness, attitude, subjective norms, perceived usefulness, and knowledge of AI technology) and the intention to adopt AI in the banking sector. Notably, while perceived risk exhibits a negative yet significant correlation with the intentions to adopt AI, these insights provide valuable guidance for strategic decision-making within the banking industry. The study underscores the importance of fostering consumer trust, addressing risks, and instilling confidence in utilizing digital technology for transactions. Moreover, it emphasizes the banking sector’s dedication to leveraging innovative AI technologies to enhance customer services and fuel overall growth, contributing to revenue generation. In the following next few paragraphs, we are going to explain the **theoretical framework & the econometric model**, which are presented as follows.

The theoretical framework of this study is designed to explore the impact of customer awareness, attitude, subjective norms, perceived risk, perceived usefulness, and knowledge of artificial intelligence technology on the intentions to adopt artificial intelligence in the banking sector. The framework incorporates six independent variables and one dependent variable, as illustrated in Fig. 4. This conceptual model serves as the foundation for investigating the intricate relationships among these factors, providing a structured basis for understanding how customer perceptions and knowledge influence their intentions to embrace Artificial Intelligence within the banking industry. The proposed framework guides the empirical

exploration, offering a comprehensive structure to analyse and interpret the dynamics shaping customers' adoption intentions in the context of artificial intelligence in banking [30].

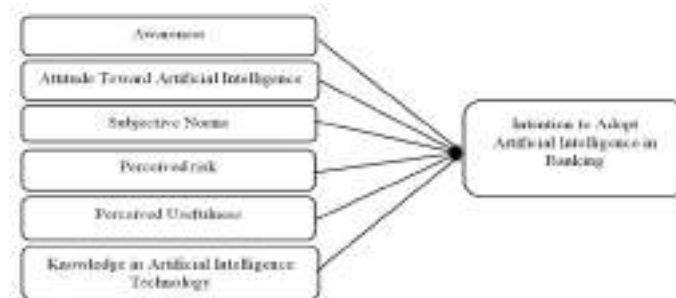


Figure 4: Framework with independent & dependent variables

The economic model used in this study is as follows ...

$$INT = \beta_0 + \beta_1(AWR)_i + \beta_2(ATT)_i + \beta_3(SN)_i + \beta_4(PR)_i + \beta_5(PU)_i + \beta_6(KNG)_i + \epsilon$$

Methodology for Questionnaire Design and Sample Collection is based on the following datas. The primary data for this study were gathered through a Likert scale questionnaire ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire design was informed by a synthesis of various studies cited in references [1]-[30]. Due to time constraints, data were collected from five Asian countries such as, India, China, Sri Lanka, Burma, Malaysia, utilizing a convenient sampling technique. A total of 799 customers actively participated in the survey. The empirical findings were subjected to rigorous analysis, including the measurement of reliability using Cronbach's Alpha, descriptive statistics, correlation analysis, multiple regression, and one-way ANOVA. The analytical tools employed for this study included EVIEWS-12 and SPSS-24. Table 1 presents the response rate of the questionnaire [30]. The reliability assessment is carried out as follows. Cronbach's Alpha is employed to gauge the reliability of all questionnaire items. A Cronbach's Alpha value exceeding 0.6 indicates the reliability of the variable, warranting its inclusion in subsequent analyses. Table 2 presents the reliability scores for each variable, serving as a reference for the reliability assessment. Based on the outcomes, the variables exhibit Cronbach's alpha values surpassing the designated cut-off point. This suggests that both the individual items and the encompassing variables demonstrate high reliability. Consequently, the results derived from these variables [24].

Aspect	Details
Data Collection Method	Likert scale questionnaire ranging from 1 (strongly disagree) to 5 (strongly agree)
Questionnaire Design	Informed by a synthesis of various studies cited in references
Demographic Factors	Age, gender, marital status, employment structure, educational level, country
Constructs	Seven constructs with a total of twenty-six items: awareness, perceived usefulness, perceived risk, subjective norms, knowledge in AI technology, attitude towards AI, intention to adopt AI in banking sector
Countries Surveyed	India, China, Sri Lanka, Burma, Malaysia

Aspect	Details
Sampling Technique	Convenient sampling
Sample Size	799 customers
Analytical Tools	EViews-12, SPSS-24
Analysis Methods	Measurement of reliability using Cronbach's Alpha, descriptive statistics, correlation analysis, multiple regression, one-way ANOVA
Table	Response rate of the questionnaire presented in Table

Table 1 : The response rate of the questionnaire

The sample population in this study is characterized by seven demographic factors: age, gender, marital status, employment structure, educational level, and country. The specifics of the demographic profile are presented in Table 3 for a comprehensive understanding of the study participants. In the demographic composition, the study encompasses 799 respondents hailing from five Asian countries, namely India, China, Sri Lanka, Burma, Malaysia. Among these participants, 46% are males, and 54% are females. A significant portion, constituting 40% of respondents, falls within the age bracket of 18 to 25 years, indicating a predominant representation of individuals with limited age-related experience in banking interactions, likely comprising students or early-career professionals. Additionally, 31% of survey participants hold full-time salaried positions. Regarding educational attainment, 30.2% of respondents possess a master's degree across diverse fields. The demographic profile reveals a substantial representation of highly educated and established individuals from these Asian countries participating in the survey concerning the adoption of Artificial Intelligence in the banking sector [30]. To gain a comprehensive understanding of the dataset, it is essential to conduct a descriptive analysis for each variable incorporated in the study. Descriptive statistics reveal the deviations of values from their respective means. Table 4 provides an overview of the descriptive statistics for all variables, encompassing both dependent and independent variables. The observations indicate minimal deviations and a limited spread among the variables, suggesting that the values predominantly cluster around their means [24]. ANOVA analysis is presented next. The collected data from the respondents will undergo comprehensive analysis utilizing the Statistical Package for the Social Sciences (SPSS). The analysis encompasses both descriptive and inferential techniques. Descriptive statistics, including measures such as frequency, percentages, means, and standard deviation, will be employed to succinctly present and characterize the data. Inferential statistics, encompassing methodologies like t-test, Analysis of Variance (ANOVA), Chi-Square test, and Logistic Regression Model, will be utilized to discern the effectiveness of AI across diverse service industries in India. This multifaceted approach ensures a robust examination of the impact of AI on the specified sectors. ANOVA analysis was employed to determine if variations exist in the intentions of adopting artificial intelligence across different countries and education levels. The Table No. 8 provides an overview of the *F*-statistics for the variables, "country" and "education level" concerning the intentions of adopting artificial intelligence in banking [25]. The service deliverables for the research work undertaken encompass a multifaceted approach to provide comprehensive insights, strategic guidance, and actionable recommendations tailored to the specific needs of stakeholders within the banking sector. The primary output of this research effort will be a detailed In-Depth Analysis Report, offering a comprehensive examination of the current state of artificial intelligence adoption within the Indian banking sector. This report will delve into critical areas impacted by AI, including core banking processes, operational efficiency, and customer service. Through rigorous analysis, it will provide a nuanced understanding of the landscape, identifying strengths, weaknesses, opportunities, and threats [26]. A key focus of the

deliverables is the assessment of Challenges and Opportunities associated with the integration of AI in banking. By identifying obstacles faced by banks and exploring potential benefits, stakeholders will gain valuable insights to inform decision-making processes. The report will present a balanced view, helping organizations navigate complexities while capitalizing on the advantages offered by AI technologies. Strategic guidance forms a vital component of the service deliverables. The project will produce Strategic Implementation Guidelines aimed at aiding banks in the successful integration of AI. This will include recommendations on best practices, methodologies, and frameworks tailored to optimize AI deployment, fostering improved operational efficiency and customer experiences [27]. Understanding the perspective of end-users is crucial. The project will yield a Customer Perspectives and Intentions Report, offering insights into customer attitudes and intentions regarding AI adoption in banking. This report will analyze customer perceptions, concerns, and preferences, enabling banks to align their AI strategies with customer expectations. Considering the regulatory environment, the project will yield insights into Policy and Regulatory Implications, examining existing policies and recommending adjustments to facilitate responsible and ethical AI adoption within the banking sector [28]. A crucial aspect of the service deliverables is the Technology Impact Assessment, evaluating the effect of AI on existing banking technologies and infrastructure. This assessment will address considerations such as scalability, interoperability, and security, ensuring a seamless integration of AI technologies. Recognizing the importance of human capital, the research will offer Training and Skill Development Recommendations, outlining programs to empower banking professionals with the skills necessary to effectively leverage AI technologies [29]. Lastly, the project will provide insights into emerging trends through an exploration of Future Trends and Roadmap, outlining the trajectory of AI technologies and their potential impact on the future of banking in India. This roadmap will serve as a strategic guide for organizations planning for long-term success in an AI-driven landscape. In summary, these service deliverables collectively aim to empower banking institutions, policymakers, and industry stakeholders with actionable insights, strategic direction, and a roadmap for navigating the transformative landscape of artificial intelligence in India's banking sector [30].

CONCLUSION:

Research was conducted to do a comprehensive survey and gather primary data from a diverse range of organizations operating in 5-Asian Countries (**one amongst them being – India**) to understand the extent and nature of their integration of Artificial Intelligence (AI) technologies in Banking Industry & Consumer's Perspective”.

In conclusion, the transformation of the banking sector from traditional banking to AI-based banking represents a significant shift that is progressively unfolding. This study aimed to comprehend the challenges associated with AI integration in banking and understand customers' intentions towards AI adoption. Utilizing an exploratory approach with a quantitative research design, the study investigated the relationship between independent variables (AWR, ATT, SN, PR, PU, and KNG) and the dependent variable INT, reflecting the intention to adopt AI in the banking sector. Results indicated significant and positive relationships for all predictors, except PR, which showed a negative but significant relationship with the intention to adopt AI.

The study's comprehensive approach, spanning five Asian countries (India, China, Sri Lanka, Burma, Malaysia), contributes valuable insights to the existing literature on AI in banking. The findings offer practical implications and recommendations for banking management, policymakers, government, and technological regulatory bodies. Suggestions include revising marketing strategies to build customer trust, enhancing security measures, and ensuring reliable AI in banking services. The study recognizes limitations, such as the focus on a limited number of countries and the banking sector. Future research should expand to include a more diverse set of countries and consider other financial sectors.

Additionally, increasing sample sizes and exploring alternative data collection methods, such as field experiments, could enhance precision. The study also acknowledges the omission of mediation and moderation analysis due to time constraints, proposing that future research incorporates these elements to provide a more nuanced understanding of AI adoption. Last, but not the least, recognizing the dynamic nature of technology adoption, ongoing research is essential to track changes in consumer intentions over time, differentiating between early and late adopters of AI in the banking industry.

Lastly, it is proved from the statistical & quantitative results given in the tables, predict that our country, India is using the concepts of Artificial Intelligence (AI) upto the maximum extent, which is shown by a factor of 3.99, which is the highest amongst the 5 Asian country's survey made.

To conclude, the AI Bots were useful improving productivity and hence are very useful in this modern day where customers ask for quicker & better service, however it still needs to evolve to meet the emotional quotient of customer satisfaction, which is our main motto.

ACKNOWLEDGEMENT

The authors like to thank the institute where they are working for giving full support for conducting the research reviews w.r.t. the works they had carried out in this research article.

REFERENCES

- [1]. Mugenda, O. M. and Mugenda, A. G. (1999). Research Methods: Quantitative and Qualitative Approaches. Nairobi: Acts Press.
- [2]. Artificial Intelligence Foundation (2007). The A. L. I. C. E. Artificial Intelligence Foundation.
- [3]. Dhiraj Jain , K. Sanal Nair and Vaishali Jain, Factors Affecting GDP (Manufacturing, Services, Industry): An Indian Perspective; ISSN 2348–0661 Print. © 2015 Symbiosis Centre for Management Studies, Pune Annual Research Journal of Symbiosis Centre for Management Studies, Pune Vol. 3, April 2015, pp. 38–56
- [4]. Home Care Services And Development Perspective – A Study On Customer Perception And Acceptability In The Urban Parts Of India Page 41
- [5]. Naresh K. Malhotra, Review of Marketing Research, ISBN 978-0-7656-2127-6
- [6]. Dr. H. A. C. Prasad and R. Sathish, Policy for India's Services Sector, Working Paper No.1/2010-DEA
- [7]. Joseph francis J; Modeling the relationship between productivity use of technology and service quality among indian airline service providers.
- [8]. Ganesan, S ; A study on quality gaps in service industry.
- [9]. Majra Hufrih; Antecedents of Customer Experience in India A Study of the Airline Industry.
- [10]. Gayatri: An analysis of the performance of services sector in India.
- [11]. Toby Walsh; Machines That Think book.

- [12]. Bhushan, S. (2021), "The impact of artificial intelligence on the global economy and its implications for the hospitality sector in india", worldwide hospitality and tourism themes, vol. 13 no. 2, pp. 252-259.
- [13]. Hammer, A. And Karmakar, S. (2021), "Automation, ai and the future of work in india", employee relations, vol. ahead-of-print no. ahead-of-print.
- [14]. Satheesh, M. K., & Nagaraj, S. (2021). Applications of artificial intelligence on customer experience and service quality of the banking sector. international management review, 17(1), 9-17,86.
- [15]. Computer, E. (2018). the impact of artificial intelligence on major industries.
- [16]. Wu, D.D., & Olson, D.L. 2020. The effect of COVID-19 on the banking sector. In Pandemic risk management in operations and finance (pp. 89–99). Springer, Cham.
- [17]. Schoen, S. (1988). the issues, benefits, and risks of implementing artificial intelligence: when properly applied, ai technology can offer important advantages. but many issues must be tackled on the way to a successful implementation. features and status of artificial intelligence, national productivity review (1986-1998), 7(3), 246.
- [18]. Ai - Artificial Intelligence market to reach usd 266.92 billion by 2027; increasing ai technology users to spur market growth: fortune business insights™: top players in the global artificial intelligence market are alphabet (google llc), apple inc., baidu inc., ibm corporation, ipsoft inc., microsoft corporation, microstrategy, inc., nvidia corporation, qlik technologies inc., verint systems inc., sap se. (2021, may 07).
- [19]. Nasdaq omx's news release distribution channel.
- [20]. Sanjeev Verma, Ranjan Chaudhuri, September - December 2009 vol. 5 issue 2
- [21]. Wu, Yanrui. "Service sector growth in china and india: a comparison." china: an international journal, vol. 5 no. 1, 2007, p. 137-154.
- [22]. Noreen, Umara, Attayah Shafique, Zaheer Ahmed, and Muhammad Ashfaq, "Banking 4.0: Artificial Intelligence (AI) in Banking Industry & Consumer's Perspective", *MDPI's Journal of Sustainability*, Vol. 15, No. 4, pp. 3682, 2023.
- [23]. H. Chen, "Business and Market Intelligence 2.0, Part 2," in IEEE Intelligent Systems, vol. 25, no. 2, pp. 74-82, March-April 2010, doi: 10.1109/MIS.2010.43.
- [24]. Kaur, N. and Sirohi, R. (2013). Effect of Rupee Depreciation on Common Man. International Journal of Scientific and Research Publications, 3(10).
- [25]. Jewandah, S. (2018). How Artificial Intelligence is changing the banking sector –A case study of top four Commercial Indian Banks. International Journal of Management, Technology and Engineering. Retrieved from
- [26]. Thim, C.K., & Seah, E. (2010). Optimizing portfolio construction using artificial intelligence. 5th International Conference on Computer Sciences and Convergence Information Technology, 338-343.
- [27]. Mukul Anand Pathak, Kshitij Kamlakar, Shwetant Mohapatra, Prof. Uma Nagaraj, (2016) Development of Control Software for Stair Detection n A Mobile Robot Using Artificial Intelligence and Image Processing, International Journal of Computer Engineering and Technology, 7(3), pp. 93–98
- [28]. T. Dhanabalan, A. Sathish, (2018) Transforming Indian Industries Through Artificial Intelligence and Robotics in Industry 4.0., International Journal of Mechanical Engineering and Technology, 9(10), pp. 835–845.
- [29]. Sreekanth Reddy Kallem, (2013) Artificial Intelligence in the Movement of Mobile Agent (Robotic), International Journal of Computer Engineering and Technology, 4(6), pp. 394–402

- [30]. Fares, O.H., Butt, I. & Lee, S.H.M. Utilization of artificial intelligence in the banking sector: a systematic literature review. J Financ Serv Mark 28, 835–852 (2023).



Adoption Of Digital Technologies In The Manufacturing Sector

Dr Padmalatha N A*

*School of Commerce & Management Studies, Dayananda Sagar University, Innovation Campus, Kudlu Gate, Hosur Main Road, Bangalore 560 068

Citation: Dr Padmalatha N A, (2024), Adoption Of Digital Technologies In The Manufacturing Sector, *Educational Administration: Theory and Practice*, 30(5), 1329-13134, Doi:10.53555/kuey.v30i5.5665

ARTICLE INFO ABSTRACT

Introduction: Manufacturing is important to a nation and its economy, and digitization of manufacturing will enhance the productivity and create new types of jobs. This sector is a big source of innovation and opportunities in the growing “clean economy.” However, the biggest challenge in digital manufacturing is to break the established roles and processes of the organization.

Method: The research approach is to identify the parameters, capabilities/skills and business values to measure ecosystems for IT investment in the manufacturing sector and identify mechanisms for pilot projects for scaling up and the challenges in adoption of digital technologies.

Results: The article tries to find out the capabilities, skills and mind sets which is needed in the organization for digital manufacturing and challenges for digital adoption using content- centric literature review on digital manufacturing.

Conclusion: Advanced manufacturing practices drives significant impact for the global footprints and portfolios. Digital systems will transform the design, manufacture and operation of the products and production systems.

Keywords: digital manufacturing; manufacturing industry; digitization values; digital adoption

1.0 Introduction

The landscape of digital technologies is wide and varied. There is a wide spectrum of technologies which are classified as digital technologies - internet of things, mobile technology, cloud computing, social media, analytics, big data, in memory computing, virtual reality, 3-D printing, 5G Mobile telephony etc. There are rapid advancements in each of these technologies and newer technologies are emerging as well, making the landscape wider, with exciting changes and increasingly complex to navigate. This ever-changing, complex to navigate landscape of digital technologies while offering immense opportunities to transform businesses, being an uncharted territory does pose challenges of adoption.

The growth and productivity enhancements of the manufacturing industry are critical to economic advancements of any country/economy. IBEF Reports (2024) indicates that manufacturing industry in India generated 16-17% of country's GDP and is projected to be one of the fastest growing sectors of the economy. The report indicates that with digitization India can become a global manufacturing hub. It is expected that digital connectivity will unlock various value and transform the manufacturing landscape forever.

The different digital technology elements either individually or in combination with other digital technology elements is expected to make significant impact on manufacturing sector. With its investments in manufacturing processes, tooling, operational elements etc. being difficult to modify investments, manufacturing would require imaginative thinking and careful planning to adopt digital technology. This article intends to explore and formulate frameworks to adopt digital technology by the manufacturing sector.

2.0 The Imagination and use cases

Whenever new technologies emerge, it is observed that immediate areas of adoption are not very obvious. This phenomenon is described by the S curve and by the Gartner's hype cycle. Given these characteristics of adoption, many times it is the human imagination which drives growth and adoption of new technology. However when there are limits to understand areas or models of adoption, the trigger to human imagination could come not from precedents but by imagining the scenarios using other fields of human pursuit. The grand

sweep of imagination to visualise the possibilities of digital technologies comes from the philosophical underpinning of evolutionary biology. (Dennett and Roy ,2015)

The great narrative that emergence of digital technologies are equivalent to emergence of light sensing (eyes) organs in animals and the possibilities are limitless as similar to the explosion of animal forms post emergence of light as a means of sensing the external world in the animals.

The living organisms for a long time in the history of life were dependent on pressure, temperature, chemical properties etc. to sense and react to the eternal world. Proximity or near proximity was critical to sense the outside world for these animal forms. Geologist Andrew Parker developed hypothesis on the biological revolution called Cambrian explosion which occurred in the sea, a few billion years ago. There was a change in the chemistry of the shallow oceans and atmosphere, which resulted in evolution of eye, the ability to sense light by the animal world. This ability to sense the world from a distance through light instead of only the proximate means like pressure, lead to explosion of life forms, the structures, the means of sourcing food, the mechanisms for protection and attack etc. (Dennett and Roy ,2015)

Philosophically, this seemingly unconnected phenomena of evolution eye and the associated Cambrian explosion of life forms on earth, provides a broad sweep of imagination to understand what could be the impact of digital technology on human organisations – government, business, social structures, military, trade, etc. While the imagination on the broader impact is unbound, the specific possibilities are numerous and have to be formulated with rigorous details, experimented to understand limitations, challenges and scaled up through incorporations of careful observations. Some of the possible triggers for imaginative thinking could be

- The structures: As the “Light switch theory” by Parker (Parker, 2003), indicates organizations need to change their sense to handle external interfaces and internal relations.
- Transparency: Many organisational philosophers opine that transparency is like sunlight, having the greatest disseminating and disinfecting qualities. When Digital technologies bring in added transparency, organisations would require mechanisms for handling transparency as well as processes protect the information, product details etc.
- The mechanisms of defence: Digital technologies increase the need for formulating effective defence mechanisms. In order for the organizations to survive in the evolving transparent world, organization needs to invest continuously in encryption and decryption schemes
- The strategy for the digital future: The ever evolving social world may result in a massive diversification of organizations with different focuses. Organizations may look into social purpose or profit. It would depend on the competitive priority which the organization wants to focus for their survival.
- Evolving ecosystem: Along with change in the organizational culture, a different type of ecosystem is needed for every sector, in terms of what is treated as an asset, the mechanisms for interfacing with the outside world, how innovations are fostered and adopted etc.

While the possibilities for innovation and adoption of digital technologies are numerous, a few use cases indicate how digital technology could be innovatively adopted by manufacturing organisations.

- **Plant Maintenance:** Areas where digital technologies can be adopted are for finding the failure characteristics of major equipment model, condition monitoring of equipment, predictive maintenance, Process controls.
- **Quality management and Regularity compliance:** Application of digital technologies in Pharmaceutical industry in areas like continuous monitoring conditions with mixing vessels, lyophilizers, tablet presses, detect counterfeit medicine and containments, etc for quality control and regulatory compliance
- **Operations of Consumer goods industry:** Digital technologies enable faster to customer preferences, reduce supply chain costs, Faster update on latest inventory count which will result in providing building good bonds with customers
- **Managing complexities of Aerospace and defence industry-** This industry has enormously complex supply networks. The complex nature of design makes a huge impact in the manufacturing of many other components, which will impact the cost, quality, delivery.

The digital technologies for manufacturing: There are many digital technologies which have specific application in manufacturing industry. There are many use cases of these specific technologies.

- Manufacturing processes: Some of the key technologies are - fabricating novel materials, sensors to detect defects and robotics to improve productivity. The 3D printing has enabled producing jet engines which can reduce time, cost and materials needed in production (GE Look Ahead, 2013).
- Digital manufacturing: Technologies like automation, robotics, additive manufacturing, human-machine interaction are transforming the manufacturing value chain from research and development, supply chain and factory operations to marketing, sales and services.
- Advanced analytics: Application of analytical tools in near real-time situations have potential for transforming process control, quality management as well optimising plant operations and supply chain. A Japan based Consumer Packaged Goods company has leveraged detailed stock keeping unit level cost data

from each of the factories and developed an analytical tool to find out where and when to ramp up the production (McKinsey , September 2021).

3.0 The Research Methodology

While it is important being imaginative while visualising the application of digital technologies, it requires a systematic assessment and planning to incorporate the possibilities offered by digital technologies in the business transformation efforts. This paper investigates some critical areas to be addressed in the journey of business transformation and develops a framework for systematic planning and execution. The areas are:

- Assessment of the ecosystem and landscape of digital technology: What are the emerging technologies, how each of these could impact or disrupt the industry
- Assessment of the value: Where is the value for my company?
- Formulation of capabilities: What new capabilities, skills, and mind-sets will we need in our organization?
- Plans for adoption: How should be the pilot project for digital technology, how to assess the pilot project and how to plan for scale up to capture business value?

The research work complements previously published studies in the manufacturing domain. The research approach is to identify the parameters, capabilities/skills and business values to measure ecosystems for IT investment in the manufacturing sector and identify mechanisms for pilot projects for scaling up and the challenges in adoption of digital technologies.

4.0 The findings and discussion

The research findings attempt to answer each of the above-mentioned questions with specific examples and use cases.

4.1 Ecosystems for the manufacturing factory of the Future

Digital technologies have changed the way in which companies position themselves. Digitally connected cars are causing traditional manufacturers to reposition as mobility and technology service providers. Given the increasing complexity of operations, technologies such as lean tools and Industry 4.0 tools are widely used in manufacturing sector. Lean management by itself is not sufficient to address the operational challenges. Manufacturing is a data rich industry, making it one of the ideal candidates for using AI. AI powered robots can work autonomously or cooperatively with humans to enhance the capacity. New advances in data processing, real-time analytics have prompted innovative IoT applications that provide insights when and where they need most. IoT and AI meet to drive increased availability, quality, and performance. Research throws up some interesting trends as indicated in these use cases.

- Condition -Based Monitoring: Sensors along with IoT devices can provide meaningful insights into the current health of various devices or items of equipment in buildings. Sensors combined with microcontrollers along with security solutions can enable predictive maintenance.
- Analytical view of historical/run time data: These systems will use analytics along with big data and industrial internet of things to have the analytical view of the manufacturing. Manufacturing analytics software like Mingo helps to solve problems at the initial stage.
- Alerts on predicted issues: These systems need to alert on defective part, production delays, upcoming critical calibration events , notifies finance teams about open order backlogs, excessive labor ticket costs, etc.
- Generating maintenance recommendations: Future manufacturing systems can use IoT to monitor and predict with the least human interferences. (Velmurugan, 2022) Smart maintenance practices , technologies such as Artificial Neural Network(ANN), Artificial Intelligence(AI), Internet Communication Technology (ICT) and machine learning maximize the possibility of maintenance recommendations
- Quality Management Systems(QMS): Robust quality management software is needed to support continuous improvement and other regulatory standards. For example, Intellect QMS software features access controls/ Permissions, Compliance management, Version Control, Quality Control, Corrective and Preventive Action (CAPA).
- Worker Safety systems: Future manufacturing organizations invest in software to streamline health and safety monitoring procedure. These systems will be integrated with safety documentations, dynamic health and safety in-app training, available as web-based and mobile app.
- Autonomous operations: Autonomous IT systems rely on machine learning and predictive analytics to correct future issues, or to respond to issues in real-time.

4.2 Investment for the future manufacturing sector

There are digital technologies which have the ability to process the historical data, integrate the data and visualize the data. It is expected that these technologies can be the drivers of good manufacturing practices in the future. Some of the technologies and the uses cases are:

Video analytics: Some of the applications of video analytics include integration of historical data with data streaming from the edge to gain a complete picture of their operations. AI algorithms leverage the information to label images and subjects and become increasingly effective at recognizing when specific events occur. These applications are used for predictive maintenance, quality management, worker safety and autonomous operations.

Predictive and Prescriptive maintenance: The ability to process data where it is created allows system to recognize patterns of anomalies instantly. These applications can be used to predict potential maintenance issues in real time, and alert manufacturers in real time. This has resulted to resolve problems without the need for human intervention. These capabilities have resulted in decreased uptime, higher productivity and Safety for people. AI can analyse the impact of failure and the cost of proactive fix. Manufacturers can then link the prediction to one of the following: Generating a maintenance ticket, shutting down the equipment, calling the vendor for the needed replacement.

Quality Assurance: AI/ML algorithms provide an extreme level of accuracy when identifying defects in products. With this methodology, the entire task of quality inspection can be automated at the edge, and the fault detection can be accomplished instantly.

4.3 Values of digitization

The survey of manufacturing executives on Steering IT into the digital manufacturing era, indicates (2014) that digitization could drive significant impact through the following ways:

Enhancing Productivity: Mobile devices in the system can give real-time information on equipment performance. The greater transparency afforded by big data adds to the effectiveness of lean tools and promotes continuous improvement.

Speed: A control tower gathers data such as production order, capacity utilization, inventories, etc. from various sources in an integrated value chain, an algorithm generates each day's ideal production plan. With the output, the company can select plans in real time, using criteria such as efficiency, lead time and customer priority. Automatic replenishment of parts can be done with its help

Quality: Supplier can be given a self-inspection process, workers to perform visual quality checks of their outputs.

Safety: Fit operators with sensors that will alert them to the presence of dangerous gases or the possibility of clash with nearby forklifts or trucks.

Quantifying the Improvement Potential: Companies that use integrated lean industry 4.0 approach, can reduce conversion costs by as much as 40%.

Enhancing resilience: Managing resilience has become a top priority. In the survey conducted by McKinsey (McKinsey Report, 2021) indicated that 93% of supply-chain leaders identified the need to increase resilience. If the company starts deploying robots before processes have been optimised, the robots will perform non-value-adding activities- that reduces the deployment's financial return.

4.4 New capabilities/ skills, and mind-sets will we need in our organization

The survey of manufacturing executives on Steering IT into the digital manufacturing era, indicates (2014) the following developments:

- With the digital invasion in manufacturing, it is possible to make things economically, more flexible, with a much lower input of labor, with lesser raw materials and new collaborative manufacturing processes. This results in manufacturing locally, whatever product each market requires.
- As manufacturing goes digital, some of the business of making things will return to developed countries. One of the major applications that affected the digital manufacturing is 3 D Printing. This technology does not need the economy of scale for manufacturing. The cost of setting up machine is the same whether it makes one thing or as many things as can fit inside the machine. This technology is widely used to make specialist parts of a car.

- New collaborative manufacturing services are available online. Communities offering 3D Printing and other production services are already forming online- a new phenomenon which might be called social manufacturing.
- Arrays of manufacturing technologies which are emerging, making the manufacturing sector processes jobs-light. But some assembling components operations remain too fidelity for robots to do well, such jobs may be transferred to low-wage countries.
- Materials used to make things are changing as carbon-fibre composites will be replacing steel and aluminium products. There will be millions of small and medium sized firms that will benefit from new materials, cheaper materials, cheaper robots, smarter software, an abundance of online software and 3-D printers than can economically print in smaller numbers
- Manpower training needs to be done differently. Training can be done by collaboration between community colleges and local firms. Trainers can simulate production lines With new ideas, factories of future needs to look into how these ideas can be converted to products by training in universities and research laboratories.
- Next generation Robots are cheaper and easier to set up. They will work with people rather than replacing them. They will fetch and carry parts, hold things, pick up tools, sort items, clean up and make themselves useful in myriad other ways. Various efforts are underway to produce such robots, especially for smaller companies, These robots must be safe enough to operate alongside workers and capable of understanding simple instructions, including voice commands.

4.5 Steps to capture value by digitization

In the pilot production line, a joint venture between MIT and Novartis, an attempt has made to produce a copy of the standard Novartis drug. It relies on a combination of chemistry and engineering processes to speed up some processes and slowing down others to make them work together. Continuous manufacturing enables to manufacture in a small regionalised plant. Such plants will benefit by

Innovation: Access to model factories and mobile labs where managers and executive can try out new technologies and gain insights into the new opportunities. Participating in hands on simulations can help to improve performance.

Pilot: Develop a minimum viable solution and improve it using iterations using agile development methods. At the same time, company should deploy all the relevant enablers to get the success.

Scale: The company should conduct the rollout in a logical sequence, that allows for integrating solutions effectively when deployed at full scale.

4.6 Quantifying the impact of Advanced Manufacturing

To provide quantitative understanding of the impact, a study made in German based manufacturing industry (BCG Report, 2015) indicated the following:

Productivity: Productivity improvements will vary by industry. Industrial component manufacturers such as machinery manufacturers may achieve some of the biggest productivity improvements. (20 percent to 30 percent), automotive companies can expect increases of 10 to 20 percent.

Revenue growth: Enhanced equipment and new data applications by manufacturers and a variety of customer products will drive an additional revenue growth of \$30 billion per year.

Employment: During the next ten years, there will be an increase in 6% employment. This requires a skill in robotic process automation, connectivity, and analytics. Employment will increase in software development, IT technologies, such as mechatronics.

Investment: Adapting production processes to incorporate industry 4.0 for manufacturing globally, requires an approximate investment of €250 billion.

5.0 Challenges

Mattias Ulbrich (2016) in the report on digital manufacturing mentions the challenges encountered when adopting these new generation technologies

Resistance to Change: People with different roles will be in different parts of the organization and in different parts of the world tended their own of doing things. Hence everyone needs to be motivated to adopt to change. By establishing permanent dialogue between business and IT, key transformation agents can enable changes in the organization. For example, digital tracking of vehicles in an automakers organization, meant training thousands of employees on products, process, quality and logistics in the new way of working.

Involvement of Senior leadership Team: The senior management team must devote time to the change process.

Change in the organizational Structure: Classical hierarchical structure may not be the ideal for the information flow. Cross-functional teams and interdisciplinary collaboration will add value to the organization.

Develop deep Technology Expertise: Outside traditional areas of IT, investments in robotics process automation, machine learning and augmented reality are needed.

Conclusion

Advanced manufacturing practices drives significant impact for the global footprints and portfolios. Digital systems will transform the design, manufacture and operation of the products and production systems. Connectivity and interaction among parts, sophisticated machines make the productive systems much faster and elevate production to new levels.

Significance of the research

The digital marketplaces are actively providing advantage to small players, suppliers, designers, managers, workers, and the entire manufacturing ecosystems. To harness the benefits, every player needs to understand IT systems, IT skills/capabilities and benefits of the digital manufacturing. In the present marketplaces where profit margins are thin and consumers demand are more sophisticated, there is a huge benefit to organizations by understanding the IT ecosystems of the future. These advantages and the wealth they create will become the basis for greater world-wide prosperity.

REFERENCES

1. Boer, de, Enno., Leurent, Helena., & Wildmer, Adrian.(2019). 'Lighthouse' manufacturer lead the way- can the rest of the world keep up?. *McKinsey & Company*.
2. Butt, Javaid .(2020). A conceptual framework to support digital transformation in Manufacturing using an integrated business process management approach. *Designs*, 4,17.
3. Dennett, Daniel., & Roy, Deb. (2015), Our Transparent Future, *Scientific American*, 64-69.
4. Hartmann, Bran., King, William P., & Narayanan, Subbu. (2015). Digital manufacturing: The revolution will be virtualized, *McKinsey Digital*
5. K Velamurugan, S, Saravanasankar, S. & Bathrinath. (2022). Smart maintenance management approach: Critical review of present practices and future trends in SMEs, *Science direct*, 62(6), 2988-2995.
6. Ulbrich, Mattias . (2016). Steering IT into the digital manufacturing area, *McKinsey & Company*.
7. Manufacturing Sector in India Industry Report (2023, Dec). *IBEF Report*. Last updated Feb, 2024
8. Future of Manufacturing, (2013, Nov 1). *GE Look ahead*.
9. A manufacturing footprint fir for the future , via advanced analytics(2021, September). *McKinsey's Operations Practice*.
10. Industry 4.0, (2015, April). The future of Productivity and Growth in manufacturing industries. *BCG*.

FINANCIAL RATIOS AND PERFORMANCE OF PSU BANKS IN INDIA- AN ANALYSIS

Dr. Abhijit Chakraborty, Associate Professor, School of Commerce and Management Studies,
Dayananda Sagar University, Bengaluru.

Dr. Abhijit Ranjan Das, Assistant Professor, School of Commerce and Management Studies,
Dayananda Sagar University, Bengaluru.

Ms. Bhavya P., Student of Executive MBA, School of Commerce and Management Studies,
Dayananda Sagar University, Bengaluru.

Abstract

Financial Ratios are considered as indicators of performance of business institutions including banks. The participants of the financial industry often gauge the operational performance and stability of a bank by considering financial ratios like PE Ratio, Cost to Capital Ratio, Leverage Ratios, and Solvency Ratios. This research article conducts a comprehensive analysis of the financial ratios and profitability trends of Public Sector Undertaking (PSU) Banks in India. Against the backdrop of dynamic economic conditions and evolving banking landscapes, understanding the financial health of PSU banks is crucial for policymakers, investors, and stakeholders alike. The study employs a multiple regression technique to analyze the relationship between financial ratios and profitability of the PSU banks in India. The findings reveal a significant relationship between financial ratios and profitability, reinforcing the importance of financial ratios as a performance indicator of PSU Banks in India. Policymakers can leverage the study's outcomes to formulate informed strategies, and investors can make well-informed decisions based on a nuanced understanding of the financial dynamics within the PSU banking landscape.

Keywords: *financial ratios, profitability, PE ratio, leverage ratio, solvency ratio.*

Introduction

Banks can function well by directing a society's deposits to the financial institution that is anticipated to provide the highest social returns and closely monitoring such institutions after they have loaned the society's limited resources. Ineffective banks hinder economic development and social welfare (Athanasoglou, 2008). Maximizing the efficiency with which savers transfer funds to borrowers enables the efficient allocation of resources to high-return activities. Productivity and economic growth are interrelated, and the contribution of a financial system to both will be greater if it generates and allocates resources more efficiently (Beck et al., 2000).

Profitability is the capacity to maximize resources to generate more money than expenses. It is the potential to profit from its actions. Profitability is determined by a bank's ability to create sufficient earnings or lower operational expenses, indicating that it operates more effectively (Neupane, 2019). The profit from operation as compared to the equity capital is measured by the Return on Equity (ROE) ratio. Investors, managers, and financial analysts have utilized it for decades to guide dividend payments, gauge management effectiveness, and predict and analyze decisions.

The regulation of banking sector must ensure that banking institutions are operating in a secured manner and are accountable to the nation as a custodian of the public deposits. The objective of enacting legislation is to guarantee that these institutions have adequate capital to protect the businesses, their customers, the government, and the economy as a whole (Baral, 2016).

Significance of Financial Ratios

Since Banking sector is the most important segment of the financial industry, it is inevitable to keep check on the performance of this sector. The different stakeholders including customers, investors, Government and employees are interested to keep an eye on the bank's performance parameters. But the performance of a bank depends on various factors and considering a standalone parameter may not expose the accurate picture. For example, a bank may earn a very good profit in a particular year should be considered to be strong bank if its debts are high, it is unable to maintain adequate liquidity or the non-performing assets are on the rise. This might have lead to the introduction of Financial ratios, which are indicators of various important parameters and at the same times easy to decode. Financial ratios play a crucial role in analyzing a bank's profitability and overall financial health. The financial ratios help dissect the performance indicators and helps the stakeholders and the bank itself on the below mentioned areas:

- **Performance Evaluation** - Financial ratios provide valuable insights into a bank's performance over time by comparing key financial metrics such as profitability, liquidity, solvency, and efficiency. Ratios such as return on assets (ROA), return on equity (ROE), and net interest margin (NIM) help assess how efficiently a bank utilizes its assets and generates profits.
- **Risk Assessment**- Ratios help in evaluating the risk exposure of a bank by analyzing its leverage, liquidity, and asset quality. Metrics such as the loan-to-deposit ratio, capital adequacy ratio (CAR), and non-performing loan (NPL) ratio provide indications of a bank's ability to manage risks and withstand adverse economic conditions.
- **Investor Decision-making**- Investors use financial ratios to assess the financial health and performance of banks before making investment decisions. Ratios like price-to-book ratio (P/B), price-to-earnings ratio (P/E), and dividend yield are commonly used by investors to gauge the valuation and attractiveness of bank stocks.
- **Regulatory Compliance** - Financial ratios are used by regulatory authorities to monitor and assess the stability and soundness of banks. Regulatory ratios such as the CAR and liquidity coverage ratio (LCR) are mandated by regulatory bodies to ensure that banks maintain adequate capital and liquidity buffers to mitigate risks.
- **Strategic Planning**- Banks utilize financial ratios to identify areas of strength and weakness, guiding strategic planning and decision-making processes. Ratios help banks benchmark their performance against industry peers and set realistic financial targets and objectives.
- **Stakeholder Communication**- Financial ratios serve as a means of communication between banks and various stakeholders, including shareholders, analysts, regulators, and customers. Banks use these ratios to transparently convey their financial performance, strategy, and risk management practices to stakeholders, fostering trust and confidence.

Financial ratios are indispensable tools for assessing a bank's profitability, risk profile, and overall financial performance. They aid in decision-making, risk management, regulatory compliance, and stakeholder communication, thereby playing a vital role in the banking industry's stability and resilience.

Literature Review

Buchory (2015) studied the Indonesian Regional Development Bank. The study found that the LDR (loan-to-deposit ratio) negatively influences the ROA (Return of Assets), which is not statistically significant. Also, OEOI (Operating Expenses to Operating Income) highly and negatively influences the ROA.

Mwongeli (2016) examined the link between government rules and business success in Kenya and analyzed whether the 2014-2016 regulations affected second-tier commercial banks' financial performance. Financial performance was judged by the degree of adequate capital. The link between the two variables was determined using a Chi-square test. According to the survey, most banks have reached the minimum capital requirement. However, the government must continue to follow the recommendations to ensure the stability of the Kenyan banking industry.

Karanja and Nasieku (2016) conducted a descriptive study on capital's effect on Kenyan commercial banks' financial performance. Central Bank of Kenya-regulated commercial banks in Kenya were the

campaign's target audience. The study used secondary sources, namely the banks' audited financial records from 2010 to 2014. Multiple regression was used to examine how capital determinants affect Kenyan commercial banks' economic performance. Tier I and II banks' core capital ratios to total risk-weighted assets fell between 2010 and 2014. Between 2010 and 2014, tier I banks' total capital to risk-weighted assets fell.

Bhattarai (2016) determined how credit risk influenced the commercial bank's performance for five years (2010 to 2015). The pooled result shows that CAR insignificantly and bank size positively correlated with the bank profitability (ROA).

Pradhan (2016) researched seventeen commercial banks in Nepal between 2006 and 2013. They found that their financial performance positively affected Nepalese commercial banks' operating efficiency, loan-to-deposit ratio, total deposit-to-asset ratio, and loan loss provision-to-equity ratio. The total capital ratio negatively affects the Nepalese commercial bank performance.

Baral (2016) evaluated 20 commercial banks between 2006 and 2013. The study revealed that the OE (Operating Efficiency), size, and ROA (Return on Assets) positively correlate with the CAR (Capital Adequacy Ratio). It implies that bank size, OE, and bank size increase with the CAR.

Setiawan and Hermanto (2017) evaluated 25 Indonesian banks from 2008 to 2013. The study revealed that CAR positively connects with bank profitability, while OEOI correlated negatively.

Musyoka (2017) measures the CAR and performance of Kenyan banks and determines how they affect each other. The study observed a significant and inverse association between CAR and the performance of Kenyan banks.

Ana and Alistair (2017) studied the effect of capital ratios on bank profitability over various economic cycles, from the late 1970s to the recent financial crisis. According to the research, excess capital negatively affects financial organizations' profitability.

Udawatta et al. (2018) investigated credit risk management's influence on commercial bank profitability. The non-performing loan ratio doesn't affect ROE or ROA. Capital adequacy ratio and ROE/ROA have a negative association. The capital adequacy ratio is unrelated to ROE or ROA.

Singh and Sharma (2018) examined the twenty-six public sector banks in India. The study reveals a strong and close relationship between the ROA and CAR, which is statistically significant.

According to the findings of a study by Ini and Eze (2018) on the effect of capital adequacy requirements on the operational efficiency of commercial banks in Nigeria, total qualifying capital, capital to risk-weighted assets, and adjusted shareholders fund all have a significant impact on ROA.

Chalise (2019) showed that total capital adequacy negatively affects bank performance (ROA). Also, the D/E (Debt-Equity) ratio and size positively and insignificantly affect bank performance. Nonetheless, the equity ratio positively affects the performance of Nepalese commercial banks.

Neupane (2019) investigated an eight-bank sample between 2011 and 2017. The study showed that OEOI negatively correlates with ROA. Also, LDR negatively and insignificantly correlates with ROA.

Linh and Trang (2019) studied bank capital and profitability. Capital and bank profitability are linked, say the results. Data show that smaller banks are more capital-sensitive. Its influence on large banks' earnings is modest. The study found that high capital levels boosted the profitability of privately held banks.

Ajayi et al. (2019) studied the influence of the capital adequacy ratio on deposit money banks' profitability taking into consideration thirty Vietnamese commercial banks of varying sizes from 2012 to 2018. The study revealed that capital influences state-owned banks' net interest margin positively. ROA and CAR have a strong positive association.

Research Gap

Indian banks must have sufficient capital to cover their risks, making capital adequacy one of the most heavily regulated areas of the global banking business. Capital adequacy is one of the most important performance factors for commercial banks because it affects how much shareholders trust and believe in the company. Still, empirical studies of how capital adequacy affects the financial performance of listed Indian banks come to different conclusions, which shows that there is no

consensus.

Cross-sectional studies show that having enough capital has a big positive effect on how well commercial banks do financially. Nestor et al. (2017) found a strong and positive link between having enough capital and how well a business does financially. At a significance level of 5%, the study also showed that having enough capital has a statistically significant effect on how well banks do financially. Some studies show that the amount of capital a bank has is bad for how well it does financially. Several studies showed that there was no link between the amounts of capital Indian banks had and how well they did financially.

The literatures considered in this study show that though many authors have investigated the impact of individual financial ratios on the profitability of the banks, but a joint impact of the financial ratios over bank's profitability was not considered. This study is an attempt to bridge this research gap.

The objective of this study is to investigate if the financial ratios are able to correctly relate to the operational performance of the banks.

Research Methodology

This study uses a descriptive and analytic research design to examine how different financial ratios affect the profitability of some Indian banks between 2018 and 2022. The descriptive research design calls for the appraisal of facts and information, which also helps describe the variables' characteristics. The subject of a descriptive study is found by making a profile of people, groups, or events and then tabulating and collecting data on how often the researched variables happen. This can be done by looking at patterns in the data. When looking at how well banks are doing, many analytical tools, like correlation and regression, are used.

SAMPLING DESIGN

The sample selected for this study was from the public sector banks in India. Based on information from the Ministry of Finance as of July 2021, the banks considered for the study are listed below.

- Central Bank of India
- Indian Bank
- Indian overseas bank
- Punjab National Bank
- Bank of India

From the above list of banks, samples were chosen based on data availability for five years, i.e. from 2018-2022.

The study uses secondary data to attain its goal. This study gets the needed information, such as balance sheets, profit and loss statements, etc., by looking at the annual reports of sample banks and another structured document.

DATA COLLECTION

Various methods and techniques were employed to collect and analyze the study data. All secondary sources are included in the necessary data for conducting this inquiry. However, the data can be confirmed by analyzing many sources. According to the needs of the study, the data collected using the data collection sheet were edited, coded, and reorganized. Microsoft Excel and SPSS version 21 are utilized to accomplish the data analysis. The collected data is entered into SPSS version 21, and additional analyses, including descriptive, correlation, and regression, are conducted by the criteria.

STATISTICAL TOOLS

This study uses SPSS to analyze the data and take the output. For data presentation and interpretation, frequency distributions consisting of ratios, tables, and charts are used. Descriptive statistics are used to measure the dependent and independent variables. Consequently, correlation tests were used to determine the relationship between the variables. Regression was used to identify how variable affect the dependent variable. At last, chi-square test is used to determine the association between the two variables

Variable used in the Study

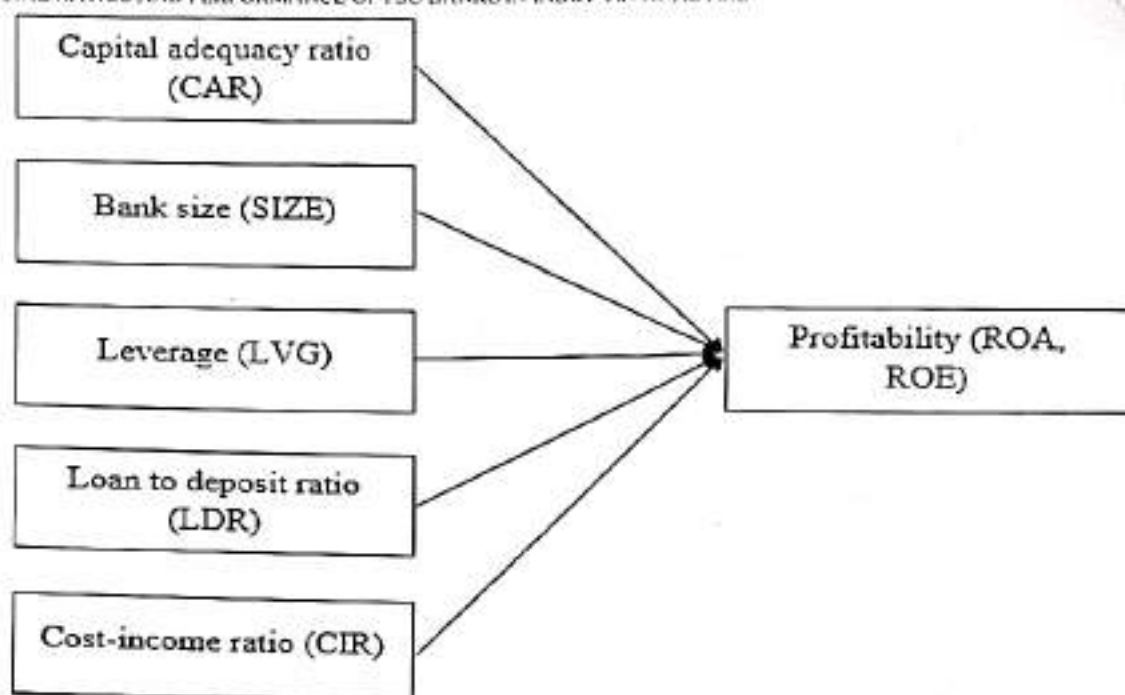
Variables	Type variable	Formula
Profitability (ROA)	Dependent	Net income/total asset
Bank size (SIZE)	Independent	Natural Log of Total Assets
Leverage (LVG)	Independent	Total Debt / Total equity
Capital adequacy ratio (CAR)	Independent	Tier 1 capital + Tier 2 capital/ Risk weighted Assets
Loan to deposit ratio (LDR)	Independent	Loan/total deposit
Cost-income ratio (CIR)	Independent	Operating income/Operating expense

OPERATIONAL DEFINITION

- **Profitability** is the amount of money created by a commercial activity that exceeds the expenses, costs, and taxes required to support the business. Profits accrue to the company's owners, who may or may not reinvest them in the company.
- **The size of a bank** is generally used to capture potential economies or diseconomies of scale in the banking sector. Larger banks tend to be more active in markets, have a greater product, and have better possibilities for diversification.
- **Leverage** is a concept that refers to how banks use their borrowing to improve their profits.
- **The capital adequacy ratio**, also known as the capital risk-weighted assets ratio, is used to protect depositors and improve the dependability and efficiency of the nation's diverse financial institutions.
- **The loan-to-deposit ratio** evaluates a bank's ability to meet its financial obligations with its deposit funds. A higher ratio poses a threat to banks because their reserves would fall due to greater lending, whereas a lower ratio indicates that banks may not be earning very much.
- **The cost-to-income ratio** is a fundamental financial metric, especially when evaluating financial institutions like banks. It analyzes the expenses and income of a business.

Conceptual Framework

The following conceptual framework shows the relationship between dependent and independent variables based on the findings of a review of significant literature, including Bhattarai (2016), Pradhan and Shrestha (2016), Chalise (2019), and Kipruto et al. (2017). Five research hypotheses have been developed to investigate the potential relationships between the variables. The hypothesis investigates whether there is a connection between statistically positive variables. The following figure depicts the basic conceptual structure:



Source: Authors' own calculation

PRESENTATION AND ANALYSIS OF THE DATA

Ratio analysis

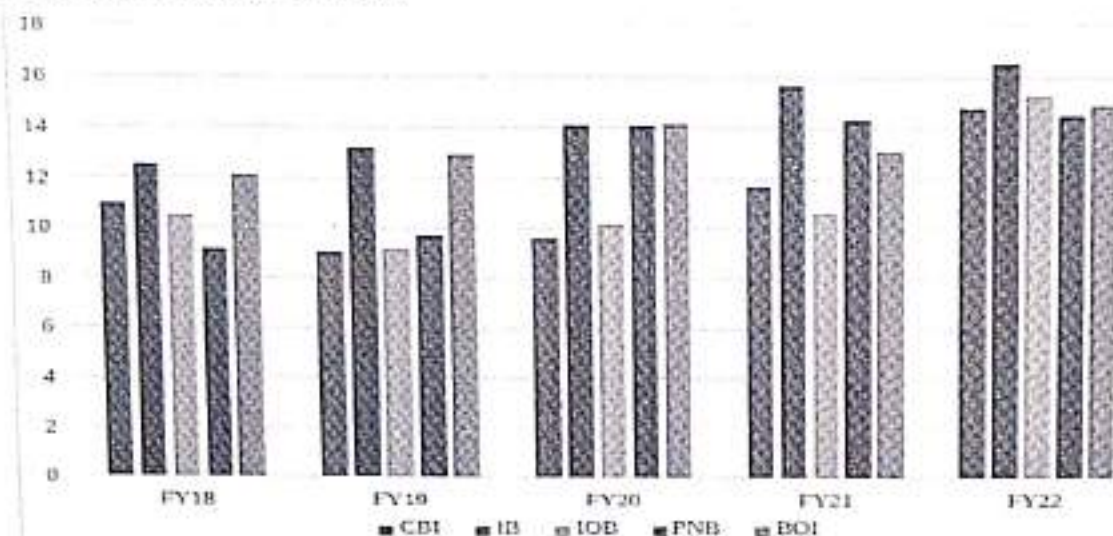
Table 4.1: Capital adequacy ratio

CAR	CBI	IB	IOB	PNB	BOI
FY18	10.95	12.55	10.5	9.2	12.14
FY19	9.044	13.21	9.25	9.73	12.94
FY20	9.61	14.12	10.21	14.14	14.19
FY21	11.72	15.71	10.72	14.32	13.1
FY22	14.81	16.53	15.32	14.5	14.93
Mean	11.23	14.42	11.20	12.38	13.46
SD	2.27	1.67	2.37	2.67	1.10
CV	20.2%	11.6%	21.2%	21.6%	8.2%

Source: Authors' own calculation

It is observed from the table that the CAR of the selected bank ranges from 11.20% to 14.42%, and it shows a fluctuating trend. However, the mean value of CBI is 11.23%, whereas IB has 14.42%, IOB has 11.20%, PNB has 12.38%, and the BOI has 13.46%. It is then found that the mean value of IB is highest at 14.42%, with an SD of 1.67. The mean value of IOB is lowest at 11.20%, with an SD of 2.37%. The result of the CV reveals that the BOI has the least CV of 8.2%, representing the BOI is more stable than other banks. As a result, the bank must maintain a minimum CAR of 10 per cent; hence, the chosen bank is conservative and has not fully employed its capital. It is then concluded that the IB have a higher CAR indicates the stronger position of the selected bank.

Figure 4.1: Capital adequacy ratio



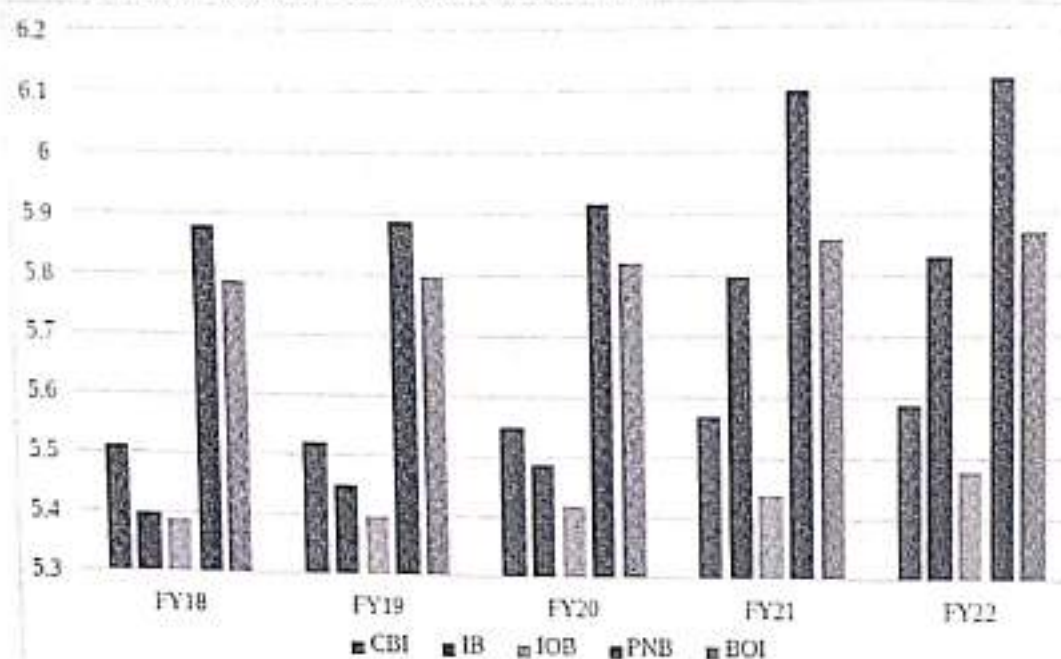
Source: Authors' own calculation

Table 4.2: Bank size

Size	CBI	IB	IOB	PNB	BOI
FY18	5.51	5.4	5.39	5.88	5.79
FY19	5.52	5.45	5.4	5.89	5.8
FY20	5.55	5.49	5.42	5.92	5.82
FY21	5.57	5.8	5.44	6.1	5.86
FY22	5.59	5.83	5.48	6.12	5.87
Mean	5.55	5.59	5.43	5.98	5.83
SD	0.03	0.20	0.04	0.12	0.04
CV	0.6%	3.7%	0.7%	2.0%	0.6%

Source: Authors' own calculation

It is noted from the above table that the size of the selected banks shows a fluctuating trend. However, the mean value of CBI is 5.55%, whereas IB has 5.59%, IOB has 5.43%, PNB has 5.98%, and the BOI has 5.83%. It is then found that the mean value of PNB is highest at 5.98%, with an SD of 0.12%. The mean value of CBI is lowest at 5.55%, with an SD of 0.03%. The result of the CV reveals that the CBI and BOI have the least CV of 0.6%, representing a consistent performance.



Source: Authors' own calculation

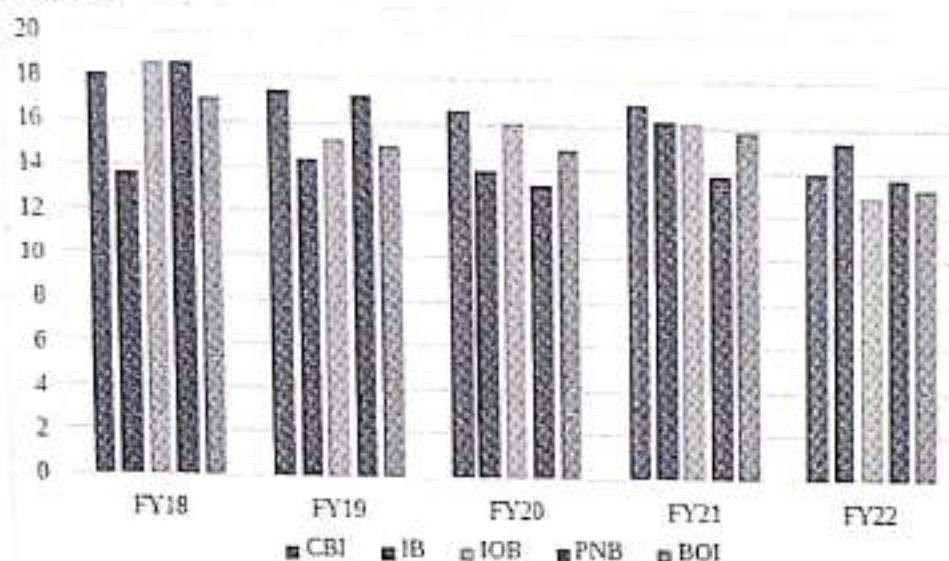
Table 4.3: Leverage

Leverage	CBI	IB	IOB	PNB	BOI
FY18	18.14	13.7	18.68	18.64	17.15
FY19	17.47	14.44	15.28	17.3	15
FY20	16.63	14.01	16.14	13.32	14.99
FY21	17.01	16.3	16.17	13.86	15.86
FY22	14.04	15.37	13.02	13.77	13.32
Mean	16.66	14.76	15.86	15.38	15.26
SD	1.57	1.06	2.03	2.42	1.40
CV	9.4%	7.2%	12.8%	15.7%	9.2%

Source: Authors' own calculation

It is indicated from the above table that the leverage of the selected banks shows a declining trend. However, the mean value of CBI is 16.66%, whereas IB has 14.76%, IOB has 15.86%, PNB has 15.38%, and the BOI has 15.26%. Hence, it is found that the mean value of CBI is highest at 16.66%, with 1.57% SD. The mean value of IB is lowest at 14.76%, with 2.03% SD. The CV analysis shows that the IB have the lowest CV, which has a consistent performance compared to other banks. It is then concluded that the CBI has been highly leveraged.

Figure 4.3: Leverage



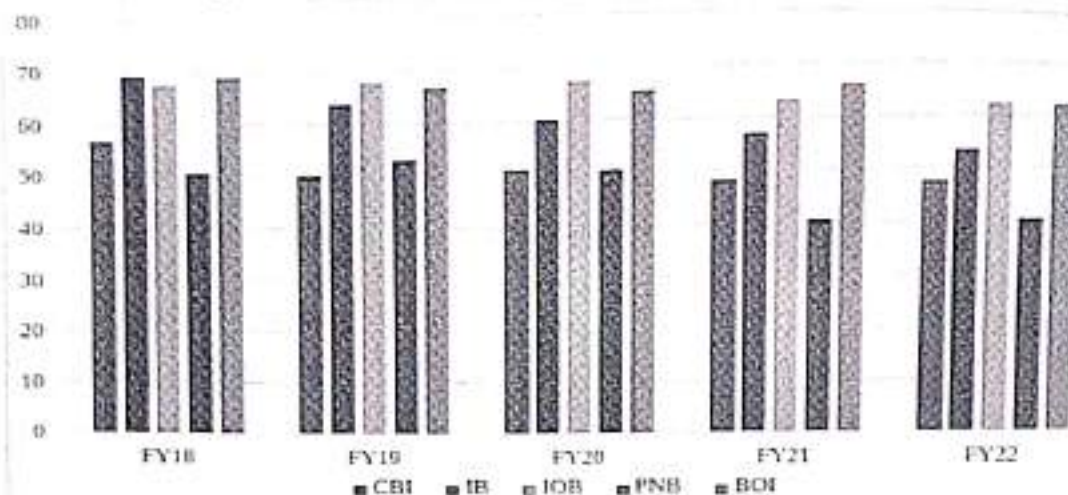
Source: Authors' own calculation

Table 4.4: Loan to deposit ratio

LDR	CBI	IB	IOB	PNB	BOI
FY18	56.75	69.13	67.51	50.87	68.91
FY19	50.03	63.75	67.66	53.02	66.72
FY20	50.96	60.33	67.4	50.8	65.51
FY21	48.5	57	63.31	40.69	65.95
FY22	47.8	53.76	62.26	40.33	62.11
Mean	50.81	60.79	65.63	47.14	65.84
SD	3.55	5.96	2.62	6.12	2.46
CV	7.0%	9.8%	4.0%	13.0%	3.7%

Source: Authors' own calculation

The above table shows the LDR of the selected bank ranges from 47.14% to 65.84% and shows a fluctuating trend. Furthermore, the mean value of CBI is 50.81%, whereas IB has 60.79%, IOB has 65.63%, PNB has 47.14%, and the BOI has 65.84%. Hence, it is found that the mean value of BOI is highest at 65.84%, with 2.46% SD. The mean value of PNB is lowest at 47.14%, with 6.12% SD. The CV analysis shows that the IOB have the lowest CV, which has a consistent performance compared to other banks. Hence, it concludes that BOI has a smaller loan book than its customer deposit base.

Figure 4.4: Loan to deposit ratio

Source: Authors' own calculation

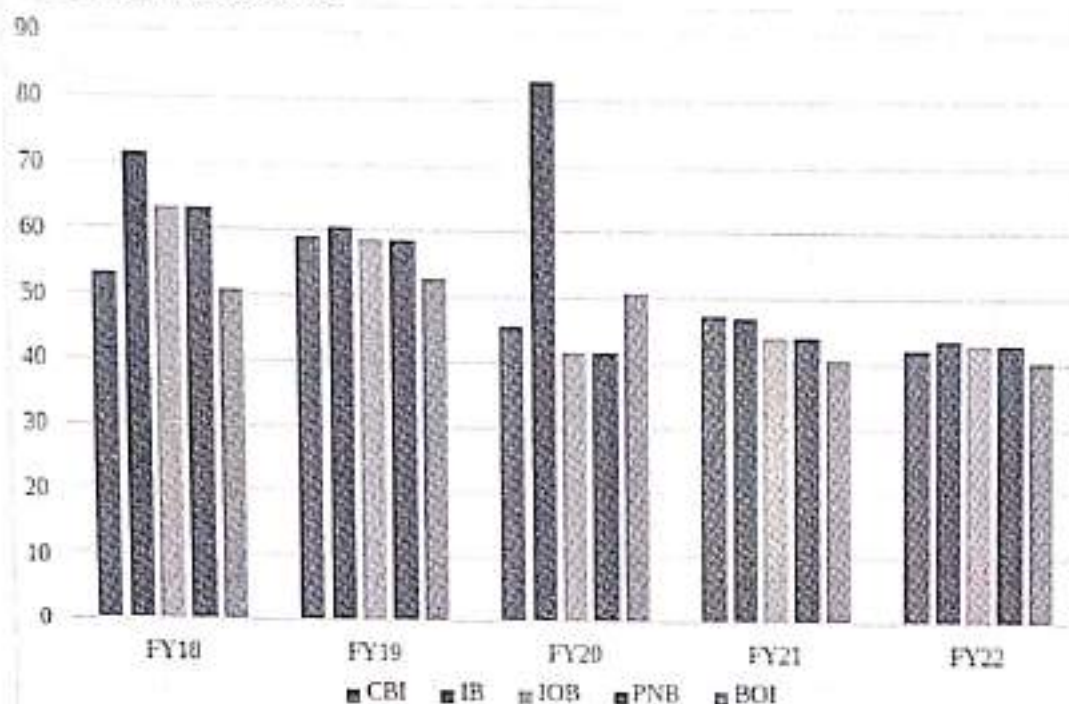
Table 4.5: Cost to income ratio

CIR	CBI	IB	IOB	PNB	BOI
FY18	53.43	71.61	63.44	63.44	50.87
FY19	59.18	60.55	58.8	58.8	53.02
FY20	45.54	82.77	41.81	41.81	50.8
FY21	47.49	47.17	44.1	44.1	40.69
FY22	42.16	43.93	43.07	43.07	40.33
Mean	49.56	61.21	50.24	50.24	47.14
SD	6.76	16.35	10.10	10.10	6.12
CV	13.6%	26.7%	20.1%	20.1%	13.0%

Source: Authors' own calculation

The table above shows the CIR of the selected banks. However, the mean value of CIR may vary from 47.14% to 61.21% and shows a fluctuating trend. However, the mean value of CBI is 49.56%, whereas IB has 61.21%, IOB has 50.24%, PNB has 50.24%, and the BOI has 47.14%. Hence, it is found that the mean value of IB is highest at 61.21%, with 16.35% SD. The mean value of BOI is lowest at 47.14%, with an SD of 6.12%. The result of the CV reveals that the BOI has the lowest CV, which has a consistent performance compared to others. Hence, it is concluded that the BOI has more profitability than others.

Figure 4.5: Cost-to-income ratio



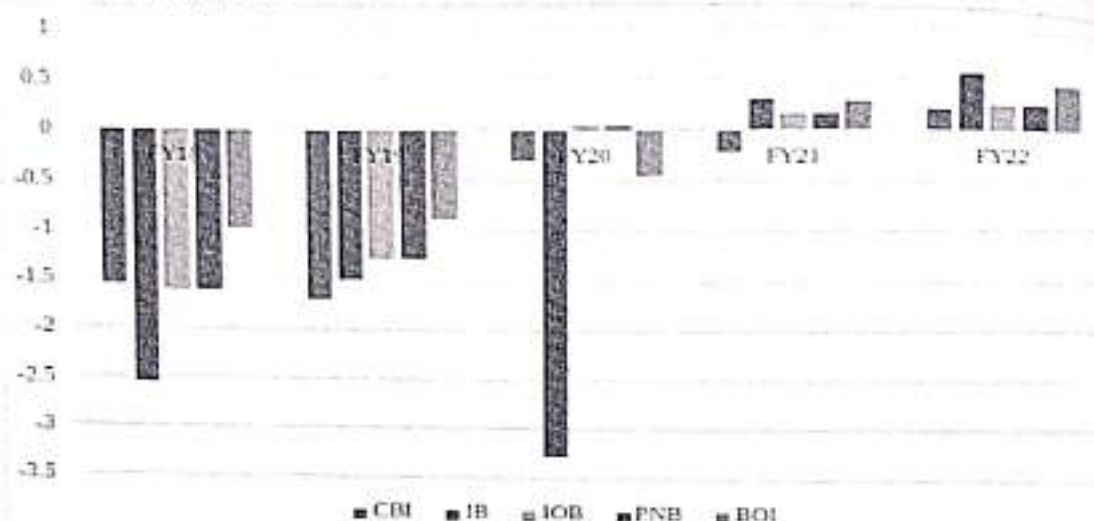
Source: Authors' own calculation

Table 4.6: Return on asset

ROA	CBI	IB	IOB	PNB	BOI
FY18	-1.56	-2.54	-1.6	-1.6	-0.99
FY19	-1.7	-1.49	-1.28	-1.28	-0.88
FY20	-0.31	-3.27	0.04	0.04	-0.45
FY21	-0.21	0.3	0.16	0.16	0.29
FY22	0.21	0.57	0.26	0.26	0.46
Mean	-0.71	-1.29	-0.48	-0.48	-0.31
SD	0.86	1.70	0.88	0.88	0.66
CV	-1.20	-1.32	-1.83	-1.83	-2.11

Source: Authors' own calculation

It is observed from the table that the ROA of the selected bank ranges from -0.31 to -1.29, and it shows a fluctuating trend. However, the mean value of CBI is -0.71%, whereas IB has -1.29%, IOB has -0.48%, PNB has -0.48, and the BOI has -0.31%. Hence, it is found that the mean value of BOI is highest at -0.31% with 0.66% SD. The mean value of IB is lowest at -1.29%, with 1.70% SD. Thus, BOI has more capital efficiency, and other bank does not have capital efficiency. The CV results reveal that the IOB and PNB are more stable than other banks. As a result, the ROA of BOI depicts a firm's management's efficiency in generating Net Income from all resources. A low ROA suggests that the company is an asset-intensive corporation.

Figure 4.6: Return on asset

Source: Authors' own calculation

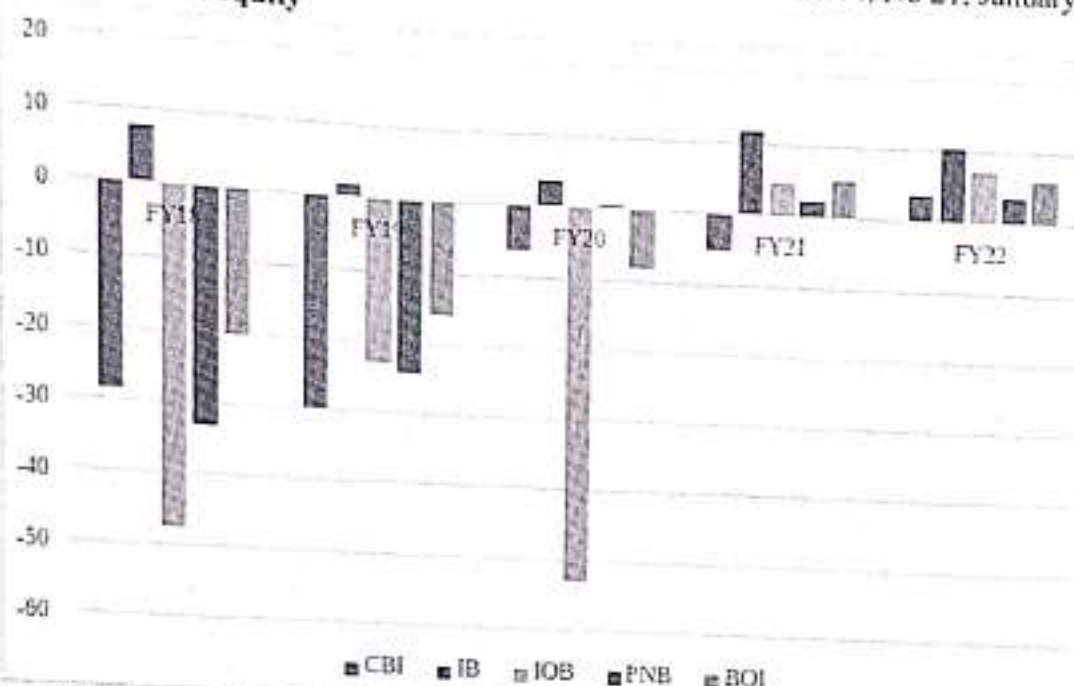
Table 4.7: Return on equity

ROE	CBI	IB	IOB	PNB	BOI
FY18	-28.38	07.95	-47.45	-32.95	-20.15
FY19	-29.79	01.97	-22.84	-24.2	-15.66
FY20	-06.07	03.94	-52.78	00.58	-07.88
FY21	-04.95	11.88	04.90	02.41	05.47
FY22	03.79	10.52	07.43	03.90	06.17
Mean	-13.08	07.25	-22.15	-10.05	-06.41
SD	15.11	04.23	28.22	17.23	12.00
CV	-01.16	00.58	-01.27	-01.71	-01.87

Source: Authors' own calculation

The table above shows the ROE of the selected banks. However, the mean value of ROE may vary from -22.15 to 7.25 and shows a fluctuating trend. However, the mean value of CBI is -13.08%, whereas IB has 7.25%, IOB has -22.15%, PNB has -10.05%, and the BOI has -6.41%. Hence, it is found that the mean value of IB is highest at 7.25%, with 4.23% SD. The mean value of IOB is lowest at -22.15%, with 28.22% SD. Thus, IB has more capital efficiency, and other bank does not have capital efficiency. The result of the CV reveals that the IB has the lowest CV, which has a consistent performance compared to others. As a result, the selected bank does not have a good performance.

Figure 4.7: Return on equity



Source: Authors' own calculation

Table 4.8: Descriptive statistics

Particulars	Minimum	Maximum	Mean	SD	Skewness	Kurtosis
CAR	9.04	16.53	12.538	2.302	-0.094	-1.300
SIZE	5.39	6.12	5.676	0.228	0.345	-1.131
LEVERAGE	13.02	18.68	15.584	1.737	0.241	-1.083
LDR	40.33	69.13	58.042	8.850	-0.477	-0.886
CIR	40.33	82.77	51.679	10.834	1.228	1.351
ROA	-3.27	0.57	-0.656	1.028	-0.841	0.054
ROE	-52.78	11.88	-8.888	18.530	-0.969	-0.041

Source: Authors' own calculation

The table above shows the descriptive statistics of the selected variable in the study. It is found that the capital adequacy ratio of the selected bank varies from 9.04% to 16.53%, with a mean value of 12.54% and an SD of 2.30. However, CAR is approximately symmetric. The size is 5.39 to 6.12, with an average value of 5.68 and an SD of 0.23, which shows that the bank size is approximately symmetric. Besides, the leverage ratio has a minimum value of 13.02 and a maximum value of 18.68 with an average value of 15.58 and an SD of 1.74, which indicates that the leverage ratio is approximately symmetric and leptokurtic. The loan to deposit ratio varies from 40.33% to 69.13%, with an average of 58.04 and an SD of 8.85. Also, LDR is approximately symmetric and leptokurtic. The cost-to-income ratio range from 40.33 to 82.77, with a mean value of 51.68 and an SD of 10.83. Although, it shows that the CIR is highly skewed and leptokurtic. However, the ROA has a minimum value of -3.27% and the maximum value of 0.57%, with an average of -0.66 and an SD of 1.028. However, CIR is moderately skewed. Furthermore, ROE has a minimum value of -52.78% and a maximum value of 11.88%, with an average of -8.88 and an SD of 18.53.

Correlation**Table 4.9: Correlation between the CAR practices and return on assets**

Particulars		CAR	SIZE	LEVERAGE	LDR	CIR	ROA
CAR	R-value	1	.408	-.703	-.126	-.322	.443
	P-value		.043	.000	.549	.116	.027
SIZE	R-value		1	-.188	-.517	-.398	.443
	P-value			.368	.008	.049	.027
LEVERAGE	R-value			1	.048	.198	-.261
	P-value				.819	.343	.208
LDR	R-value				1	.265	-.283
	P-value					.201	.171
CIR	R-value					1	-.965
	P-value						.000
ROA	R-value						1

Source: Authors' own calculation

A bivariate correlation was used to measure the CAR practices and ROA association. The researcher considers the CAR, Size, Leverage, LDR and CIR independent variables, whereas the ROA is dependent. However, the CAR and bank size are positively associated with the ROA and have a correlation value of 0.443 ($p < 5\%$), which is statistically significant. The correlation value of leverage is -0.261 ($p > 5\%$), and LDR is -0.283 ($p > 5\%$), which is not statistically significant and reveals that leverage and LDR are negatively and insignificantly associated with the ROA. Besides, the correlation value of CIR is -0.965, and the significance value is 0.000, which is statistically significant and shows that CIR is negatively associated with the ROA. Finally, it concludes that CAR and bank size are positively associated, whereas CIR is negatively associated with the ROA.

Table 4.11: Correlation between the CAR practices and return on equity

Particulars		CAR	SIZE	LEVERAGE	LDR	CIR	ROE
CAR	R-value	1	.408	-.703	-.126	-.322	.753
	P-value		.043	.000	.549	.116	.000
SIZE	R-value		1	-.188	-.517	-.398	.281
	P-value			.368	.008	.049	.173
LEVERAGE	R-value			1	.048	.198	-.693
	P-value				.819	.343	.000
LDR	R-value				1	.265	-.211
	P-value					.201	.311
CIR	R-value					1	-.235
	P-value						.257
ROE	R-value						1

Source: Authors' Own calculation

A bivariate correlation was used to measure the CAR practices and ROE association. The researcher considers the CAR, Size, Leverage, LDR and CIR independent variables, whereas the ROE is dependent. However, the CAR is positively associated with the ROE and has a correlation value of 0.753 ($p < 5\%$), which is statistically significant. The correlation value of bank size is 0.281 ($p > 5\%$),

LDR is -0.211 ($p > 5\%$), and CIR is -0.235 ($p > 5\%$), which is not statistically significant and reveals that the variable such as bank size, LDR and CIR is negatively and insignificantly associated with the ROE. Besides, the correlation value of leverage is -0.693, and the significance value is 0.000, which is statistically significant and shows that leverage is negatively associated with the ROE. Finally, it concludes that CAR is positively associated, whereas leverage is negatively associated with the ROE.

RESULTS, SUGGESTIONS AND CONCLUSIONS

- It is observed from the table that the CAR of the selected bank ranges from 11.20% to 14.42%, and it shows a fluctuating trend. However, the mean value of CBI is 11.23%, whereas IB has 14.42%, IOB has 11.20%, PNB has 12.38%, and the BOI has 13.46%. It is then found that the mean value of IB is highest at 14.42%, with an SD of 1.67. The mean value of IOB is lowest at 11.20%, with an SD of 2.37%. The result of the CV reveals that the BOI has the least CV of 8.2%, representing the BOI is more stable than other banks. As a result, the bank must maintain a minimum CAR of 10 per cent; hence, the chosen bank is conservative and has not fully employed its capital. It is then concluded that the IB have a higher CAR indicates the stronger position of the selected bank.

- It is noted that the size of the selected banks shows a fluctuating trend. However, the mean value of CBI is 5.55%, whereas IB has 5.59%, IOB has 5.43%, PNB has 5.98%, and the BOI has 5.83%. It is then found that the mean value of PNB is highest at 5.98%, with an SD of 0.12%. The mean value of CBI is lowest at 5.55%, with an SD of 0.03%. The result of the CV reveals that the CBI and BOI have the least CV of 0.6%, representing a consistent performance.

- It is indicated that the leverage of the selected banks shows a declining trend. However, the mean value of CBI is 16.66%, whereas IB has 14.76%, IOB has 15.86%, PNB has 15.38%, and the BOI has 15.26%. Hence, it is found that the mean value of CBI is highest at 16.66%, with 1.57% SD. The mean value of IB is lowest at 14.76%, with 2.03% SD. The CV analysis shows that the IB have the lowest CV, which has a consistent performance compared to other banks. It is then concluded that the CBI has been highly leveraged.

- It shows the LDR of the selected bank ranges from 47.14% to 65.84% and shows a fluctuating trend. Furthermore, the mean value of CBI is 50.81%, whereas IB has 60.79%, IOB has 65.63%, PNB has 47.14%, and the BOI has 65.84%. Hence, it is found that the mean value of BOI is highest at 65.84%, with 2.46% SD. The mean value of PNB is lowest at 47.14%, with 6.12% SD. The CV analysis shows that the IOB have the lowest CV, which has a consistent performance compared to other banks. Hence, it concludes that BOI has a smaller loan book than its customer deposit base.

- It shows the CIR of the selected banks. However, the mean value of CIR may vary from 47.14% to 61.21% and shows a fluctuating trend. However, the mean value of CBI is 49.56%, whereas IB has 61.21%, IOB has 50.24%, PNB has 50.24%, and the BOI has 47.14%. Hence, it is found that the mean value of IB is highest at 61.21%, with 16.35% SD. The mean value of BOI is lowest at 47.14%, with an SD of 6.12%. The result of the CV reveals that the BOI has the lowest CV, which has a consistent performance compared to others. Hence, it is concluded that the BOI has more profitability than others.

- It is observed that the ROA of the selected bank ranges from -0.31 to -1.29, showing a fluctuating trend. However, the mean value of CBI is -0.71%, whereas IB has -1.29%, IOB has -0.48%, PNB has -0.48%, and the BOI has -0.31%. Hence, it is found that the mean value of BOI is highest at -0.31% with 0.66% SD. The mean value of IB is lowest at -1.29%, with 1.70% SD. Thus, BOI has more capital efficiency, and other bank does not have capital efficiency. The CV results reveal that the IOB and PNB are more stable than other banks. As a result, the ROA of BOI depicts a firm's management's efficiency in generating Net Income from all resources.

- The mean value of ROE may vary from -22.15 to 7.25 and shows a fluctuating trend. However, the mean value of CBI is -13.08%, whereas IB has 7.25%, IOB has -22.15%, PNB has -10.05%, and the BOI has -6.41%. Hence, it is found that the mean value of IB is highest at 7.25%, with 4.23% SD. The mean value of IOB is lowest at -22.15%, with 28.22% SD. Thus, IB has more capital efficiency, and other bank does not have capital efficiency. The result of the CV reveals that the IB has the

lowest CV, which has a consistent performance compared to others. As a result, the selected bank does not have a good performance.

It is found that the capital adequacy ratio of the selected bank varies from 9.04% to 16.53% with a mean value of 12.54% and an SD of 2.30. However, CAR is approximately symmetric. The size is 5.39 to 6.12, with an average value of 5.68 and an SD of 0.23, which shows that the bank size is approximately symmetric. Besides, the leverage ratio has a minimum value of 13.02 and a maximum value of 18.68 with an average value of 15.58 and an SD of 1.74, which indicates that the leverage ratio is approximately symmetric and leptokurtic. The loan to deposit ratio varies from 40.33% to 69.13%, with an average of 58.04 and an SD of -0.48. Also, LDR is approximately symmetric and leptokurtic. The cost-to-income ratio range from 40.33 to 82.77, with a mean value of 51.68 and an SD of 10.83. Although, it shows that the CIR is highly skewed and leptokurtic. However, the ROA has a minimum value of -3.27% and the maximum value of 0.57%, with an average of -0.66 and an SD of 1.028. However, CIR is moderately skewed. Furthermore, ROE has a minimum value of -52.78% and a maximum value of 11.88%, with an average of -8.88 and an SD of 18.53.

CAR and bank size are positively associated with the ROA and have a correlation value of 0.443 ($p < 5\%$), which is statistically significant. The correlation value of leverage is -0.261 ($p > 5\%$), and LDR is -0.283 ($p > 5\%$), which is not statistically significant and reveals that leverage and LDR are negatively and insignificantly associated with the ROA. Besides, the correlation value of CIR is -0.965, and the significance value is 0.000, which is statistically significant and shows that CIR is negatively associated with the ROA. Finally, it concludes that CAR and bank size are positively associated, whereas CIR is negatively associated with the ROA.

The correlation value of CAR is -0.805, and the significance value is 0.000, which shows that the value is less than 5% and is statistically significant. It is then inferred that the CAR is negatively associated with the ROA.

CAR is positively associated with the ROE and has a correlation value of 0.753 ($p < 5\%$), which is statistically significant. The correlation value of bank size is 0.281 ($p > 5\%$), LDR is -0.211 ($p > 5\%$), and CIR is -0.235 ($p > 5\%$), which is not statistically significant and reveals that the variable such as bank size, LDR and CIR is negatively and insignificantly associated with the ROE. Besides, the correlation value of leverage is -0.693, and the significance value is 0.000, which is statistically significant and shows that leverage is negatively associated with the ROE. Finally, it concludes that CAR is positively associated, whereas leverage is negatively associated with the ROE.

The correlation value of CAR is -0.250, and the significance value is 0.227, which shows that the value is higher than 5% and is not statistically significant. It is then concluded that the CAR is negatively and insignificantly associated with the ROE.

The regression result shows that the beta coefficient value of CAR is 0.176 ($p < 5\%$), which implies that the CAR positively affects the ROA. However, the beta coefficient value of size is 0.009 ($p < 5\%$), representing that the size does not affect the ROA. The beta coefficient value of leverage is 0.045 ($p < 5\%$), showing that the leverage positively and insignificantly affects the ROA. Also, the beta coefficient value of LDR is -0.017 ($p > 5\%$), indicating that LDR negatively and insignificantly affects the ROA. The beta coefficient value of CIR is -0.909 ($p < 5\%$), showing that the CIR positively affects the ROA.

The regression result shows that the beta coefficient value of CAR is -0.805 and the t-value of -6.505 ($p < 5\%$), implying that the CAR negatively affects the ROA.

The regression result shows that the beta coefficient value of CAR is 0.545 ($p < 5\%$), which implies that the CAR positively affects the ROE. However, the beta coefficient value of size is -0.085 ($p < 5\%$), representing that the size negatively and insignificantly affects the ROE. The beta coefficient value of leverage is -0.321 ($p < 5\%$), showing that the leverage negatively and insignificantly affects the ROE. Also, the beta coefficient value of LDR is -0.175 ($p > 5\%$), indicating that LDR negatively and insignificantly affects the ROE. The beta coefficient value of CIR is 0.016 ($p > 5\%$), showing that the CIR positively and insignificantly affects the ROE.

The regression result shows that the beta coefficient value of CAR is -0.250, and the t-value of -1.241 ($p < 5\%$) implies that the CAR is negatively and insignificantly affects the ROE.

CONCLUSIONS

This study aimed to analyze whether financial ratios are associated with the profitability of banks in India. The study considered the capital adequacy practices such as CAR, Size, Leverage, LDR and CIR as independent variables, whereas the ROA is dependent. The current study adopted the descriptive and analytic research to examine how financial ratios affect the profitability of selected Indian banks between 2018 and 2022. The correlation analysis shows that CAR and bank size are positively associated, whereas CIR is negatively associated with the ROA. Also, CAR is positively associated, whereas leverage is negatively associated with the ROE. However, it shows that CAR is negatively associated with the ROA but insignificantly associated with the ROE. The regression result reveals that CAR negatively and significantly affects the ROA but insignificantly affects the ROE. Therefore, it can be concluded that the relationship between the independent variables has only a moderate effect on the profitability of selected Indian banks.

References

- Pradhan, R. S., & Parajuli, P. (2017). Impact of capital adequacy and cost income ratio on performance of Nepalese commercial banks. *International Journal of Management Research*, 8(1), 6-18.
- Chalise, S. (2019). The Impact of Capital Adequacy and Cost-Income Ratio on Performance of Nepalese Commercial Banks. *SSRG International Journal of Economics and Management Studies (SSRG-IJEMS)*, 6(7), 78-83.
- Baral, M. (2016). Determinants of Capital Adequacy Ratio of Nepalese Commercial Banks. *Nepalese Journal of Management*, 3(3), 12-23.
- Neupane, A. (2019). Banking Crime and Its Impact on the Banking Industry. *NJA LJ*, 13, 181.
- Setiawan, A., & Hermanto, B. (2017). Comparative study: determinant on banking profitability between buku 4 and buku 3 bank in indonesia. *Benefit: Jurnal Manajemen dan Bisnis*, 2(1), 92-101.
- Buchory, H. A. (2015). Banking profitability: How does the credit risk and operational efficiency effect. *Journal of Business and Management Sciences*, 3(4), 118-123.
- Bhattarai, Y. R. (2016). Effect of credit risk on the performance of Nepalese commercial banks. *NRB Economic Review*, 28(1), 41-64.
- Singh, S., & Sharma, D. K. (2018). Impact of credit risk on profitability: A study of Indian public sector banks. *International Journal of Research in Economics and Social Sciences (IJRESS)*, 8(2), 492-498.
- Musyoka, B. K. (2017). *The effect of capital adequacy on the financial performance of commercial banks in Kenya* (Doctoral dissertation, University of Nairobi).
- Nzioki, J. S. (2011). Impact of capital adequacy on the financial performance of commercial banks quoted at the Nairobi stock exchange (unpublished Master's thesis) University of Nairobi.
- Odunga, R. M., Nyangweso, P. M., Carter, D. A., & Mwarumba, M. (2013). Credit Risk, "Capital Adequacy and Operating Efficiency Of Commercial Banks in Kenya". *International Journal of Business and Management Invention*, 2(9), 6-12.
- Eng, T. S. (2013). Pengaruh NIM, BOPO, LDR, NPL & CAR Terhadap Roa Bank Internasional Dan Bank Nasional Go Public Periode 2007-2011. *Jurnal dinamika manajemen*, 1(3).
- Rachdi, H. (2013). What determines the profitability of banks during and before the international financial crisis? Evidence from Tunisia. *International Journal of Economics, Finance and Management*, 2(4).
- Ochieng, J. O. (2014). *The effect of central bank of Kenya prudential guidelines and regulations on the financial performance of commercial banks in Kenya* (Doctoral dissertation, University of Nairobi).

Impact Of Organizational Communication On Employee Relations And Productivity Among Millennial And Gen Z At Workplace

Prof. G Nikita^{1*}, Peddy Sadhvi Reddy², Dr. Vasudevan Sundararajan³

¹*Assistant Professor, Symbiosis Centre for Management Studies, Bengaluru, Symbiosis International (Deemed University), nikita1913@gmail.com, +91 8897710539

²MBA (Communication Management), Symbiosis School of Media and Communication, Bengaluru Symbiosis International (Deemed University), sadhvi.reddy23@ssmc.edu.in

³Professor, SCMS, Dayananda Sagar University, vasudevan@dsu.edu.in+ 91 95389 19857

Citation: Prof. G Nikita et al. (2024), Impact Of Organizational Communication On Employee Relations And Productivity Among Millennial And Gen Z At Workplace, India, *Educational Administration: Theory and Practice*, 30 (5), 13100 -13121
Doi: 10.53555/kuey.v30i5.3597

ARTICLE INFO

ABSTRACT

It is important that an organization thrives and expand, this can be done if it identifies the need to make sure that your employees are able to openly and honestly share their ideas and opinions with one another. Both the management and the employees play important roles in the company's success. According to a report by PwC in 2021, millennials and generation Z make up 38% of global workforce and this percentage is expected to rise to 58% by 2030. This research seeks to learn more about their perspectives on the workplace and examine whether or not these biases affect their efficiency and effectiveness. It was found that organizational communication affects employee relations when the employees are able to build a positive rapport with their managers, the relationship flourishes, thereby having no hindrances in the communication. It was also observed that there are significant differences in how millennials and generation Z view their roles and responsibilities in the workplace. The primary goals of this research are (1) to assess the affect of organizational communication employee relations (2) to analyze if organizational communication affects employee relations and productivity and (3) to understand the current perception of employees about the organization that may affect productivity at workplace.

Keywords: Intergenerational communication, employee relations, Millennials, Gen Z, Gen Y workplace communication, work performance, productivity, organizational communication, motivation

CHAPTER 1: INTRODUCTION

Current corporate India is a mix of five different generations, there are significant impacts for such a workplace due to the generational differences in preferred methods of interaction, skill sets, and approaches to work. Therefore, it becomes now, more than ever, to understand the characteristics of these individuals from different generations in order to bridge the communication gap, make employees feel comfortable approaching those from other generations and improve overall work performance. The ability to communicate effectively in the workplace is essential to the development and upkeep of high-quality working relationships inside organizations. Effective communication in the workplace is crucial since every administrative job and activity requires some sort of communication, either directly or indirectly. Communication may be seen as the process of passing knowledge and shared understanding from one person to another. As a consequence of this, in order to enhance the efficiency of communications, administrators need to cultivate an understanding of the significance of their obligations and remain committed to fulfilling them. The capacity of an administrator to be an influential leader will be significantly boosted by effective communication in the workplace (Birikorang et al. 2014).

Not only can unclear communication lead to mistakes and missed deadlines, but it is also the primary cause of a wide variety of other significant problems in the workplace, such as low morale among employees and bad job performance. The managers should devote the appropriate amount of effort to ensure that the project's objectives and directions are clear and should also work to cultivate an atmosphere that promotes the free flow

of ideas among the team members (Goutam, 2013). Having an understanding of the characteristics that distinguish the various generations makes it possible to leverage on the advantages offered by each generation, inspire individuals, and maintain and foster cooperative relationships among the teams at the workplace. (Valickas, 2017). Managers should therefore establish a setting in which work-related problems, proposals, concerns, opinions and ideas are discussed and treated in a professional and proficient manner through positive and effective communication. This environment should be created so that administrators can fulfill their responsibilities. Understanding the communication preferences and practices of today's Gen Y and Gen Z workers may have significant positive effects on both the business and its workforce.

Leaders cannot function with a one-size-fits-all mindset in today's intergenerational workforce. The economy, technology, school systems, parenting styles, and other factors all have an influence on how workers learn, interact, and operate. Employers are omitting essentials for successful leadership by believing that all younger-generation workers - Generation Y (millennials) and Generation Z - display the same qualities. The most effective leaders understand their people's diverse workplace requirements and styles of learning (Schooley, 2023). In Spite of having several discussions regarding how its is important to to understand the these generational differences, there is a large gap between the companies that have a multigenerational workforce and the companies that have dominant generations, and many organizations tend to overlook age diversity as part of their DEI initiatives, even though leaders even today recognize that a multigenerational workforce is essential to the positive growth of the organization.

This involves employing workers from a wider range of backgrounds, assisting employees in climbing the corporate ladder, delegating greater decision-making authority to them, and fostering dialogues. Young people who are looking for work say they are sensitive to anything that even somewhat resembles performance (Jennifer Miller, 2021). Both employers and workers have a vital role to play in understanding the significance of effectively communicating with one another to help employees of all ages, which would indeed enable them to remain employable over a long period of time.

Many studies have shown that organizational communication helps unleash the power of the business and its people. Employees that communicate successfully within the organization's hierarchy will see an improvement in productivity. The simple act of delivering enough and essential information at the appropriate moment can save a significant amount of work time, enabling for more tasks to be completed. Communication is also essential for improving employee-employer relations. Excellent collaboration equals better production. Knowing what needs to be done is another benefit of communication in an organization since it allows tasks to be completed more quickly. Hence it becomes interesting to understand the relationship between organizational communication and employee relations and its effect on productivity while also understanding the perceptions of the gen Y and gen Z at the workplace. It is possible for companies to benefit from the unique views and skill sets that employees from all these generations bring to the table. The chance that they have is to actively create and shape a culture that is conducive to their needs in the years to come. To effectively harness the transformation, a proactive move is what is required. Understanding and incorporating the perceptions of these generations can benefit businesses because it increases the likelihood that employees across all generations will feel heard and understood at work, which in turn, increases their sense of loyalty and commitment to the company.

Organizations may use the information in this paper to design and implement programmes and activities that will inspire and engage the millennial and Gen Z workforce. It may help organizations get insights into how to better communicate with their employees, which in turn can boost employee relations and productivity. By understanding the opinions of these generations it could benefit a lot of organizations as they are the future workforce. With its focus on corporate employees, this study can serve as a guide for future studies that aim to examine the nature of organizational communications in companies across different sectors. In addition, it can serve as a resource for academics and students conducting their own study within the purview of organizational communication.

CHAPTER 2: LITERATURE REVIEW

2.1 Organizational communication

According to Goutam (2013) because of the nature of our working environment, we rely on one another to accomplish all that we set out to do. As real shifts are taking place in modern organizations, which are confronting the new reality of firmer staffing, high workloads, working overtime, and a greater emphasis on achievement, risk-taking, and adaptability, it is a self-evident fact that workplace communication plays an important role in employee motivation and performance. The management of an organization's employee relations results in a particular necessity for successful communication, which is a subset of the overall need to communicate that occurs within this context. (Goutam, 2013)

As stated by Sadia, it is essential to have a solid understanding of the many aspects of organizational communication as well as the effects these aspects have on the efficiency of internal communication and the productivity of workers inside a company. Research in this area is extremely uncommon, and it is necessary to have an understanding of how distinctive characteristics can be added by the organizational link. This will allow for the formation of a close relationship with the dimensions of effective internal communication for

improving productivity and the staff cooperation model, and it will also include the likely vulnerabilities associated with this stage of life and the many influences that are associated with it. (Sadia et al., 2016)

It is possible to increase work satisfaction by concentrating on the establishment of an effective communication environment. In addition, employees who belong to various generations may describe what really constitutes a great communication atmosphere in quite different ways (Mehra & Nickerson, 2019). According to Bucăța & Rizescu, the process of communication inside an organization is a crucial instrument for management, as well as a particularly complicated aspect of the management system. As a tool for management, communication serves the purpose of easing interpersonal interactions and creating conditions that are constructive to the growth of a company from the inside out (Bucăța & Rizescu, 2017).

2.1.2 Employee communication for creating engaging workspaces

The role of employee communication is essential in the configuration of an integrated employee relations attitude that is favorable to employee voice. Employee engagement is defined as the communication of ideas, suggestions, concerns, or opinions regarding issues related to working with the intention of improving the functioning of the organization or the unit (Morrison, 2011). In this view, employee communication is seen as a component of the corporate environment that serves as an antecedent of employee engagement (Mazzei, 2018). Employee communication retains people in feeling a sense of belonging to the company, builds a transparency culture between management and employees, enables people to share knowledge and create meanings, motivates the employees to communicate their thoughts and opinions with top management, involves employees in conversation about their responsibilities and goals, and facilitates the linking of the objectives and values of employees to that of the company. (Mazzei et al., 2019)

2.1.3 Employee Engagement and Workspace Productivity

The findings of the study conducted by Alshammari indicate that employee engagement is positively linked to a variety of other variables, including job involvement, employee communication, and elongated employee care. Employee engagement is also positively linked to working efficiency, work satisfaction, team and co-worker relationships and even career advancement. The findings make it abundantly clear that employee engagement is inextricably linked with employee feelings and perceptions about the organization and the value associated with it. This, in turn, gives employees the freedom and autonomy to approach their work in a manner that ultimately results in the employees' improved performance. (Alshammari, 2015)

The findings of the study by Omunakwe, Nwinyokpugi Indicate that the productivity level will increase if the elements of workplace interpersonal relationships (employee communication, team building, social support) are adopted in organizations and managers devote their attention to it in an unwavering manner. The findings of the research indicate that interpersonal relationships in the workplace have an impact on organizational productivity. (Omunakwe et al., 2018)

2.1.4 Intergenerational Employee Communication

According to Yan Guan, people tend to prefer their own generation or authority group more than other age or authority groups, which results in communication that is stereotyped and biased towards outgroups. According to the findings of this study, young people in Asia have potentially more pessimistic views about intergenerational communication compared to their Western counterparts (Yan Guan, 2009). Discussions in mainstream publications on differences in generational groups in the workplace imply that members of more recent generations, such as Generation Y and X, have different work ethics than do those of the Silent generation and the Baby Boomers generation (Hansen & Leuty, 2011).

Poor communication while speaking with individuals of various age groups results in a lack of credibility, which makes the workplace/business challenging. This lack of trust leads to arguments and confrontations, as well as systematically impacts the harmony surrounding them (Zehrer & Leiß, 2020). According to the findings of this research by Radulescu, employees would prefer HR strategies that take into consideration generations as a whole. As a result, we have come to the conclusion that it could be better for businesses to reconsider their preferences for programs that are targeted at particular generations. This finding is in keeping with the findings of the primary practices that contribute to the growth of multigenerational companies, which are as follows:

- a) greater competition for talent;
- b) more generations able to work in mixed groups; and
- c) a clearer connection between productivity and the workplace environment.

The initiatives that are centered on prioritizing the demands and wishes of Millennials and Generation Z is a popular trend among firms at the moment. (Radulescu et al., 2018)

2.1.5 Generation Y and Generation Z at the Workplace

According to Myers & Sadaghiani, there is widespread concern about how communication with Millennials will affect organizations and how they will develop relationships with other members of the organization. Millennials are characterized as individuals who were born between 1979 and 1994. Stereotypes about this generation portray them as being self-absorbed, unmotivated, disrespectful, and disloyal (Myers & Sadaghiani, 2010).

The Millennial Generation in the workplace is receiving a growing amount of attention due to the fact that it has been established that Millennials express distinct attitudes, values, views, and goals in the workplace compared to the generations who came before them. (Chou , 2012)

Despite the significant rise in the volume of research that has been conducted on Millennials in the workplace, there are still two significant research topics that need to be addressed. To be more specific, when it comes to their introduction into the workforce, what kind of leadership and communication styles do Millennials exhibit? (Chou , 2012)

It is critical to have an understanding of the ways in which millennials collaborate with their contemporaries as well as the signs that workers may be experiencing intergenerational cultural differences (LaCore, 2015). They are digital natives, and technology is ingrained in their identities since Gen Z individuals were born and raised with the technology that exists today. Although members of this generation are currently working in organizations, very little is known about the traits, requirements, qualities, and work styles of this generation. They approach work in a manner that is distinct from both Generation Y and Generation X. Without a solid knowledge of this generation; organizations suffer difficulty in recruiting and retaining its members, which is necessary for the organizations to continue their sustainable development (Gaidhani et al. 2019).

By better understanding the differences and similarities that exist between the generations, professionals in human resources, psychologists, employees, and managers can develop policies that improve communication, enhance corporate knowledge management and productivity, and improve satisfaction, commitment, and retention. When it comes to the workforce, it is beneficial to have a fundamental awareness of the differences that occur between various generations (Cennamo & Gardner, 2008).

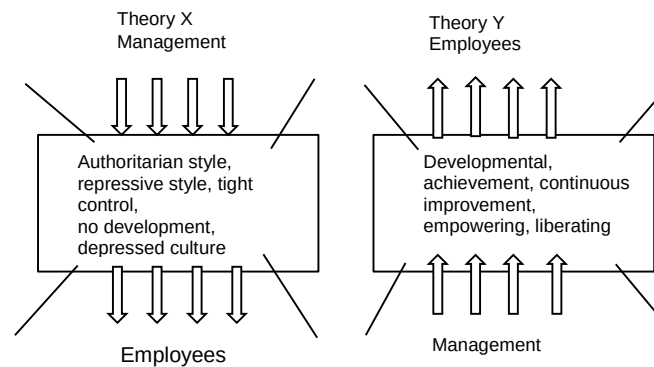
It is possible to say that inability to recognize generational differences in the workplace may result in unfavorable organizational consequences such as ineffective communications, intergenerational disputes, negative feelings towards work colleagues, and a decrease in morale and productivity. (Omar Ali Alferjany & Alias, 2020). These differences may be seen in many aspects of the workplace. It is vital to continue the examination of the different generations' experiences in the workplace. At the same time, it is essential to recognize the commonalities that exist among employees of all ages and degrees of skill. Both of these things are essential. This knowledge has the potential to be used into managerial practices in order to enhance communication and understanding. When there is a steady flow of effective communication in businesses, strong bonds are developed between staff and management. As a result, workers gain trust, which in turn leads to increased levels of productivity on their part (Sadia et al., 2016). It seems that prior generations had different expectations and drivers of behavior than the current generations, particularly generation Z and also generation Y. When members of these generations join the workforce, they will bring with them a set of requirements that are all their own. It is important for the organization to find out what matters to these generations in advance so that it can increase its attractiveness both within and outside of the business world. This will allow the organization to demonstrate a workplace culture that will give it a distinct advantage in the lookout for talented employees from these generations which will indeed enable the organization to sustain its growth and continue to be successful throughout its presence (Gaidhani et al., 2019)

2.2. Theoretical framework

This paper will employ general theories in general organizational behavior theories as follows:

2.2.1. McGregor's Theory X and Theory Y

Theory X leadership is not opportunistic since there is minimal connection between the leader and the follower in terms of satisfying the follower's needs. It all comes down to the leader (William J. Carnes, 2009). Managers in Theory X are detail-focused and concerned with data and numbers. They do not show the slightest bit of concern for human welfare. So, appealing to their sense of morality or empathy is not a logical course of action. Even if he or she is assigned an impossible job or deadline, an employee working for a boss according to theory X should be positive and constructive rather than critical and negative while explaining the reasons why the expectation cannot be met. Theory Y is contextual, and it postulates that leaders should be more adaptable to the followers. To put it another way, the leaders of Theory Y would have a far simpler time adjusting to the circumstances than the leaders of Theory X may have. (William J. Carnes, 2009). People are able to enjoy their job if they exercise significant self-control and do it under ideal conditions, as postulated by assumptions of Theory Y. Leaders that adhere to Theory Y provide greater performance and results, which in turn enable individuals to advance their careers. (Mohammad Saiful Islam, 2017)



(Source: *Fundamentals of Management*, Otokiti (2006))

The study will use theory X and theory Y to make assumptions based on the personalities of the generations and also about the leadership of the organization based on what the employees of a particular organization have to say. This theory will help understand if the employees have a pessimistic or optimistic view about the organization and its influence in participating in the communication process.

2.2.3 Anxiety/Uncertainty Management Theory (AUM)

According to Gudykunst (1993), there is a sequence of characteristics that are intrinsic towards each communicator and are influenced by their natural inclinations and life experience. These factors cause anxiety and uncertainty in interpersonal connection and cause communication to become less successful. The model can be demonstrated as follows:

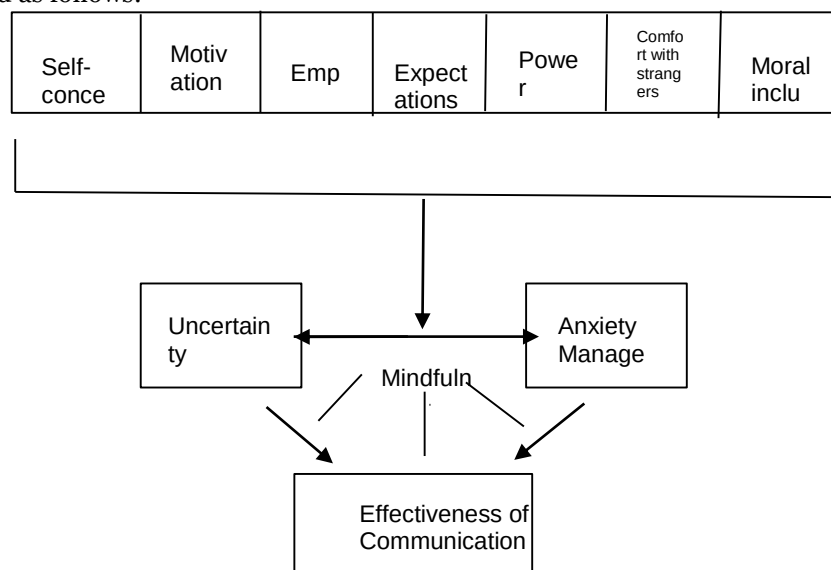


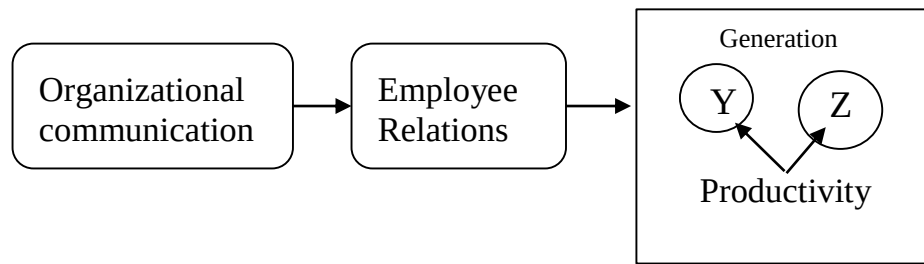
Fig 2: Gudykunst (1998)

Anxiety/uncertainty will occur when presented with interpersonal interactions, depending on the amount to which each of these elements affects the individual. (Brady D. Lund, 2020)

When interacting with persons of other generations, members of one generation may be less receptive than those of their own generation to the perspectives and ideas of those of other generations. There is a possibility that members of a different generation may incorrectly generalize about some people from a different generation. The Anxiety and Uncertainty Management Theory could be able to provide some insight on the question of whether or not this evaluation is acceptable.

2.4. Conceptual framework

The conceptual framework is centered on how organizational communication influences employee relations at work. Employee interactions have an impact on workplace productivity. The attitude and perceptions of the organization's employees have an impact on productivity since it determines their motivation to work and the quality of the work they deliver. The following is the conceptual framework of this research –



Intergenerational Communication: The workplace has evolved into a multigenerational setting. Generational differences can make productive communication more difficult. Miscommunication, misunderstanding, and, in extreme cases, no communication at all may result from the generational difference between baby boomers, Generation X, and Millennials and Gen Z.

Employee Relations: Employee relations are the interactions between both employers and employees. Effective employee relations extends much beyond whether or not the employees of the firm get on very well. Effective employee relationship requires efficient communication, employee engagement efforts, a systematic employee experience strategy, and proper implementation of all of these.

Productivity: Employee productivity is a measure of how much work an employee completes in a given amount of time. It may also be used to quantify a group's or team's performance.

2.5 Statement of problem

Many organizations still suffer with challenges linked to communication, such as a lack of feedback and an inability to interact across various generations. This presents a dilemma since it is important to learn how to interact across generations. Intergenerational communication is a major difficulty that organizations confront, and it may be caused by a lack of precision in understanding the views of specific generations. This may lead to lower employee motivation, which can have an effect on productivity.

Another problem that organizations encounter is a lack of feedback, which may leave employees feeling devalued and unsupported. Feedback is critical for employee development and growth, particularly for new employees. As a result, this study investigates the effect of organizational communication on employee relations and productivity while also understanding how the generations of Y and Z feel at their workplace and also trying to understand from their perspective as to how there can be effective communication in terms of delivering feedback and also improving employee relations.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Research Design

This study employs a mixed method approach. As a part of quantitative study, the methods employed were a structured questionnaire containing both open and closed ended questions was studies with 103 respondents belonging to the Y and Z generations. The questionnaire was designed to understand the current workplace situations of the organizations that these generations work. The questionnaire also had questions regarding their current relationship with both the leadership (managers) and the employees at their workplace. Once the survey responses were collected, the data was coded and was analyzed using the IBM SPSS 26.0 software in which the regression sampling technique was employed. The technique used within this was stepwise backward regression which identified the significant values for the dependent variables that were given to the software. The results were verified by looking at the ANOVA table as well as the graphs that were displayed by the software. For the regression analysis the dependent variables that were taken into consideration were: Employee Relations, the coefficients and the significance were identified for this question as well as Productivity, the coefficients and the significance were identified for the question. Along with this the organizational communication and the perceptions of the employees were also analyzed using **stepwise backward regression**.

For qualitative study in - depth interviews with a set of 5 employees working in the corporations were identified from each of the generations of Y and Z and were interviewed. The questions posed to them were regarding the organizational communication at the firms they work in and if they face any hindrances while communicating with their managers. These employees were also asked for some suggestions regarding how this communication can be improved and made seamless. The quantified data helped in understanding the dominant perceptions regarding the workplace of Gen Y and Gen Z and their relationship with the organization.

3.2 Sampling framework

This study was conducted on the members of generation Y and generation Z, to understand their workplace perceptions and the kind of communication that is employed at the organization and hence the target population that were identified were the generations Y and Z working in the corporates who belong to different

parts of India. Millennials or Generation Y were born between 1981 to 1996 and Generation Z was taken from 1997 to 2001. A snowball sampling technique was employed for the same. A total of 108 respondents were studied through 103 responses in the questionnaire survey and 5 respondents in the in-depth interview.

3.3. Objective of the study

The main objective of the study is to investigate the effect of organizational communication on employee relations and productivity based on the following objectives:

- To understand whether or not the members of generation Y and Z are satisfied with the organizational communication at their workplace.
- To suggest measures to improve the overall productivity at the workplace by understanding what the members of generation Y and Z want, thereby by also suggesting measures to improve intergenerational communication.
- To understand the current perceptions about their organization among Gen Y and Gen Z at their workplace

The research seeks to provide answers to the research questions developed for this study, which are as follows:

- a) Is there a relationship between organizational communication and employee relations and productivity?
- b) What is the role of continuous feedback on employee productivity?
- c) Do the generations Y and Z have certain beliefs and values which affect organizational communication?
- d) What are the ways that are favorable for Gen Y and Gen Z to improve productivity at the workplace?

The following hypotheses were tested through this research:

H1: Good Organizational communication affects employee relations positively at the workplace

H2: Employee relations have an effect on the productivity at the workplace

H3: The perceptions that the employees have about the organization affects the productivity at the workplace.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Data Analysis

ANALYSIS FOR THE GENERATION Y (MILLENNIALS) USING IBM SPSS 26.0

Input: Q8 = {Q4, Q5, Q11, Q12, Q14}

Outputs:

Model Summary ^a						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change
1	.592 ^a	.351	.300	.723	.351	6.847
2	.558 ^b	.311	.276	.735	-.040	2.320

Figure 1

R Square: 35% of the variation of Q8 is experienced by Q4, Q5, Q11, Q12, Q14

R: It is the square root of R Square and its value should be between -1 to +1, the value of R in this output is 0.592.

Adjusted R square: It is used when you have several component models with different variables, the highest adjusted R Square must be chosen.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.727	3	3.576	6.847	.001 ^b
	Residual	19.845	38	.522		
	Total	30.571	41			
2	Regression	9.515	2	4.757	8.812	.001 ^c
	Residual	21.057	39	.540		
	Total	30.571	41			

Figure 2

In the ANOVA table, the **value of F is 8.812**, which is high. **Significance or P should be less than 0.05**. Hence, it can be concluded that out of several variables' transparency in communication, comfort in expressing ideas by employees, frequency of communication, seamless communication and employee relations (Q4, Q5, Q11, Q12, Q14) have a significant impact on the dependent variable internal organizational communication (Q8).

		Unstandardized Coefficients		Standardized Coefficients	
Model		B	Std. Error	Beta	t
1	(Constant)	-1.346	.658		-1.865
	q4	.264	.188	.208	1.523
	q5	.512	.205	.342	2.503
	q12: How much would you rate the team you're working for in terms of communicating seamlessly- 1 - Poor 2 - Fair 3 - Good	.501	.164	.334	2.631
2	(Constant)	-.796	.609		-1.306
	q5	.090	.200	.309	2.507
	q12: How much would you rate the team you're working for in terms of communicating seamlessly- 1 - Poor 2 - Fair 3 - Good	.518	.167	.352	2.637

Figure 3
Coefficients^a

		Collinearity Statistics
Model		VIF
1	(Constant)	
	q4	1.085
	q5	1.082
	q12: How much would you rate the team you're working for in terms of communicating seamlessly- 1 - Poor 2 - Fair 3 - Good	1.019
2	(Constant)	
	q5	1.010
	q12: How much would you rate the team you're working for in terms of communicating seamlessly- 1 - Poor 2 - Fair 3 - Good	1.010

Figure 4

The most significant variables out of all the inputs that were given are: Q5 and Q12.

The values of standardized Beta for the significant variables are as follows:

For Q5, Beta = 0.399

For Q12, Beta = 0.352

Arranging the values from most significant to least significant

$$Q5 (Beta = 0.399) > Q12 (Beta = 0.352)$$

The highest value of Beta is for Q5, meaning that Q5 is the most significant variable for the dependent variable Q8.

For Unstandardised B:

One unit change in variable Q5 there would be 0.598 unit change in Q8 (Dependent variable)

For standardised Beta:

1% change in Q5 would be equal to 0.399 change in Q8 (Dependent variable)

Collinearity Statistics:

Vif is less than 4, that means there is no multicollinearity.

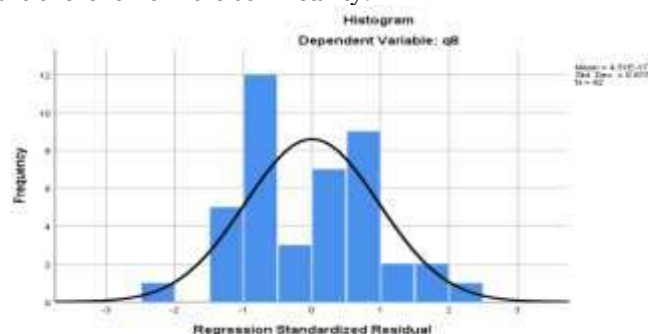


Figure 5

The histogram is almost normal, hence it does not violate the assumptions of the regression for Q8.

Input: Q14 = {Q4, Q5, Q6, Q8, Q10}

Model Summary ^a							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1
1	.789 ^a	.623	.570	.453	.623	11.879	5
2	.788 ^b	.621	.580	.449	-.002	.194	1
3	.785 ^c	.617	.586	.445	-.004	.382	1
4	.774 ^d	.599	.579	.449	-.017	1.711	1

Figure 6

R Square: 62% of the variation of Q14 is experienced by Q4, Q5, Q6, Q8, Q10

R: It is the square root of R Square and its value should be between -1 to +1, the value of R in this output is 0.789

Adjusted R square: It is used when you have several component models with different variables, the highest adjusted R Square must be chosen.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.215	5	2.443	11.879	.000 ^a
	Residual	7.404	36	.206		
	Total	19.619	41			
2	Regression	12.175	4	3.044	15.130	.000 ^c
	Residual	7.444	37	.201		
	Total	19.619	41			
3	Regression	12.098	3	4.033	20.377	.000 ^d
	Residual	7.521	38	.198		
	Total	19.619	41			
4	Regression	11.760	2	5.880	29.179	.000 ^a
	Residual	7.859	39	.202		
	Total	19.619	41			

Figure 7

In the ANOVA table, the value of **F is 29.179**, which is high.

Significance or **P should be less than 0.05. For this analysis significance is 0.000**

Hence, it can be concluded that out of several variables (Q4, Q5, Q6, Q8, Q10), some variables have a significant impact on the dependent variable Q14.

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.489	.600		.815	.420
	q4	.388	.121	.355	3.202	.003
	q5	.190	.149	.158	1.278	.210
	q6	-.080	.134	-.072	-.601	.551
	q8	.416	.098	.519	4.252	.000
	q10	-.152	.345	-.047	-.441	.662
2	(Constant)	.286	.380		.752	.457
	q4	.392	.119	.359	3.285	.002
	q5	.204	.143	.170	1.423	.163
	q6	-.082	.132	-.073	-.618	.540
	q8	.418	.097	.522	4.328	.000
3	(Constant)	.192	.346		.556	.582
	q4	.387	.118	.355	3.278	.002
	q5	.177	.136	.148	1.308	.199
	q8	.402	.092	.502	4.355	.000
4	(Constant)	.451	.287		1.574	.123
	q4	.412	.118	.377	3.497	.001
	q8	.447	.086	.559	5.176	.000

Figure 8

		Coefficients ^a				Correlations	
Model		Partial	Part	Tolerance	VIF		
1	(Constant)						
	q4	.471	.328	.850	1.176		
	q5	.208	.131	.685	1.460		
	q6	-.100	-.062	.735	1.360		
	q8	.578	.435	.703	1.422		
2	(Constant)						
	q4	.475	.333	.856	1.168		
	q5	.228	.144	.719	1.391		
	q6	-.101	-.063	.738	1.359		
	q8	.580	.438	.705	1.418		
3	(Constant)						
	q4	.470	.329	.860	1.163		
	q5	.208	.131	.791	1.264		
	q8	.577	.437	.759	1.318		
4	(Constant)						
	q4	.489	.354	.882	1.134		
	q8	.638	.525	.882	1.134		

Figure 9

The most significant variables out of all the inputs that were given are: Q4 and Q8

The values of standardized Beta for the significant variables are as follows:

For Q4, Beta = 0.377

For Q8, Beta = 0.559

The highest value of Beta is for Q8, meaning that Q8 is the most significant variable for the dependent variable Q14.

Arranging the values from most significant to least significant

Q8 (Beta = 0.559) > Q4 (Beta = 0.377)

For Unstandardised B:

One unit change in variable Q8 there would be 0.447 unit change in Q14 (Dependent variable)

For standardized Beta:

1% change in Q8 would be equal to 0.559 change in Q14 (Dependent variable)

Collinearity Statistics:

Vif is less than 4, that means there is no multicollinearity.

Charts:

Charts

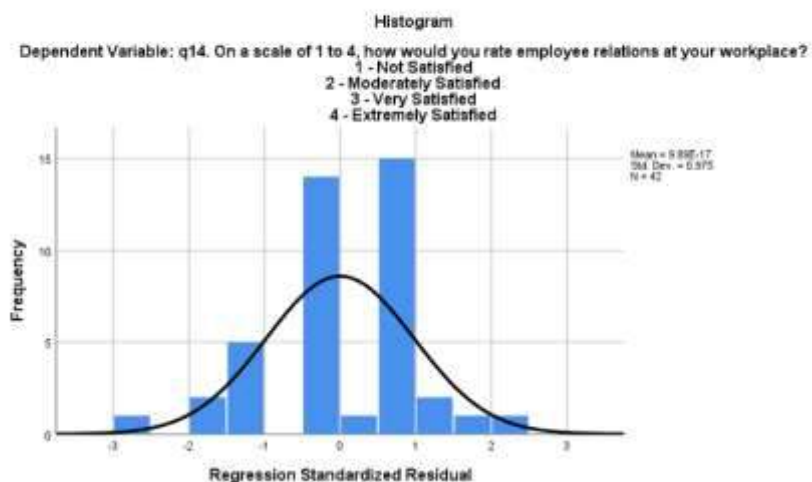


Figure 10

The histogram is almost normal, hence it does not violate the assumptions of the regression for Q14.

Input: Q20 = {Q4, Q5, Q6, Q8, Q10, Q11, Q12, Q13, Q14, Q16}

Outputs:

Model Summary ^a										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.643 ^a	.414	.225	.408	.414	2.188	10	31	.047	
2	.643 ^b	.413	.248	.401	-.001	.040	1	31	.842	
3	.641 ^c	.410	.267	.396	-.003	.144	1	32	.707	
4	.636 ^d	.404	.282	.382	-.006	.336	1	33	.566	
5	.631 ^e	.398	.296	.369	-.006	.349	1	34	.559	
6	.608 ^f	.370	.283	.392	-.028	1.629	1	35	.210	
7	.590 ^g	.348	.277	.394	-.022	1.282	1	36	.265	1.914

Figure 11

R Square: 34% of the variation of Q20 is experienced by Q4, Q5, Q6, Q8, Q10, Q11, Q12, Q13

R: It is the square root of R Square and its value should be between -1 to +1, the value of R in this output is 0.590.

Adjusted R square: It is used when you have several component models with different variables, the highest adjusted R Square must be chosen.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.625	10	.364	2.188	.047 ^b
	Residual	5.150	31	.166		
	Total	8.786	41			
2	Regression	3.629	9	.403	2.902	.027 ^b
	Residual	5.157	32	.161		
	Total	8.786	41			
3	Regression	3.609	8	.451	2.871	.035 ^b
	Residual	5.180	33	.157		
	Total	8.786	41			
4	Regression	3.653	7	.520	3.288	.009 ^b
	Residual	5.233	34	.154		
	Total	8.786	41			
5	Regression	3.499	6	.583	3.861	.005 ^b
	Residual	5.287	35	.151		
	Total	8.786	41			
6	Regression	3.293	5	.651	4.233	.004 ^b
	Residual	5.533	36	.154		
	Total	8.786	41			
7	Regression	3.056	4	.764	4.933	.003 ^b
	Residual	5.730	37	.155		
	Total	8.786	41			

Figure 12

In the ANOVA table, the value of **F is 4.933**, which is moderately high.

Significance or **P should be less than 0.05. For this analysis significance is 0.003**

Hence, it can be concluded that out of several variables (Q4, Q5, Q6, Q8, Q10, Q11, Q12, Q13, Q14, Q16), some variables have a significant impact on the dependent variable Q20.

7	(Constant)	1.780	.496		3.586	.001					
	q5	.204	.111	.254	1.831	.075	.118	.288	.243	.916	1.082
	q11	.158	.089	.242	1.768	.085	.234	.279	.235	.941	1.062
	q13. How would you rate your team's ability to handle crises as a team?	-.492	.162	-.439	-3.046	.004	-.392	-.448	-.404	.849	1.177
	1 - Poor										
	2 - Fair										
	3 - Good										
	q16	.439	.248	.247	1.769	.085	.361	.279	.235	.903	1.108

Figure 13

The most significant variables out of all the inputs that were given are: Q5, Q11, Q13, Q16

The values of standardized Beta for the significant variables are as follows:

For Q5, Beta = 0.254

For Q11, $Beta = 0.242$

For Q13, $Beta = -0.439$

For Q16, $Beta = 0.247$

The highest value of Beta is for Q5, meaning that Q5 is the most significant variable for the dependent variable Q20.

Arranging the values from most significant to least significant

Q5 ($Beta = 0.254$) > Q16 ($Beta = 0.247$) > Q11 ($Beta = 0.242$) > For Q13 ($Beta = -0.439$)

For Unstandardised B:

One unit change in variable Q5 there would be 0.204 unit change in Q20 (Dependent variable)

For standardized $Beta$:

1% change in Q5 would be equal to 0.254 change in Q20 (Dependent variable)

Collinearity Statistics:

Vif is less than 4, that means there is no multicollinearity.

Charts:

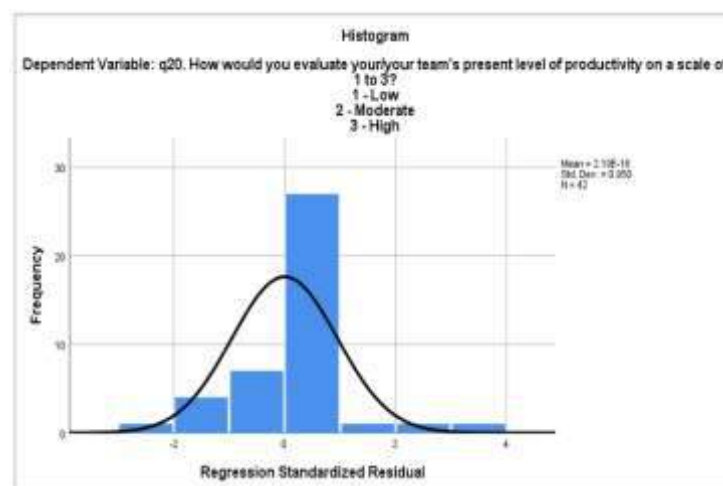


Figure 14

The histogram is almost normal, hence it does not violate the assumptions of the regression for Q20.

Input: Q23 = {Q4, Q5, Q8, Q22, Q24, Q25}

Outputs:

Model Summary ^h								
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Change Statistics		
						F Change	df1	df2
1	.647 ^a	.419	.278	.386	.419	2.970	8	33
2	.647 ^b	.418	.298	.381	-.001	.033	1	33
3	.645 ^c	.416	.316	.376	-.002	.119	1	34
4	.642 ^d	.413	.331	.372	-.003	.203	1	35
5	.621 ^e	.385	.319	.375	-.027	1.669	1	36
6	.607 ^f	.369	.319	.375	-.017	1.007	1	37
7	.577 ^g	.333	.299	.381	-.035	2.122	1	38

Figure 15

R Square: 33% of the variation of Q23 is experienced by Q4, Q5, Q8, Q22, Q24, Q25

R: It is the square root of R Square and its value should be between -1 to +1, the value of R in this output is 0.577.

Adjusted R square: It is used when you have several component models with different variables, the highest adjusted R Square must be chosen.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.548	8	.444	2.970	.013 ^a
	Residual	4.928	33	.149		
	Total	8.476	41			
2	Regression	3.543	7	.508	3.489	.008 ^a
	Residual	4.933	34	.145		
	Total	8.476	41			
3	Regression	3.528	6	.588	4.155	.003 ^a
	Residual	4.950	35	.141		
	Total	8.476	41			
4	Regression	3.497	5	.699	5.056	.001 ^a
	Residual	4.979	36	.138		
	Total	8.476	41			
5	Regression	3.267	4	.817	5.800	.001 ^a
	Residual	5.210	37	.141		
	Total	8.476	41			
6	Regression	3.125	3	1.042	7.396	.001 ^a
	Residual	5.351	38	.141		
	Total	8.476	41			
7	Regression	2.828	2	1.413	9.753	.000 ^a
	Residual	5.650	39	.145		
	Total	8.476	41			

Figure 16

In the ANOVA table, the value of **F is 9.753**, which is moderately high.

Significance or **P should be less than 0.05. For this analysis significance is 0.000**

Hence, it can be concluded that out of several variables (Q4, Q5, Q8, Q22, Q24, Q25), some variables have a significant impact on the dependent variable Q23.

7.	(Constant)	.661	.358	1.850	.072						
	q5	.156	.104	.236	1.796	.080	.268	.277	.235	.989	1.011
	q22. How pleased are you with your job on a scale of 1 to 3? 1 - Not Satisfied 2 - Moderately Satisfied 3 - Extremely Satisfied	.531	.139	.503	3.828	.000	.527	.523	.500	.989	1.011

Figure 17

The most significant variables out of all the inputs that were given are: Q5, Q22

The values of standardized *Beta* for the significant variables are as follows:

For Q5, *Beta* = 0.236

For Q22, *Beta* = 0.503

The highest value of *Beta* is for Q22, meaning that Q22 is the most significant variable for the dependent variable Q23. Arranging the values from most significant to least significant

Q22 (*Beta* = 0.503) > Q5 (*Beta* = 0.236)

For Unstandardised B:

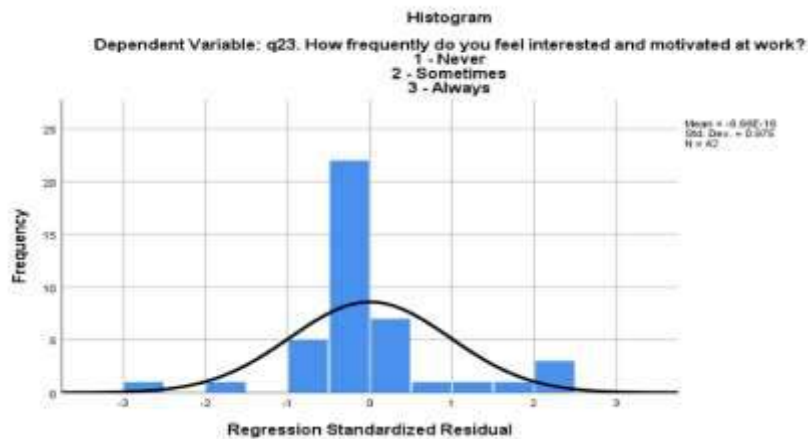
One unit change in variable Q22 there would be 0.531 unit change in Q23 (Dependent variable)

For standardized *Beta*:

1% change in Q22 would be equal to 0.503 change in Q23 (Dependent variable)

Collinearity Statistics:

Vif is less than 4, that means there is no multicollinearity.

Charts:**Figure 18**

The histogram is almost normal, hence it does not violate the assumptions of the regression for Q23.

ANALYSIS FOR THE GENERATION Z (GEN Z) USING IBM SPSS

Input: Q8 = {Q4, Q5, Q11, Q12, Q14}

Outputs:

Model Summary ^d						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change
1	.653 ^a	.426	.373	.683	.426	8.030
2	.652 ^b	.425	.383	.678	-.001	.135
3	.635 ^c	.403	.371	.684	-.022	2.126

Figure 19

R Square: 40% of the variation of Q8 is experienced by Q4, Q5, Q11, Q12, Q14.

R: It is the square root of R Square and its value should be between -1 to +1, the value of R in this output is 0.635.

Adjusted R square: It is used when you have several component models with different variables, the highest adjusted R Square must be chosen.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.736	5	3.747	8.030	.000 ^b
	Residual	25.198	54	.467		
	Total	43.933	59			
2	Regression	18.672	4	4.668	10.164	.000 ^c
	Residual	25.261	55	.459		
	Total	43.933	59			
3	Regression	17.696	3	5.899	12.590	.000 ^d
	Residual	26.238	56	.469		
	Total	43.933	59			

Figure 20

In the ANOVA table, the value of **F is 12.590**, which is high.

Significance or **P should be less than 0.05. For this analysis significance is 0.000**

Hence, it can be concluded that out of several variables (Q4, Q5, Q11, Q12, Q14), some variables have a significant impact on the dependent variable Q8.

3	(Constant)	-.559	.425		-1.313	.194	
	q4	.349	.185	.235	1.883	.065	.498
	q5	.398	.155	.305	2.544	.013	.492
	q14. On a scale of 1 to 4, how would you rate employee relations at your workplace? 1 - Not Satisfied 2 - Moderately Satisfied 3 - Very Satisfied 4 - Extremely Satisfied	.337	.127	.296	2.643	.011	.459

Figure 21

The most significant variables out of all the inputs that were given are: Q4, Q5, Q14

The values of standardized *Beta* for the significant variables are as follows:

For Q4, *Beta* = 0.235

For Q5, *Beta* = 0.305

For Q14, *Beta* = 0.296

The highest value of *Beta* is for Q5, meaning that Q5 is the most significant variable for the dependent variable Q8. Arranging the values from most significant to least significant

Q5 (*Beta* = 0.305) > Q14 (*Beta* = 0.296) > Q4 (*Beta* = 0.235)

For Unstandardised B:

One unit change in variable Q5 there would be 0.398 unit change in Q8 (Dependent variable)

For standardized *Beta*:

1% change in Q5 would be equal to 0.305 change in Q8 (Dependent variable)

Collinearity Statistics:

Vif is less than 4, that means there is no multicollinearity.

Charts:

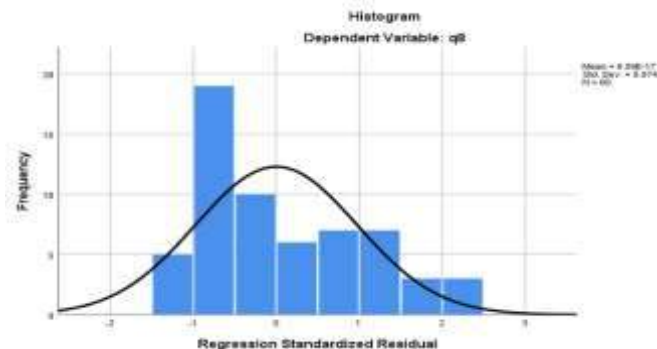


Figure 22

The histogram is almost normal, hence it does not violate the assumptions of the regression for Q8.

Input: Q14 = {Q4, Q5, Q6, Q8, Q10}

Outputs:

Model Summary ^a							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.530 ^a	.281	.215	.672	.281	4.230	5
2	.529 ^a	.280	.227	.667	-.002	.118	1
3	.526 ^a	.276	.237	.662	-.004	.278	1
4	.503 ^a	.253	.227	.667	-.023	1.774	1

Figure 23

R Square: 25% of the variation of Q14 is experienced by Q4, Q5, Q6, Q8, Q10

R: It is the square root of R Square and its value should be between -1 to +1, the value of R in this output is 0.503.

Adjusted R square: It is used when you have several component models with different variables, the highest adjusted R Square must be chosen.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.550	5	1.910	4.230	.003 ^b
	Residual	24.384	54	.452		
	Total	33.933	59			
2	Regression	9.496	4	2.374	5.343	.001 ^b
	Residual	24.437	55	.444		
	Total	33.933	59			
3	Regression	9.373	3	3.124	7.123	.000 ^b
	Residual	24.561	56	.439		
	Total	33.933	59			
4	Regression	8.695	2	4.297	9.667	.000 ^b
	Residual	25.239	57	.443		
	Total	33.933	59			

Figure 24

In the ANOVA table, the value of **F is 9.667**, which is moderately high.

Significance or **P should be less than 0.05. For this analysis significance is 0.000**

Hence, it can be concluded that out of several variables (Q4, Q5, Q6, Q8, Q10), some variables have a significant impact on the dependent variable Q14.

4	(Constant)	.439	.448		.980	.331	
	q4	.400	.153	.306	2.609	.012	.382
	q6	.380	.133	.336	2.863	.006	.405

Figure 25

The most significant variables out of all the inputs that were given are: Q4, Q6

The values of standardized *Beta* for the significant variables are as follows:

For Q4, Beta = 0.306

For Q6, Beta = 0.336

The highest value of Beta is for Q6, meaning that Q6 is the most significant variable for the dependent variable Q14.

Arranging the values from most significant to least significant

Q6 (Beta = 0.336) > Q4 (Beta = 0.306)

For Unstandardised B:

One unit change in variable Q6 there would be 0.380 unit change in Q14 (Dependent variable)

For standardized Beta:

1% change in Q6 would be equal to 0.336 change in Q14 (Dependent variable)

Collinearity Statistics:

Vif is less than 4, that means there is no multicollinearity.

Charts:

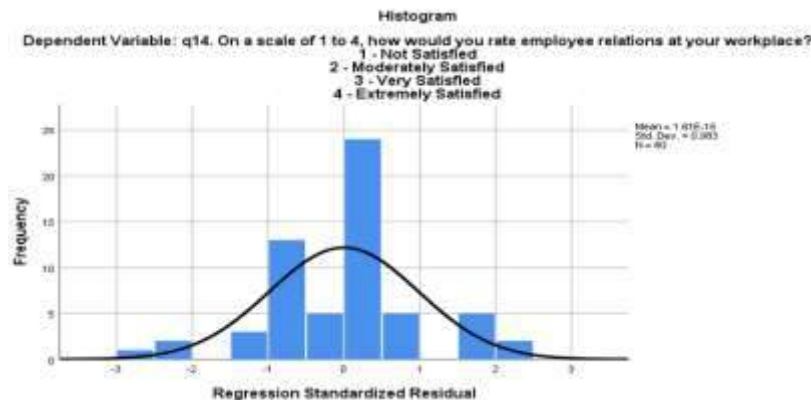


Figure 26

The histogram is almost normal, hence it does not violate the assumptions of the regression for Q14.

Input: Q20 = {Q4, Q5, Q6, Q8, Q10, Q11, Q12, Q13, Q14, Q16}

Model Summary ^a										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.707 ^a	.499	.397	.454	.499	4.886	10	49	.000	
2	.707 ^a	.499	.409	.450	.000	.012	1	49	.914	
3	.706 ^a	.499	.420	.445	.000	.019	1	50	.891	
4	.708 ^a	.498	.430	.441	-.001	.106	1	51	.746	
5	.703 ^a	.495	.438	.439	-.003	.334	1	52	.566	
6	.699 ^a	.489	.441	.437	-.006	.631	1	53	.431	
7	.682 ^a	.465	.426	.443	-.024	2.532	1	54	.117	2.017

Figure 27

R Square: 46% of the variation of Q20 is experienced by Q4, Q5, Q6, Q8, Q10, Q11, Q12, Q13, Q14, Q16

R: It is the square root of R Square and its value should be between -1 to +1, the value of R in this output is 0.682.

Adjusted R square: It is used when you have several component models with different variables, the highest adjusted R Square must be chosen.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.078	10	1.008	4.886	.000 ^a
	Residual	10.106	49	.206		
	Total	20.183	59			
2	Regression	10.076	9	1.119	5.537	.000 ^a
	Residual	10.108	50	.202		
	Total	20.183	59			
3	Regression	10.071	8	1.259	6.349	.000 ^a
	Residual	10.112	51	.198		
	Total	20.183	59			
4	Regression	10.050	7	1.436	7.368	.000 ^a
	Residual	10.133	52	.195		
	Total	20.183	59			
5	Regression	9.985	6	1.664	8.649	.000 ^a
	Residual	10.198	53	.192		
	Total	20.183	59			
6	Regression	9.864	5	1.973	10.323	.000 ^a
	Residual	10.320	54	.191		
	Total	20.183	59			
7	Regression	9.380	4	2.345	11.938	.000 ^a
	Residual	10.803	55	.196		
	Total	20.183	59			

Figure 28

In the ANOVA table, the value of **F is 11.938**, which is moderately high.

Significance or **P should be less than 0.05. For this analysis significance is 0.000**

Hence, it can be concluded that out of several variables (Q4, Q5, Q6, Q8, Q10, Q11, Q12, Q13, Q14, Q16), some variables have a significant impact on the dependent variable Q20.

7	(Constant)	.936	.323		2.897	.005					
	q4	.261	.115	.259	2.278	.027	.188	.294	.225	.750	1.332
	q5	-.341	.108	-.385	-3.153	.003	.020	-.391	-.311	.652	1.533
	q11	.366	.074	.559	4.955	.000	.577	.556	.489	.766	1.306
	q13. How would you rate your team's ability to handle crises as a team?	.264	.114	.258	2.308	.025	.393	.297	.228	.781	1.280
	1 - Poor										
	2 - Fair										
	3 - Good										

Figure 29 The most significant variables out of all the inputs that were given are: Q4, Q5, Q11, Q13

The values of standardized *Beta* for the significant variables are as follows:

For Q4, *Beta* = 0.259

For Q5, *Beta* = -0.385

For Q11, *Beta* = 0.559

For Q13, *Beta* = 0.258

The highest value of *Beta* is for Q11, meaning that Q11 is the most significant variable for the dependent variable Q20.

Arranging the values from most significant to least significant

Q11 (*Beta* = 0.559) > Q4 (*Beta* = 0.259) > Q13 (*Beta* = 0.258) > Q5 (*Beta* = -0.385)

For Unstandardised B:

One unit change in variable Q11 there would be 0.264 unit change in Q20 (Dependent variable)

For standardized *Beta*:

1% change in Q11 would be equal to 0.559 change in Q14 (Dependent variable)

Collinearity Statistics:

Vif is less than 4, that means there is no multicollinearity.

Charts:

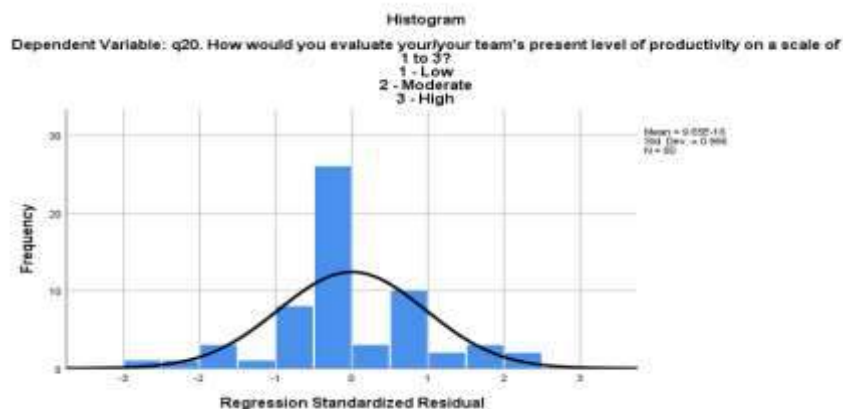


Figure 30 The histogram is almost normal, hence it does not violate the assumptions of the regression for Q20.

Input: Q23 = {Q4, Q5, Q8, Q22, Q24, Q25}

Model Summary ^a							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	df1
1	.476 ^a	.226	.137	.403	.226	2.538	6
2	.470 ^b	.221	.148	.401	-.005	.368	1
3	.462 ^c	.213	.155	.399	-.008	.535	1
4	.441 ^d	.195	.151	.400	-.019	1.274	1
5	.398 ^e	.158	.128	.405	-.037	2.497	1

Figure 31 R Square: 15% of the variation of Q23 is experienced by Q4, Q5, Q8, Q22, Q24, Q25

R: It is the square root of R Square and its value should be between -1 to +1, the value of R in this output is 0.398.

Adjusted R square: It is used when you have several component models with different variables, the highest adjusted R Square must be chosen.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.472	8	.412	2.538	.031 ^b
	Residual	8.443	52	.162		
	Total	10.915	58			
2	Regression	2.413	5	.483	3.008	.018 ^c
	Residual	8.503	53	.160		
	Total	10.915	58			
3	Regression	2.327	4	.582	3.657	.010 ^d
	Residual	8.588	54	.159		
	Total	10.915	58			
4	Regression	2.124	3	.708	4.430	.007 ^e
	Residual	8.791	55	.160		
	Total	10.915	58			
5	Regression	1.725	2	.862	5.256	.008 ^f
	Residual	9.190	56	.164		
	Total	10.915	58			

Figure 32 In the ANOVA table, the value of **F is 5.256**, which is moderately high.

Significance or **P should be less than 0.05. For this analysis significance is 0.008**

Hence, it can be concluded that out of several variables (Q4, Q5, Q8, Q22, Q24, Q25), some variables have a significant impact on the dependent variable Q23.

5	(Constant)	1.191	.299	3.982	.000					
	q5	.162	.080	.279	2.272	.027	.289	.291	.279	.999
	q22: How pleased are you with your job on a scale of 1 to 3? 1 - Not Satisfied 2 - Moderately Satisfied 3 - Extremely Satisfied	.255	.114	.274	2.229	.030	.264	.286	.273	.999

Figure 33 The most significant variables out of all the inputs that were given are: **Q5, Q22**

The values of standardized *Beta* for the significant variables are as follows:

For Q5, Beta = 0.279

For Q22, Beta = 0.274

The highest value of Beta is for Q5, meaning that Q5 is the most significant variable for the dependent variable Q23.

Arranging the values from most significant to least significant

$$\text{Q5 (Beta = 0.279) > Q22 (Beta = 0.274)}$$

For Unstandardised B:

One unit change in variable Q5 there would be 0.182 unit change in Q23 (Dependent variable)

For standardized Beta:

1% change in Q5 would be equal to 0.559 change in Q23 (Dependent variable)

Collinearity Statistics:

Vif is less than 4, that means there is no multicollinearity.

Charts:

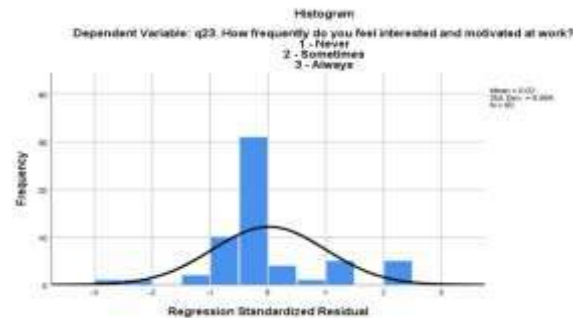


Figure 34 The histogram is almost normal, hence it does not violate the assumptions of the regression for Q23.

4.2 RESULT OF HYPOTHESIS AND DISCUSSION

Test of Hypothesis H1:

This hypothesis was formulated to understand if organizational communication affects the employee relations. As a result of the analysis,

In the generation Y perspective: The dominant coefficients, Q5 and Q12 are being affected. The values of the coefficients are found to be positive. The plots follow normality

Hence, the hypothesis H1 is found to be true.

In the generation Z perspective: The dominant values coefficients, Q4, Q5 and Q14 are being affected. The values of the coefficients are found to be positive. The plots follow normality.

Hence the hypothesis H1 is found to be true.

Test of Hypothesis H2:

The hypothesis was formulated to understand if the employee relations at the workplace affect productivity.

In the generation Y perspective: The dominant coefficients, Q4 and Q8 are being affected.

The values of the coefficients are found to be positive. The plots follow normality. The dominant coefficients of Q20 which are Q5, Q11, Q16 are found to be positive and Q13 is found to be negative. Even though the significance is 0.003, the hypothesis is not supported.

In the generation Z perspective: The dominant coefficients Q4 and Q6 are being affected. The values of the coefficients are found to be positive. The plot follows normality. The dominant coefficients Q4, Q11, Q13 are found to be positive and Q5 is found to be negative.

Even though the significance is 0.000, because of the slight negative correlation, the hypothesis is not supported.

Test of Hypothesis H3:

The Hypothesis was formulated to understand if the attitude and the perceptions of the employees affects the productivity at the workplace.

In the generation Y perspective: The dominant coefficients Q5 and Q22 are being affected

The values of the coefficients are found to be positive and the plots follow normality.

Hence, the hypothesis is found to be true.

In the generation Z perspective: The dominant coefficients Q5 and Q22 are being affected. The values of the coefficients are found to be positive and the plots follow normality.

Hence, the hypothesis is found to be true.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

The purpose of this study was to understand how organizational communication affects employee relations and productivity at work. The current workplace is a mix of five different generations and through this research the work perceptions of the generations of Y and generation Z was trying to be understood. The study found that organizational communication affects employee relations at work, mainly because when no rapport is built between the managers and the employees there might be hindrances in communication especially if the managers and the employees belong to a different generation.

According to an employee (belongs to the Gen Z) who currently works as a *Consultant for TCS (Tata Consultancy Services)*, "it is important to build a good enough rapport with the employees since the day they join the organization. The rapport should be contributed 50 - 50. The employees should also talk and come up

with their personal experiences. At the same time when the employees come to the managers with their personal concerns, the managers should try not to make them feel extra conscious about it”

Another employee (belongs to Gen Y) who currently works as a *Risk Analyst at Carrier Global*, ‘The HR and buddy programs should be taken seriously by the managers. Pulse surveys should be conducted regularly and the feedback should be made more streamlined, agile and personalized.’ Organizational communication can be improved when employees receive transparent and timely feedback from their managers. As an effect of the organizational communication, the employees have certain perceptions and attitudes towards the workplace, these perceptions have an impact on productivity. The attitude they have towards the workplace about how motivated and proud they are about the organizations influences the quality of the work they deliver.

The study also found that the employees majority of respondents who belonged to the generation Y are proud to be a part of the organization that they are currently working in as compared to generation Z who are not very proud. Both the generations Y and Z are moderately motivated at the workplace and generation Z mostly feel motivated at the workplace as compared to generation Y who feel motivated at work sometimes. Both of the members of these generations are moderately comfortable sharing their opinions with their managers. A positive organizational communication leads to better relationships between employees and the leadership, thereby improving the attitude and perceptions of the employees who in turn deliver maximum output to increase the productivity of the organization.

5.1 Recommendations

Based on the findings the below recommendations can be made -

→ It is important to have instilled a sense of togetherness and purpose between both the employees and leadership of the organization. It becomes extremely necessary for the leaders now more than ever to make all the generations realize the power and depth of unconditional teamwork and what it could do both for the individual and the organization.

Purpose driven communication often enhances organizational communication.

→ Communicating better, having empathy towards all the generations and recognizing the employees for their work can positively impact the productivity of the organization.

5.2 Area for future research

The study can also be conducted with employees of the generation Y and generation Z in other sectors in order to have a comprehensive understanding of sector-wise perceptions. Also, the form of communication that these generations prefer may be analyzed, as well as the ways in which it can be aligned with how companies deliver organizational messaging. The motivations and the actual personality traits of the employees belonging to the Gen Y and Z generations can be understood to suggest improvements to establish harmony at the workplace. Variables other than the employee relations and productivity can be analyzed that might be linked to organizational communication.

1.6 Limitations of the study

The focus of the study was on employees of generations Y and Z working in corporate organizations; however, more research is required to discover whether or not the characteristics found are generalizable to individuals working in other kinds of companies operating in other sectors. The research does not take into account the demographic backgrounds of the employees or the role that these backgrounds play in hindering effective organizational communication. This study used a snowball sampling strategy, and the total number of participants in the sample were only 102.

6. REFERENCES

1. Adu-Oppong, & Agyin-Birikorang. (2014, October). Communication in the Workplace: Guidelines for Improving Effectiveness. *Global Journal of Commerce and Management Perspective*, Vol.3(5):208-213(2319 – 7285).
2. Alshammari. (2015, December). Workplace Productivity through Employee Workforce Engagement: A Review Study. *International Journal of Business and Social Science*, 6(12).
3. Brady D. Lund and Matthew Walston. (2020, April). Anxiety-uncertainty management theory as a prelude to Mellon's Library Anxiety. *The Journal of Academic Librarianship* 46(4):102160
4. Bucăța, G., & Rizescu, A. M. (2017, March 1). The Role of Communication in Enhancing Work Effectiveness of an Organization. *Land Forces Academy Review*, 22(1), 49–57. <https://doi.org/10.1515/raft-2017-0008>
5. Cennamo, L., & Gardner, D. (2008, November 7). Generational differences in work values, outcomes and person-organization values fit. *Journal of Managerial Psychology*, 23(8), 891–906. <https://doi.org/10.1108/02683940810904385>
6. Chou. (2012, May). Millennials in the Workplace: A Conceptual Analysis of Millennials' Leadership and Followership Styles. *International Journal of Human Resource Studies*, 2(2).

7. Gaidhani. (2019). Understanding the attitude of Generation Z towards the workplace. *International Journal of Management, Technology, and Engineering*.
8. Gudykunst, W. B. (1993). Toward a theory of effective interpersonal and intergroup communication: An anxiety/uncertainty management (AUM) perspective. In R. L. Wiseman & J. Koester (Eds.), *Intercultural communication competence* (pp. 33–71). Sage Publications, Inc.
9. Gudykunst, W. B. (1998). *Bridging differences: Effective intergroup communication* (3rd ed.). Sage Publications, Inc.
10. Guan. (2009). *A Cross-Cultural Study of Intergenerational Communication in Workplace* The University of Southern Mississippi the Aquila Digital Community <https://aquila.usm.edu/cgi/viewcontent.cgi?article=2087&context=dissertations>
11. Goutam. (2013, April). Effective Communication at Workplace. *IRC'S INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SOCIAL & MANAGEMENT SCIENCES*, 1(2). <https://ircjournals.org>
12. Jennifer Miller. (2021, February). For younger job seekers, diversity and inclusion in the workplace aren't a preference; They're a requirement. *The Washington Post*.
13. LaCore, E. (2015, August 10). Supporting millennials in the workplace. *Strategic HR Review*, 14(4). <https://doi.org/10.1108/shr-06-2015-0046>
14. Morrison, E.W. (2011), "Employee voice behavior: Integration and directions for future research", *The Academy of Management Annals*, Vol. 5 No. 1, pp. 373-412.
15. Mazzei, A. (2018), "Employee engagement", in Heath, R.L. and Johansen, W. (Eds), *The International Encyclopedia of Strategic Communication*, Wiley-Blackwell, Boston.
16. Mazzei, A., Butera, A., & Quarantino, L. (2019, November 18). Employee communication for engaging workplaces. *Journal of Business Strategy*, 40(6), 23–32. <https://doi.org/10.1108/jbs-03-2019-0053>
17. Mehra, P., & Nickerson, C. (2019, July 8). Organizational communication and job satisfaction: what role do generational differences play? *International Journal of Organizational Analysis*, 27(3), 524–547. <https://doi.org/10.1108/ijoa-12-2017-1297>
18. Mohammad Saiful Islam & Sharmin Akter Eva. (2017, November). Application of McGregor's Theory X and Theory Y: Perception of Management toward the Employees in the Banking Industry of Bangladesh. *The International Journal Of Business & Management* (ISSN 2321–8916). Vol. 5, Issue:11.
19. Myers, K. K., & Sadaghiani, K. (2010, March 5). Millennials in the Workplace: A Communication Perspective on Millennials' Organizational Relationships and Performance. *Journal of Business and Psychology*, 25(2), 225–238. <https://doi.org/10.1007/s10869-010-9172-7>
20. Omar Ali Alferjany, & Alias. (2020, November). Generational Differences in values and attitudes within the workplace. University Tenaga Nasional, Malaysia, Article www.psychologyandeducation.net
21. Omunakwe, Nwinyokpugi, & Adiele. (2018, December). Workplace interpersonal relationships and organizational productivity in deposit money banks in port harcourt. Federal University Wukari, *Journal of Economics, Management & Social Science*, 4(4).
22. Radulescu, M. M., Ghinea, V. M., & Cantaragiu, R. (2018, May 1). Intergenerational gap dynamics. *Proceedings of the International Conference on Business Excellence*, 12(1), 829–842. <https://doi.org/10.2478/picbe-2018-0074>
23. Sadia, A., Mohd Salleh, B., Abdul Kadir, Z., & Sanif, S. (2016, December 31). The Relationship between Organizational Communication and Employees Productivity with New Dimensions of Effective Communication Flow. *Journal of Business and Social Review in Emerging Economies*, 2(2), 93–100. <https://doi.org/10.26710/jbsee.v2i2.35>
24. Skye Schooley. (2023, February). How to Manage Millennials vs. Gen Z in the Workplace. *Business.com*
25. William J. Carnes. (2009). *The Contingency Theory of Leadership: A Practical Perspective*. Metropolitan State College of Denver.

Digitalisation On Automotive Supply Chain for Climate Competitiveness: A Systematic Bibliometric Analysis

Velagapudi Manikrishna¹, Velaga Sri Sai², Tripuraneni Jaggaiah³, Saketh Reddy Karnati⁴, Sanjeev Chinnamanthur⁵ and Suresh Ranganathan⁶

Abstract

The automotive industry, a cornerstone of global manufacturing, is undergoing a profound transformation driven by digitalization. This research paper explores the impact of digitalization on the automotive supply chain and its role in enhancing climate competitiveness. As the industry strives to meet stringent environmental standards and consumer demands for sustainability, leveraging digital technologies becomes imperative. We use R Studio software to perform bibliometric analysis in this study. Our initial repository for data came from the Scopus database. Following a keyword search and before applying the limited criteria, we were able to find 3202 papers. We then started integrating the limited criteria, which included the following: stream: Business Management & Accounting, source type: Journal, no author, duplicate titles, and language: English. After applying these criteria, we were able to find 935 papers. We selected citations, bibliographical data, abstracts and keywords, funding information, and other data before exporting our database from Scopus.

Keywords: Supply Chain Digitalization, Climate Competitiveness, and Closed-Loop Supply Chain.

INTRODUCTION

The global manufacturing sector depends on the automotive industry, which is fundamental to economic growth and social mobility (Ahmed et al., 2020). It is critical to acknowledge that the sector of interest is the basis of the contemporary world, being the cornerstone of progress and the instrument of employment (Bhatia et al., 2022). At the same time, the challenges related to environmental sustainability have become more significant in the last several years. Moreover, it is necessary to understand that the automotive industry presents massive injection in the gross domestic product of many countries. Similarly, employment generation in manufacturing, sales, services, and others has depended on the industry (Kumar & Yamaoka, 2006). Additionally, the industry has led the world in technological advancement, influencing the growth of engineering, materials science, and electronics (Zhou et al., 2023). Constant research and innovation have seen safety features improve, fuel consumption efficiency increase, and integration of some of the latest technologies (Parsaiyan et al., 2019).

The complexity of the automotive supply chain is that it covers the entire planet involved in the manufacturing and distribution process (Maheshwari et al., 2023). The global-scale nature of the supply chain results in a range of implications for international trade and economic integration. On the one hand, automobiles have reshaped citizens' lives, allowing people to have unique mobility patterns and lifestyles (Ma & Cheng, 2023). The interaction process between the automotive industry and external stakeholders has created a fertile ground for sustainability development (van Loon et al., 2018). Digitalization is one of the most transformative forces affecting all aspects of human life in Industry 4.0 and beyond (Aldrighetti et al., 2023). The past supply chain management landscape was characterized by linear and often siloed processes with limited real-time observation

¹ Assistant Professor International Institute of Business Studies, India. ORCID : 0000-0002-6022-8782

² Assistant Professor GITAM University, India, email: velagasrisai@gmail.com ORCID: 0000-0002-5138-6236

³ Professor, India International Institute of Business Studies

⁴ Assistant Professor, India International Institute of Business Studies. ORCID: 0000-0002-4360-5152

⁵ Research Scholar Dayanand Sagar University, India. ORCID: 0000-0002-5539-3441

⁶ Associate Professor Dayanand Sagar University, India. ORCID:0000-0001-7876-015

due to manual intervention (Zhou et al., 2023). As a result, traditional supply chains were riddled with delays, inefficiencies, and failure to respond adequately to consumers' requirements (Fargetta & Scrimali, 2023).

The definition of digitalization in supply chain management involves the efforts toward the complete integration of digital technologies across the entire value chain (Zhou et al., 2023). Considering the range of technologies applied within digitalization, this concept can be generally defined as integrating a spectrum of technologies, including IoT, AI, Blockchain, data analytics, and cloud computing, to mention a few (Valsamidis, 2020). These tools create a well-connected, intelligent supply and demand network. For example, the IoT sensors integrated into physical assets are used for tracking and monitoring in real-time terms of goods, inventories, or equipment (Aldrighetti et al., 2023). Advanced analytical tools process big data and provide valuable insights for decision-making (Rasool et al., 2023). Predictive analytics allows us to minimize risks and optimize efforts and expenditures throughout the entire supply chain (Seyedghorban et al., 2020).

LITERATURE REVIEW

(Taj et al., 2023), suggest that real-time monitoring of vehicles, components, and equipment through IoT technologies provides visibility and traceability in the supply chain. (Theissler et al., 2021) emphasis that the application of IoT for predictive maintenance that cuts downtime and improves operational performance across the board in the automotive manufacturing process. (Nti et al., 2022), performs a literature review that includes AI and machine learning algorithms in demand forecasting, production planning, and quality control. The solutions facilitate decision-making when placing and executing orders. Finally, (Bhattacharya et al., 2024) reveal AI's role in logistics optimization, cost cutting, and supply tracking.

Another perspective on Blockchain and the automotive supply chain is provided by (Ghomi-Avili et al., 2023), who cover the implications of Blockchain for secure and transparent transaction records, anti-fraud initiatives, and the safety of supply chain information. Additionally, it considers the potential of Blockchain to increase trust and reduce adversarial attitudes between partners for supply chain cooperation (De Giovanni, 2022). Another relevant reflection on this topic is provided by (Quariguasi Frota Neto & Dutordoir, 2020) regarding the personality of using data analytics for the automotive supply chain risk management, including disturbances and uncertainties. (Tavana et al., 2022) Understand the importance of data analytics in adjusting inventory levels in the automotive sector and the opportunity to improve order processing and reduce order completion intervals. Finally, (Fu et al., 2023) research the implications of electric vehicles for climate competitiveness and the reduction of carbon emissions by the automotive sector.

For instance, (Kalverkamp & Young, 2019) take a closer look at the corporate sustainability approach in the automobile industry and underline the importance of implementing environmental responsibility into businesses' strategies. Another good example is a research conducted by (Suhandi & Chen, 2023) that examines the adoption of sustainability practices and their effects on cars' impact on the climate and climate competitiveness of automotive companies. (Chiriac, 2011) outlines the best innovations in the automobile industry, which have significantly impacted companies' climate competitiveness. More specifically, they focus on technological breakthroughs as a critical factor. Finally, a paper by (Fahimnia et al., 2013) examines the relationship between sustainable supply chain practices and climate competitiveness in the automobile industry. Again, the focus is on environmental responsibility and its influence on competitiveness.

Research by (Sarkar et al., 2019) delves into strategies for reducing the carbon footprint in supply chains, highlighting the role of digital technologies in optimizing transportation, production, and distribution processes. (Yadav et al., 2024) examines how sustainable supply chain practices contribute to reducing greenhouse gas emissions and improving climate competitiveness. (Taj et al., 2023) explores the application of IoT for real-time monitoring of supply chain processes, enabling better visibility into environmental impacts and enhancing climate competitiveness. (Modares et al., 2023) Discuss IoT's use in tracking and optimizing transportation processes, reducing emissions, and promoting sustainable logistics.

(Chu et al., 2022) examines how blockchain technology enhances transparency and traceability in supply chains, contributing to sustainable sourcing and reducing environmental risks. (Yadav et al., 2024) emphasizes the role of Blockchain in creating a trustworthy and verifiable record of carbon emissions and sustainability practices.

(Hu & Bidanda, 2009) discusses the application of AI in predictive analytics for supply chain management, optimizing inventory levels, demand forecasting, and transportation planning to reduce carbon emissions. (Andryushchenko et al., 2020) explores how AI-driven algorithms enhance decision-making processes, leading to more sustainable and climate-competitive supply chain strategies. (Blouin & Audy, 2023) Explores the potential of circular economy principles in supply chains, emphasizing the role of digitalization in creating closed-loop systems for sustainable resource utilization.

METHODOLOGY

In this work, we do bibliometric analysis using R Studio software. We acquired our base data from the Scopus database, and our keywords were supply chain digitalization, climate competitiveness, and closed loop supply chain; after searching via keywords and before limited to criteria, we reached 3202 papers, and then we started to apply the limited criteria, such as (stream: Business Management & Accounting, source type: Journal, no author, duplicate titles, and language: English); after we applied those criteria, we reached 935 papers (Ahmad et al., 2023; Donthu et al., 2021; Gan et al., 2022; Kaurav & Gupta, 2022; Lim et al., 2022; Pandey et al., 2023; Valenzuela-Fernández & Escobar-Farfán, 2022). see Figure 1.

The Research Questions are

RQ1. What is the country's production over time & word cloud on digitalization in achieving climate competitiveness within the supply chain?

RQ2. Which are the most prolific authors, and what are the most relevant words and keyword co-occurrences in digitalization to achieve climate competitiveness within supply chains?

RQ3. What is the relationship between fundamental themes, authors, co-authors, countries, and sources in digitalization and achieving climate competitiveness within the supply chain?

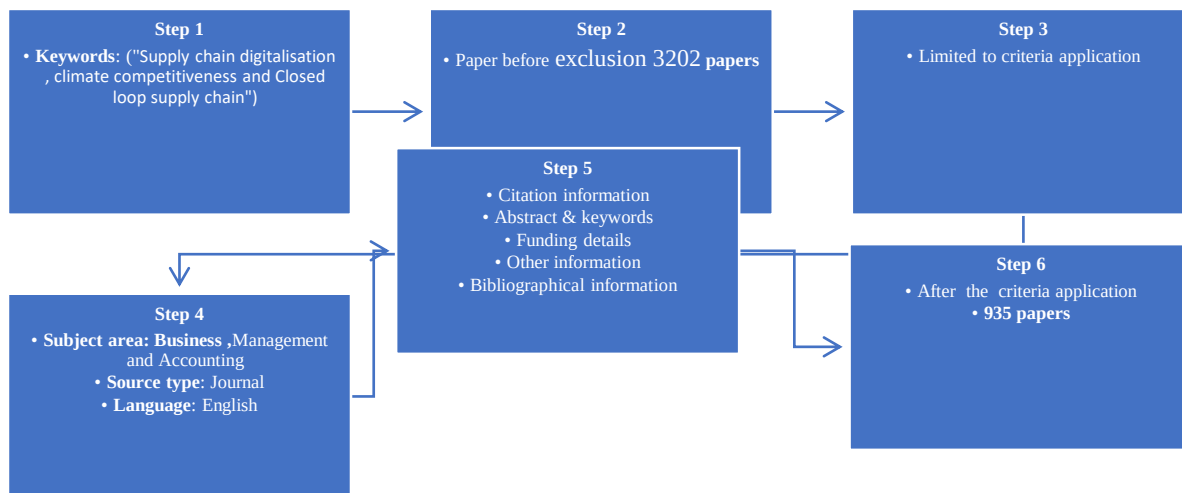


Figure 1: Limiting criteria process

RESULTS & DISCUSSIONS

Main Information



Figure 2: Main Information

The provided data contains information about a research dataset spanning from 2001 to 2024, sourced from 152 different publications (journals, books, etc.). The dataset comprises 935 documents with an annual growth rate of 12.5%. The average age of the documents is 6.07 years, and each document receives an average of 54.68 citations. The dataset references a total of 38,984 sources. In terms of document contents, there are 2,817 Keywords Plus (ID) and 2,173 Author's Keywords (DE). The dataset involves 1,896 authors, with 52 single-authored documents. Authors collaborated in creating 58 single-authored documents, with an average of 3.12 co-authors per document. International co-authorships contribute to 34.65% of collaborations. Regarding document types, the dataset comprises 876 articles, 7 conference papers, 5 editorials, 2 typos, and 45 reviews.

This dataset presents a comprehensive collection of scholarly works with diverse document types, significant international collaboration, and a notable number of citations per document, suggesting its relevance and impact in the academic domain. The data reflects a dynamic and growing body of literature over the specified timespan.

Most Relevant Words

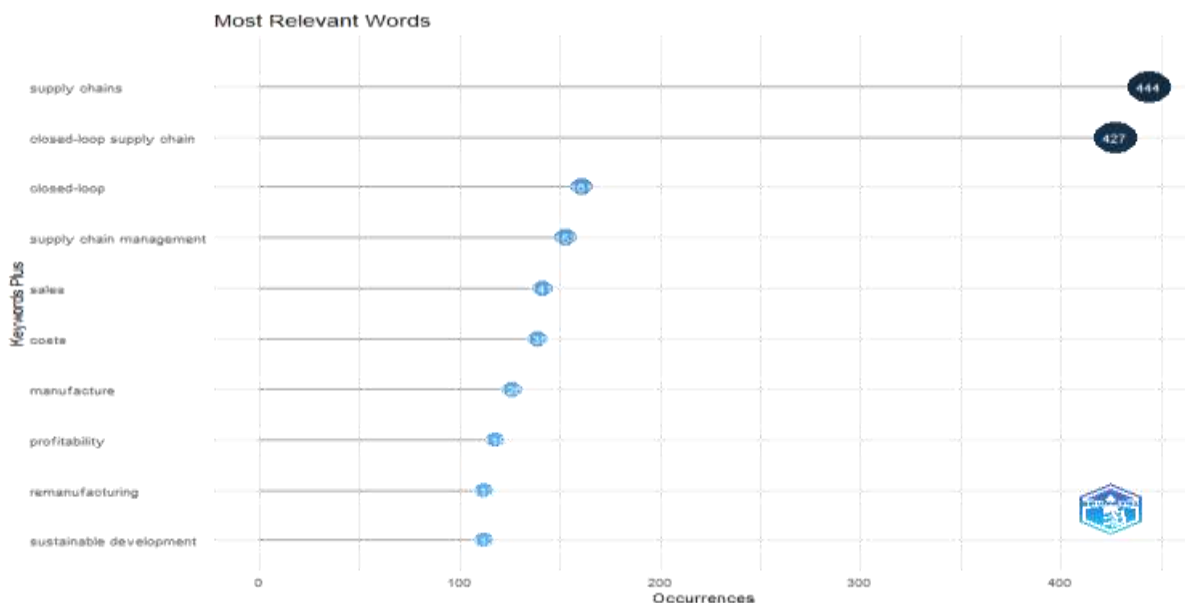


Figure 3: Most Relevant Words

The provided word frequency data reveals the prevalence of various terms in the field of supply chain management, mainly focusing on closed-loop supply chains, sustainability, and decision-making processes. The most mentioned words are "supply chains" and "closed-loop supply chain," with 444 and 427 appearances, respectively. As such, this shows significant attention to the entire process of supply chains, with the close supply chain loop synonym highly used as a pointer to an increased interest in sustainable and circular supply chain practices. Sales, costs, and profitability are frequent, indicating a highly pronounced business focus in supply chain use. In addition, the terms remanufacturing, recycling, and sustainable development are used frequently, showing interest in environmental awareness and being a pointer to the growing global environmentalism trend. Linear matrix inequalities, integer programming, and game theory are the only ones used, showing extensive use of advanced supply chain methods and decision-making use.

In addition, several specific concepts, such as "carbon," "circular economy," and "environmental impact," indicate the particular attention that has been paid to issues of environmental sustainability. At the same time, "life cycle," "competition," and "economic and social effects" highlight the multidimensionality of supply chain activities border in their social and economic impacts on different aspects of the economy and social life. The abundance of such terms as "logistics," "product design," and "inventory control" implies a comprehensive approach to the supply chain that involves all of the aspects mentioned above. To conclude, word frequency analysis demonstrates the intricate nature of word research in the modern supply chain domain. The prevalence of terms associated with sustainability, decision, economy, and environmental considerations reveals a complex and multidisciplinary approach to understanding and improving supply chain processes. Researchers and practitioners are actively involved in examining innovative strategies, analytical approaches, and sustainable practices to optimize supply chain performance and address economic and environmental challenges.

Word Cloud



Figure 4: Word Cloud

The frequency data offers a complete picture of the most common themes and topics in the discipline of supply chain management. First, the term "supply chains" occurs 444 times, emphasizing the significance and wide scope of the industry-designed processes, challenges, and innovations. This broad categorization likely encompasses a wide range of topics, including logistics, inventory management, and distribution strategies, showcasing the holistic approach researchers and practitioners take to understand and optimize the end-to-end supply chain.

A notable emphasis on sustainability is evident through the high frequency of terms related to closed-loop supply chains, with 427 occurrences. This underscores the growing significance of environmentally conscious practices in supply chain management. The emphasis on closed-loop systems, recycling, and remanufacturing reflects a concerted effort within the academic community to explore and implement eco-friendly approaches,

aligning with global initiatives for sustainable development. The frequent appearances of other terms, such as "sustainable development," "recycling," and "circular economy," showcase the consistent effort of researchers to align supply chains with the principles of protecting the environment.

Furthermore, the data highlights the complexity of decision-making processes involved in supply chain management. The word 'decision making' are used 87 times, which shows the unique frames of understanding and the need to optimize decision making. The latter can encompass strategic activities related to supply chain construction, operational elements of inventory management, and tactical decisions to be made about suppliers. Thus, the versatility of decision-making is explained by the need to use data as the basis for effective choice and maintain efficiency and responsiveness under various market conditions. The words 'linear matrix inequalities,' 'integer programming,' and 'game theory' demonstrate the relationship between technology and supply chain management. Ultimately, the search results show the latter as an area that requires technology and intelligent systems integration to support mathematical models and computational tools to solve significant problems.

Further supplementing the focus on the quantitative side of supply chain management described before, the data starts to manifest a preoccupation with these processes' economic and social dimensions. Namely, certain phrases like "economic and social effects" and "commerce" that occur with frequencies of 29 and 69, respectively, reflect the acknowledgment that this aspect should be taken into account. What these results convey is that researchers aim to consider not only the optimal operations but also the repercussions of implementing these decisions on the broader society and economy, which nurtures a comprehensive approach to the discipline.

Country Production Over Time

The dataset provided displays the annual count of articles published in scholarly journals for the four countries USA, China, United Kingdom, and India from 2001 to 2024. When observing the trends for United States, it can be seen that this country always maintains a leading position for article production within this period. In 2003, only 6 articles were published in academic journal, while in 2024, USA published 322 articles. Such a steady increase indicates a long-term and considerable share contribution to academic literature. This could be explained by USA's developed research infrastructure and active scientific environment across various study fields.

Another vital contributor is China, showing a substantial increase in research output . China features minimal publications at the beginning of the revealed dataset period, but publication growth is remarkable, reaching 783 articles by 2024 . Given the growth, China's increasing investment in research and development, developing influence in global academia, and article contribution to the identified issue are becoming more evident. The United Kingdom and India are in comparatively close research output proximity, with both countries experiencing progressive growth. The UK demonstrates growth from 3 publications in 2005 to 130 contributions in 2024, showcasing linear progression. India's growth, on the other side, is more intensive, with a publication count reaching almost 300 contributions, starting from just several articles in 2009. It is particularly interesting to evaluate that similar trends differ in terms of absolute values, indicating growing research productivity in India specifically. Thus, all four countries provide meaningful insights into research publication dynamics in the field.

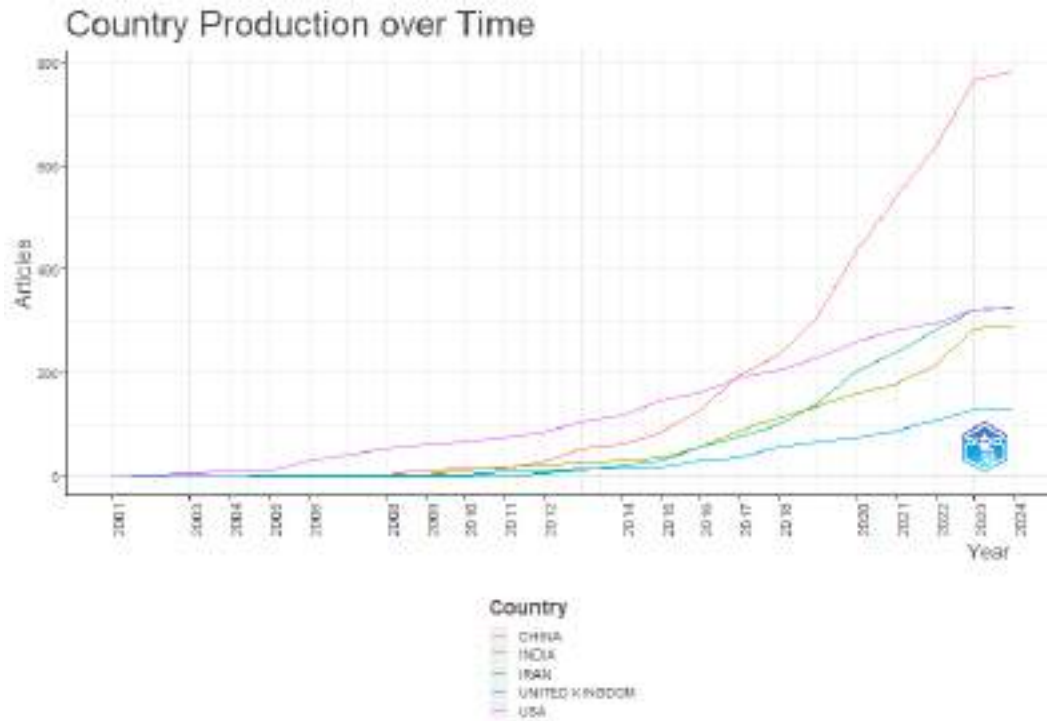


Figure 5: Country Production Over Time

The dataset shows that Iran presents a separate pattern in terms of research article production. Its publication frequency grows from 6 in 2012 to 325 in 2024. Although the figure is much lower compared to the US and China, the increasing rate can also be indicative of the rising interest in Iranian scholars and cooperation with the international academic community. This trend corresponds to Iran's emphasis on developing its scientific and research potential, which becomes possible due to significant investment in higher education and research institutions.

Most Relevant Authors

The presented data provides valuable information regarding the authors' productivity and contribution to the field, enlightening on their influence output. Several standout authors had a high number of articles published, with Govindan K, Van Wassenhove LN, and Wang Y being among those, suggesting their great influence over the domain. Govindan K, for example, although authoring the most papers, has a high fractionalized count, indicating a great variety of topics and collaborations, showcasing a comprehensive research portfolio. In contrast, authors such as Souza GC and Guide VDR, while having a respective number of fractionalized counts, exhibit a more focused research impact on fewer topics within the domain.

The analysis of authorship data offers valuable contributions to how supply chain management research is characterized as a collaborative endeavor. This arises from measuring and comparing the total and fractured article counts to understand the tendencies toward specialization, collaboration, or the progression of authors' contributions to this area's expanding knowledge base.

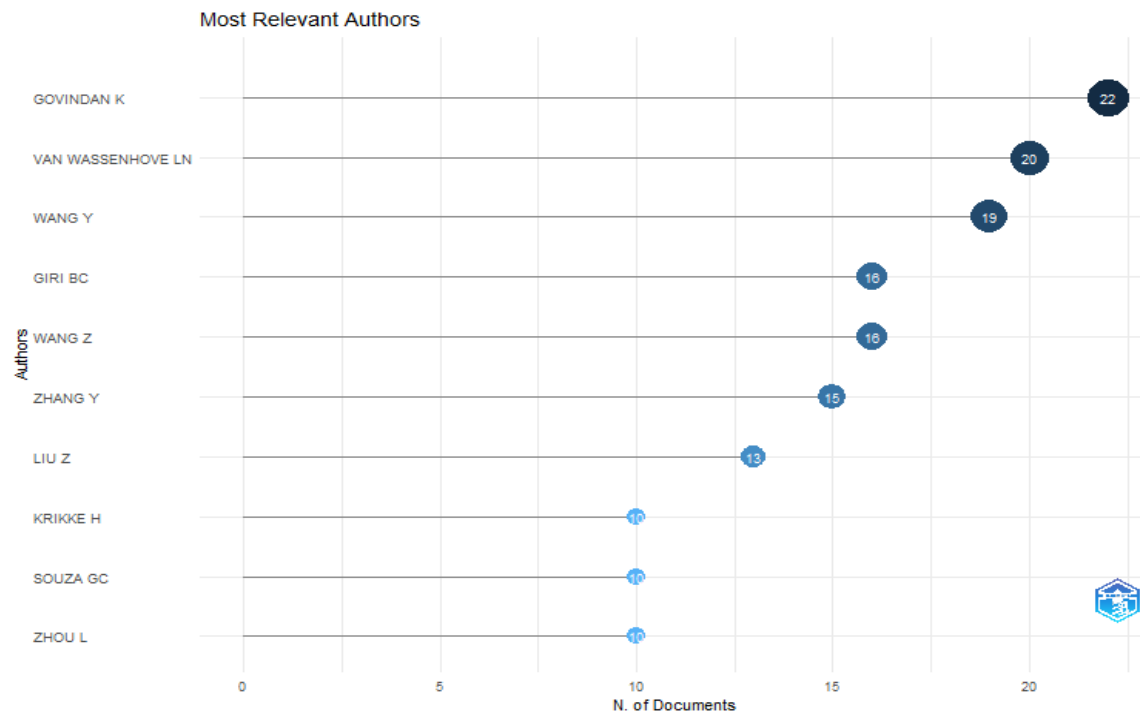


Figure 6 : Most Relevant Authors

Cluster Analysis

The data given represents a network analysis of two clusters related to supply chain management. As can be seen from Cluster 1, the nodes like "supply chains," "closed-loop supply chain," and "sustainable development" have a high betweenness centrality value. This means that the nodes play an important role as bridges, helping the other nodes in the cluster connect with one another in a more effective way.

Furthermore, the high closeness centrality of these nodes exposes that "supply chains" and "closed-loop supply chains" are closely located to other nodes in Cluster 1. In other words, these concepts are highly related to many other topics forming Cluster 1 and thus are essential for the general understanding of supply chain management as a whole. As for PageRank, "supply chains" and "closed-loop supply chains" are influential nodes. Essentially, PageRank estimates the importance of nodes in the network based on the number of incoming links. Therefore, the high PageRank values of these nodes suggest that "supply chains" and "closed-loop supply chains" are highly impactful and authoritative. In Cluster 1, "sensitivity analysis," "logistics," and "circular economy" are also significant nodes, influencing the general structure of the network and dissemination of knowledge within the cluster.

As for Cluster 2, the nodes "supply chain management," "sales," and "costs" have high betweenness centrality. These nodes form a bridge between the different parts of the network and act as intermediaries. High betweenness values in Cluster 2 nodes mean that these concepts are crucial for the knowledge flow in the cluster. It is also noted that "manufacture" and "profitability," along with "remanufacturing," have closeness centrality, connecting them with nearly every node in the cluster. Thus, these concepts are the closest to relationships in Cluster 2. The PageRank method shows that nodes "sales," "costs," "linear matrix inequalities," "game theory," and "recycling" have great influence and a high position of authority. "Linear matrix inequalities" and "game theory" influence the knowledge circulation the most in Cluster 2.

Table 1 : Cluster Analysis

Node	Cluster	Betweenness	Closeness	PageRank
supply chains	1	126.420553	0.02040816	0.10287851
closed-loop supply chain	1	97.3679673	0.02040816	0.09834677
closed-loop	1	16.9943181	0.02	0.04103537
sustainable development	1	7.39798196	0.01923077	0.02903694
decision making	1	4.61607708	0.01923077	0.02476304
integer programming	1	4.65184543	0.01724138	0.0234621
closed-loop supply chains (clsc)	1	2.82390662	0.01785714	0.01918258
reverse logistics	1	1.13483989	0.01587302	0.01698523
sensitivity analysis	1	3.84407746	0.01886792	0.02065653
product design	1	1.98219594	0.01785714	0.01640791
logistics	1	1.24858063	0.01612903	0.01495293
circular economy	1	0.64221637	0.01538462	0.01289418
optimization	1	1.50901361	0.01724138	0.01335631
stochastic systems	1	1.14324704	0.01666667	0.01536714
environmental impact	1	1.22440537	0.01754386	0.01308015
life cycle	1	0.17101567	0.01428571	0.00982429
closed-loop supply chain networks	1	0.61584912	0.01538462	0.0122002
economic and social effects	1	0.34183115	0.01492537	0.01023241
inventory control	1	0.12892799	0.01408451	0.00940425
sustainable supply chains	1	0.18981947	0.01449275	0.00906746
multiobjective optimization	1	0.33188385	0.01449275	0.00970256
closed-loop supply chain network designs	1	0.36502526	0.01428571	0.00891575
nonlinear programming	1	0.41426446	0.01538462	0.01002112
uncertainty analysis	1	0.30151494	0.01428571	0.00888898
stochastic models	1	0.30702919	0.01515152	0.01006989
genetic algorithms	1	0.08814426	0.01388889	0.00760682
recovery	1	0.02420305	0.01333333	0.00726802
green supply chain	1	0.13980865	0.01351351	0.00688864
supply chain management	2	11.0337105	0.02040816	0.03193859
sales	2	10.8967765	0.02040816	0.03976488
costs	2	8.2751195	0.01960784	0.03801648
manufacture	2	5.13133611	0.01886792	0.03334767
profitability	2	5.52973485	0.01886792	0.03188013
remanufacturing	2	5.58730073	0.01851852	0.0312571
recycling	2	3.96933832	0.01785714	0.02615856
linear matrix inequalities	2	5.19067123	0.01960784	0.02900021
game theory	2	1.75797315	0.01587302	0.02152871
commerce	2	2.65707245	0.01724138	0.02104758
remanufactured products	2	0.55647649	0.01612903	0.01531098
competition	2	0.37352014	0.01470588	0.01056404
carbon	2	0.74697222	0.01639344	0.01183788
environmental management	2	0.15054752	0.01428571	0.0091967
original equipment manufacturers	2	0.13023355	0.01428571	0.00934832

emission control	2	0.16029458	0.01470588	0.00953944
environmental regulations	2	0.16701618	0.01470588	0.00876926
manufacturing	2	0.09609204	0.01315789	0.00801247
reverse supply chains	2	0.03433132	0.01315789	0.00723001
stackelberg games	2	0.03432146	0.01298701	0.00852846
third parties	2	0.03513096	0.01282051	0.0080176
cost effectiveness	2	0.0654876	0.01351351	0.00720882



Figure 7: Cluster Analysis

Concluding, the network analysis allows obtaining meaningful information about two clusters in supply chain management. This information includes the critical subsets, significant subjects, also the connections between them, and the role in the knowledge dissemination and collaboration activities of the cluster members.

KEYWORD CO-OCCURRENCES

Two clusters, which are "supply chains" and "sales," were analyzed with the set of centrality and density measures. In the case of Callon Centrality, the value for "supply chains" is 6.71 and 6.27 for "sales." It means that the "supply chains" factor is more important in the network where it is placed. Finally, it is possible to analyze the Callon Density. The presented metric reflects the density of connections inside the cluster. In this case, "supply chains" have 29.69 Callon Density, while "sales" is presented with 25.90. Such results prove a more integrated and coherent network for "supply chains" compared to "sales."

Moreover, "supply chains" take the second place according to Rank Centrality and Rank Density. In contrast, "sales" statistics are reaching the top Ranks for both metrics, showing a more central and fundamental role. However, the Cluster Frequency also shows that "supply chains" appear 3494 times compared to 1766 for "sales." Thus, looking at the centrality and density metrics, it is possible to say that different structures and roles are identified. The high centrality, density, and frequency in "supply chains" show the essentials and tightly connected network. At the same time, "sales" show top centrality and density results that prove their central and high statuses, as well as global frequency metrics in the dataset.



Figure 8 : Keyword Co-Occurrences

Coupling Network

The presented data describes several groups, which are defined by topics and their percentage of participation in conferences, collection frequencies, and the calculated indices. The first group with 50 frequency is identified by a high centrality value 0.467 coefficient, which shows a close connection within "supply chain management," "sustainable supply chains," and "sustainable development" topics. The high impact value 1 of color code #E41A1C80 demonstrates the specialty of this group.

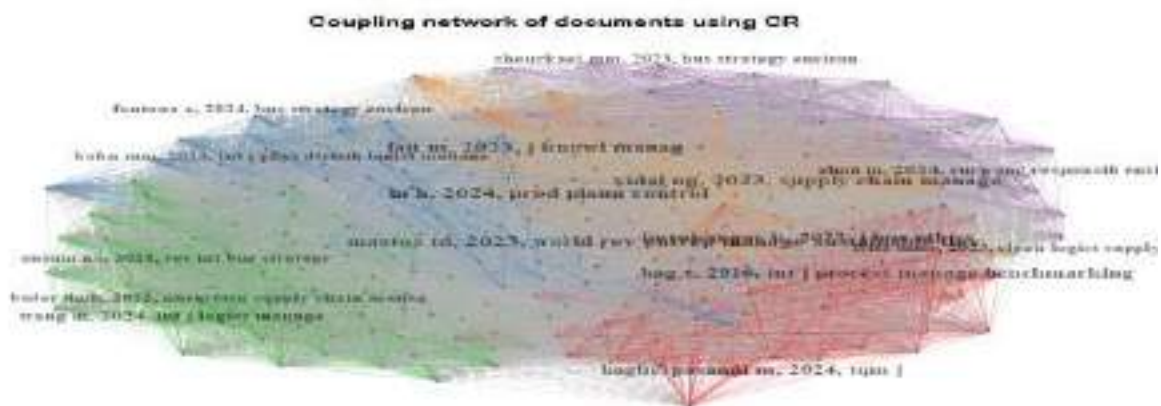


Figure 9: Coupling Network

Group 2 has a frequency of 56 and a centrality value 0.368, slightly weaker than Group 1. Nonetheless, the observed topics present a strong level of centrality. "Supply chain management" clearly relates to "sustainable development" and "sustainable supply chains," thus exposing a pronounced centrality. Moreover, the impact value of 1 reflects the notable influence of these topics. In addition, Group 2 is characterized by the color code #377EB880, underlining its distinctiveness.

To sum up, due to the analysis of these labeled groups, it was revealed that these topics – "supply chain management," "sustainable supply chains," and "sustainable development" – always emerge as highly connected and influential clusters. These groups are signified by the color codes, highlighting their distinctive features. For example, Group 1, which demonstrates both high frequency and centrality metrics, appears to be the most influential. At the same time, other groups may show the difference in these metrics but still contribute to the network in their manner.

CONCLUSION

The literature reviewed extensively has several key findings, as outlined, indicating that digitalization is the core concept in maintaining climate competitiveness in the supply chains. First, digitalization involves IoT, Blockchain, artificial intelligence, and data analytics, which is critical to converting traditional to sustainable and climate-competent networks. Secondly, the application of IoT and Blockchain technologies improves real-time connectivity, visibility, and transparency throughout the supply chain. This results in environmental benefits while fostering trust and responsibility among stakeholders.

As can be seen, Artificial Intelligence facilitates data-driven decision-making in supply chains based on predictive analytics. Therefore, it helps to eliminate waste, reduces the need for adjusting demands and supply, which have a positive impact on the carbon competitiveness factor. In turn, Blockchain is presented as a reliable technology in sustainable sourcing and traceability, as it eliminates the chance of forgery and provides an unchangeable source of information. As a result, the detailed record of sustainability practices helps address the concept of climate competitiveness – reducing organizations' harm to the environment while increasing their viability. Moreover, data analytics processes related to the identified factors are essential because they indicate where and how organizations are sustainable. Lastly, new digitalizing opportunities pose challenges such as the readiness for digital transformation, interoperability issues, and lack of collaborative networks. Therefore, organizations must be prepared to face these and other potential challenges.

Among the other human-centric considerations, organizational readiness and the involvement of individuals in the technology adoption process are critical for success. Human roles are neglected factors in integrating digitalization with sustainable supply chain practices, and it is essential to consider some future directions. Specifically, it is valuable to incorporate circular economy principles with digital utilization to develop closed-loop supply chain units. This will secure economies of sustainable resource utilization and correspond to the goals of competitiveness in a heated climate. The aspect of strategic organizational approaches is also discussed, and there is an essential focus on linking digitalization to broader sustainability initiatives. Organizations handling the issue interactively with the motive leading are more effectively pre-disposed to stay competitive with the climate. The ethical concerns are also determinant, uniquely in data protection and passionate backing. It is a severe problem that is essential to the proper correlation among the supply chain units. Trust's role between supply chain participants and other included parties is vital for successful digital endeavors, and ethical behaviors are instrumental in forming and maintaining this trust.

REFERENCES

- Ahmad, F., Bask, A., Laari, S., & Robinson, C. V. (2023). Business management perspectives on the circular economy: Present state and future directions. *Technological Forecasting and Social Change*, 187(October 2022), 122182. <https://doi.org/10.1016/j.techfore.2022.122182>
- Ahmed, S. M., Karmaker, C. L., Doss, D. A., & Khan, A. H. (2020). Modeling the barriers in managing closed loop supply chains of automotive industries in Bangladesh. *International Journal of Supply and Operations Management*, 7(1), 76–92. <https://doi.org/10.22034/IJSOM.2020.1.5>
- Aldrighetti, R., Battini, D., Das, A., & Simonetto, M. (2023). The performance impact of Industry 4.0 technologies on closed-loop supply chains: insights from an Italy based survey. *International Journal of Production Research*, 61(9), 3003–3028. <https://doi.org/10.1080/00207543.2022.2075291>
- Andryushchenko, G. I., Gridneva, T. M., Tsaritova, K. G., Savina, M. V., & Blinnikova, A. V. (2020). Problems and features of the human side of digital supply chain mechanism. *International Journal of Supply Chain Management*, 9(4), 561–569.
- Bhatia, M. S., Srivastava, R. K., Jakhar, S. K., & Kumar, S. (2022). What's critical for closed-loop supply chain operations? - Findings from the Indian small and medium manufacturing enterprises. *Journal of Cleaner Production*, 372. <https://doi.org/10.1016/j.jclepro.2022.133791>
- Bhattacharya, S., Govindan, K., Ghosh Dastidar, S., & Sharma, P. (2024). Applications of artificial intelligence in closed-loop supply chains: Systematic literature review and future research agenda. *Transportation Research Part E: Logistics and Transportation Review*, 184. <https://doi.org/10.1016/j.tre.2024.103455>
- Blouin, F., & Audy, J.-F. (2023). Circular economy in winter road maintenance: Analysis of contract models for deploying a closed-loop supply chain. *Cleaner Logistics and Supply Chain*, 9. <https://doi.org/10.1016/j.clscn.2023.100127>
- Chiriac, S. E. (2011). Sustainable development: Shifting the focus from an economic to a multidisciplinary approach and from a local to a global action. *Quality - Access to Success*, 12(SUPPL.1), 410–415.

- Chu, X., Wang, R., Lin, Y., & Li, Y. (2022). Building trust in online trade-in programs with a blockchain-enabled system. *Transportation Research Part E: Logistics and Transportation Review*, 164. <https://doi.org/10.1016/j.tre.2022.102833>
- De Giovanni, P. (2022). Leveraging the circular economy with a closed-loop supply chain and a reverse omnichannel using blockchain technology and incentives. *International Journal of Operations and Production Management*, 42(7), 959–994. <https://doi.org/10.1108/IJOPM-07-2021-0445>
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133(May), 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Fahimnia, B., Sarkis, J., Dehghanian, F., Banihashemi, N., & Rahman, S. (2013). The impact of carbon pricing on a closed-loop supply chain: An Australian case study. *Journal of Cleaner Production*, 59, 210–225. <https://doi.org/10.1016/j.jclepro.2013.06.056>
- Fargetta, G., & Scrimali, L. R. M. (2023). A sustainable dynamic closed-loop supply chain network equilibrium for collectibles markets. *Computational Management Science*, 20(1). <https://doi.org/10.1007/s10287-023-00452-4>
- Fu, S., Chen, W., Ding, J., & Wang, D. (2023). OPTIMAL FINANCING STRATEGY IN A CLOSED-LOOP SUPPLY CHAIN FOR CONSTRUCTION MACHINERY REMANUFACTURING WITH EMISSIONS ABATEMENT. *Journal of Industrial and Management Optimization*, 19(2), 1459–1485. <https://doi.org/10.3934/jimo.2022002>
- Gan, Y. na, Li, D. duo, Robinson, N., & Liu, J. ping. (2022). Practical guidance on bibliometric analysis and mapping knowledge domains methodology – A summary. *European Journal of Integrative Medicine*, 56(October), 102203. <https://doi.org/10.1016/j.eujim.2022.102203>
- Ghomi-Avili, M., Niaki, S. T. A., & Tavakkoli-Moghaddam, R. (2023). A blockchain-based system for a network design problem considering pricing decisions and sustainability. *Journal of Cleaner Production*, 423. <https://doi.org/10.1016/j.jclepro.2023.138696>
- Hu, G., & Bidanda, B. (2009). Modeling sustainable product lifecycle decision support systems. *International Journal of Production Economics*, 122(1), 366–375. <https://doi.org/10.1016/j.ijpe.2009.06.011>
- Kalverkamp, M., & Young, S. B. (2019). In support of open-loop supply chains: Expanding the scope of environmental sustainability in reverse supply chains. *Journal of Cleaner Production*, 214, 573–582. <https://doi.org/10.1016/j.jclepro.2019.01.006>
- Kaurav, R. P. S., & Gupta, P. (2022). Trends in Multidiscipline Management Research: Past, Present and Future of FIIB Business Review. *FIIB Business Review*, 11(4), 382–404. <https://doi.org/10.1177/23197145221136966>
- Kumar, S., & Yamaoka, T. (2006). Closed loop supply chains - A study of US and Japanese car industries. *Human Systems Management*, 25(1), 51–70.
- Lim, W. M., Kumar, S., & Ali, F. (2022). Advancing knowledge through literature reviews: ‘what’, ‘why’, and ‘how to contribute.’ *Service Industries Journal*, 42(7–8), 481–513. <https://doi.org/10.1080/02642069.2022.2047941>
- Ma, Y., & Cheng, S. (2023). Channel coordination in a closed-loop supply chain with fairness concerns under further extended producer responsibility. *Managerial and Decision Economics*, 44(2), 876–891. <https://doi.org/10.1002/mde.3719>
- Maheshwari, S., Kausar, A., Hasan, A., & Jaggi, C. K. (2023). Sustainable inventory model for a three-layer supply chain using optimal waste management. *International Journal of System Assurance Engineering and Management*, 14, 216–235. <https://doi.org/10.1007/s13198-022-01839-3>
- Modares, A., Kazemi, M., Emrooz, V. B., & Roozkhosh, P. (2023). A NEW SUPPLY CHAIN DESIGN TO SOLVE SUPPLIER SELECTION BASED ON INTERNET OF THINGS AND DELIVERY RELIABILITY. *Journal of Industrial and Management Optimization*, 19(11), 7993–8028. <https://doi.org/10.3934/jimo.2023028>
- Nti, I. K., Adekoya, A. F., Weyori, B. A., & Nyarko-Boateng, O. (2022). Applications of artificial intelligence in engineering and manufacturing: a systematic review. *Journal of Intelligent Manufacturing*, 33(6), 1581–1601. <https://doi.org/10.1007/s10845-021-01771-6>
- Pandey, D. K., Hunjra, A. I., Hassan, M. K., & Rai, V. K. (2023). Venture capital financing during crises: A bibliometric review. *Research in International Business and Finance*, 64(September 2022), 101856. <https://doi.org/10.1016/j.ribaf.2022.101856>
- Parsaiyan, S., Amiri, M., Azimi, P., & Taqavi Fard, M. T. (2019). Developing a multi-method simulation model of a green closed-loop supply chain and determining pricing and advertising policy against a competitor. *International Journal of Business Performance and Supply Chain Modelling*, 10(4), 283–322. <https://doi.org/10.1504/IJBPSM.2019.105690>
- Quariguasi Frota Neto, J., & Dutordoir, M. (2020). Mapping the market for remanufacturing: An application of “Big Data” analytics. *International Journal of Production Economics*, 230. <https://doi.org/10.1016/j.ijpe.2020.107807>
- Rasool, F., Greco, M., Morales-Alonso, G., & Carrasco-Gallego, R. (2023). What is next? The effect of reverse logistics adoption on digitalization and inter-organizational collaboration. *International Journal of Physical Distribution and Logistics Management*, 53(5–6), 563–588. <https://doi.org/10.1108/IJPDLM-06-2022-0173>
- Sarkar, B., Guchhait, R., Sarkar, M., & Cárdenas-Barrón, L. E. (2019). How does an industry manage the optimum cash flow within a smart production system with the carbon footprint and carbon emission under logistics framework? *International Journal of Production Economics*, 213, 243–257. <https://doi.org/10.1016/j.ijpe.2019.03.012>
- Seyedghorban, Z., Tahernejad, H., Meriton, R., & Graham, G. (2020). Supply chain digitalization: past, present and future. *Production Planning and Control*, 31(2–3), 96–114. <https://doi.org/10.1080/09537287.2019.1631461>
- Suhandi, V., & Chen, P.-S. (2023). Closed-loop supply chain inventory model in the pharmaceutical industry toward a circular economy. *Journal of Cleaner Production*, 383. <https://doi.org/10.1016/j.jclepro.2022.135474>

- Taj, S., Imran, A. S., Kastrati, Z., Daudpota, S. M., Memon, R. A., & Ahmed, J. (2023). IoT-based supply chain management: A systematic literature review. *Internet of Things*, 24, 100982. <https://doi.org/https://doi.org/10.1016/j.iot.2023.100982>
- Tavana, M., Kian, H., Nasr, A. K., Govindan, K., & Mina, H. (2022). A comprehensive framework for sustainable closed-loop supply chain network design. *Journal of Cleaner Production*, 332. <https://doi.org/10.1016/j.jclepro.2021.129777>
- Theissler, A., Pérez-Velázquez, J., Kettelgerdes, M., & Elger, G. (2021). Predictive maintenance enabled by machine learning: Use cases and challenges in the automotive industry. *Reliability Engineering & System Safety*, 215, 107864. <https://doi.org/https://doi.org/10.1016/j.ress.2021.107864>
- Valenzuela-Fernández, L., & Escobar-Farfán, M. (2022). Zero-Waste Management and Sustainable Consumption: A Comprehensive Bibliometric Mapping Analysis. *Sustainability (Switzerland)*, 14(23), 1–24. <https://doi.org/10.3390/su142316269>
- Valsamidis, S. I. (2020). The Key Drivers for the Digitalization of the Supply Chain. *International Journal of Operations Research and Information Systems*, 11(3), 1–18. <https://doi.org/10.4018/IJORIS.2020070101>
- van Loon, P., Delagarde, C., & Van Wassenhove, L. N. (2018). The role of second-hand markets in circular business: a simple model for leasing versus selling consumer products. *International Journal of Production Research*, 56(1–2), 960–973. <https://doi.org/10.1080/00207543.2017.1398429>
- Yadav, S., Kumar Mangla, S., Priyamvada, P., Borkar, A., & Khanna, A. (2024). An energy-efficient model for PPE waste management in a closed-loop supply chain. *Business Strategy and the Environment*, 33(2), 1191–1207. <https://doi.org/10.1002/bse.3541>
- Zhou, H., Wang, Q., Li, L., Teo, T. S. H., & Yang, S. (2023). Supply chain digitalization and performance improvement: a moderated mediation model. *Supply Chain Management*, 28(6), 993–1008. <https://doi.org/10.1108/SCM-11-2022-0434>

IJBS®

The IUP Journal of **Business Strategy**

Vol. 20 No. 4 (Quarterly)

Hyderabad, December 2023

**Relationship Between Mission Statement Components
and ROA: A Study of Small-Cap Financial Firms** **5**

Brad Ward

**Adoption of Green Information Systems
for Sustainable Business Processes in India:
A Review** **20**

Geeta Raut and Udit Taneja

Case Study
HDFC Bank's Digital Transformation Journey **37**

Smita Ray and Anil Anirudhan

Research Note
**Sustainable Business Practices for Profitability:
A Review** **49**

Suneeta Hegde and Pavithra Salanke



IUP Publications
(A Division of The ICFAI Society)
www.iupindia.in

Sustainable Business Practices for Profitability: A Review

Sustainability is a phenomenon of three major components—people, planet, and profit—which are in direct relationship with social, environmental, and economic factors. The natural urge of humans to give back to society pays off rich dividends to the organizations. The increased awareness of sustainability and global concerns around environmental, social, and governance (ESG) issues among institutional investors and employees in general has brought a greater focus on sustainable production. This, combined with statutory compulsion, has created avenues for research in this area. The study examines the nexus between statutory requirement and short-term profits in business. The purpose of the paper is not just to support the argument of sustainability with profit, but also explore the motivation derived from sustainable practices. It reviews the competitive advantages that businesses have to offer with sustainability practices and the impact of sustainability practices on the profits of organizations.

It has been observed that the emerging economies are always under pressure to perform. Multinational business interests and approvals from the West to sustainability practices have created a considerable amount of pressure on businesses to practice sustainability. The recently held G20 summit in India highlighted sustainability priorities for member nations. Every participating country has an important role to play in advancing global sustainability.

There is an urgent need to make the planet a priority. Post-pandemic recovery requires multilateral cooperation in resolving the problems related to market recovery, labor challenges, climate, and health infrastructure. Economic vulnerability of debt-burdened economies always makes business sustenance difficult. Addressing debt issues poses a major challenge in the implementation of sustainability practices.

The term 'triple bottom line' (TBL) dates back to the 1990s when business was not influenced by digital technology and artificial intelligence. TBL as a sustainability concept was propounded by Elkington (1997). The concept gained significant popularity with the emergence of the term "sustainable development" from the Brundtland Report in 1987. Sustainability can be defined as "development that meets the needs of the present generations without compromising the ability of the future generations to meet their own needs" (Brundtland, 1987). This essentially means the resources need to be managed responsibly and the benefits need to be passed down to the next generation. It is a social obligation of every human being.

TBL provides a framework for measuring the performance of the business and the success of the organization using three lines: economic, social, and environmental. TBL expresses the expansion of the environmental agenda in a way that integrates the economic and social factors

(Elkington, 1997). Elkington's definition used the terms profit, people, and planet in parallel with economic, social, and environmental factors. Profit is the primary motto of every business; however, people are part of business and planet cannot be neglected. These three aspects should be considered in combination and not in silos.

In the organizational paradox literature, there is an argument as to whether paradoxical tensions are inherent in the system or socially constructed. Smith and Lewis (2011) presented a dynamic equilibrium model on how cyclical responses to paradoxical tensions help enable sustainability. Constant use of paradoxical lens is required for asserting the present needs of the organizations. The need to remain competitive in the market calls for more research on the foundation of sustainability paradox in organizations. Employee attitude forms a major factor in this scenario. There is a need to explore human emotions. Employee attitude towards sustainability is the key element for successful environmental, social and governance (ESG) implementation.

The current study seeks to understand what it means to employees to work in an organization with a sustainable strategy and how sustainability practices affect the organizational culture through a review of literature.

The study was conducted using preferred reporting items for systematic review and meta-analyses (Figure 1). A Boolean search of the EBSCO database and Google Scholar were performed between June and September 2023 to sequentially identify policy-related publications on sustainability. The search included journal articles, reviews, conference proceedings, and editorial material in English. The final review (Table 1) was conducted through country-specific database search. A renewed approach was used to carry out this review, that is, the topic was divided under four subheadings and relevant literature was studied and commented on. This essentially was a search for influencers of organizational behavior in line with the concept of profit, people, and planet.

The literature review found many sustainability studies focusing either on the

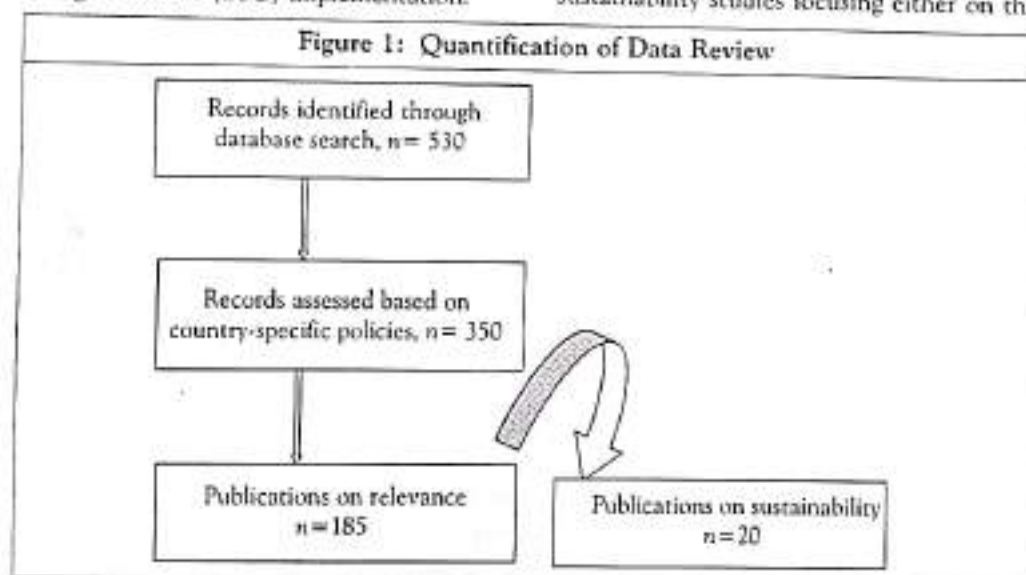


Table 1: Final Data Review

Articles	Proceedings	Journal Publication	Doctoral Dissertation
2	2	15	1

environment or society and how sustainability concepts appeared in the past. The review was carried out under four major segments: planet focus, profit focus, regulatory focus, and people focus.

Environmental/Planet Focus

Prabawani (2013) defined sustainability as the expectations of improving the social and environmental performance of the present generation. This should include careful consideration of future generation requirements and the use of renewable resources. Besides, the level of pollution emission should not exceed the recycling capacity of the environment (Elkington, 1997). The concept of sustainability underwent a considerable amount of evolution.

Sustainability is referred to as a fundamental and complex concept that mandates the balance of ecological factors for the ecosystem to survive (Aras and Crowther, 2009). In simple terms, sustainability refers to a belief in the enhancement and preservation of the natural environment.

Dyllick and Hockerts (2002) defined sustainability as societal development and evolution in the direction of a wealthy and more comfortable world where the natural environment is preserved for future generations. Further, they discussed the growth of sustainable development in the past three decades and application of this concept to businesses.

To meet the changing societal demands, organizations must form long-term strategies

and incorporate environmental and social aspects into their product offerings and decision-making. At the same time, companies must also strive to satisfy the short-term profitability interests and demands of shareholders. The motto of business is to make profit, but responsible profit.

Economic/Profit Focus

Sustainability must also generate value and financial gains for businesses. The lack of a rigid framework for sustainability in the literature presents a unique challenge. The use of the term sustainability is inconsistent. It always indicates one of the factors (Alhaddi, 2015)—economic, environmental, or social.

The economic line of TBL framework refers to the impact of the organization's business practices on the economic system (Elkington, 1997). Economy is regarded as the subsystem of sustainability. The growth of the organization is directly linked to the growth of the economy. In other words, it focuses on the economic value provided by the organization to the surrounding system. It also implies beneficial and fair business practices contributing to human capital and the community (Elkington, 1997). Thus, the interaction between the community and the organization addresses issues related to community involvement, employee relations, and fair wages.

According to Elkington (1997), TBL expresses the environmental agenda that integrates economic and social aspects. TBL can be used as a framework to measure business success. The organizations must use

social and environmental lines as an integrated part of business success. This is also referred to as the practical framework of sustainability (Rogers and Hudson, 2011).

The tangible and intangible assets contribute to corporate governance (Madhani, 2015). In business terms, this concept stands for responsible business management which is geared towards long-term value generation. Past research defined a significant relationship between asset composition and corporate governance. Madhani (2015) also explored the relationship between corporate governance and business profit. The study majorly focused on Indian business houses that are listed on the Indian stock exchange. The study examined whether organizations with sustainable practices are more likely to withstand economic downturn and found that such organizations outperformed their industry peers financially.

Environmental initiative impact on business was studied by Kearney and Diether (2009). The study was carried out on 18 sustainability-focused industries to examine the impact of environmental activities on organizational performance. The industries studied included retail, technological, automotive, chemical, food and media.

Compliance Factor/Regulatory Focus

Sustainability policies for business should include self-regulating mechanisms which enable the business to regulate and ensure efficient compliance in line with prevalent law requirements, ethical positioning, and global demand. Regulations and regulatory bodies have profound influence on initiation of sustainability practices in a company.

The law is complicated and varies across countries, regions, states, sometimes even

cities. Now, there is a global focus on issues such as greenhouse gas emission, carbon footprint, sector-specific law, forest protection, electronic gadget recycling, and hospital waste management, etc. These standards are more stringent particularly in cross-border trade. The EU policy on zero emissions and climate neutral economy by 2050 ensures that the manufacturers that export products should abide by EU's carbon border adjustment mechanism tax (CBAM). It is mandated for importers to submit quarterly CBAM reports and there are heavy penalties on misreporting.

Nidumolu *et al.* (2009) outlined five distinct stages of a company's journey into sustainability. According to them, viewing compliance as opportunity is important for business; they also talked about making value chains sustainable. Further, they focused on designing sustainable products and services, and developing new models of business based on law requirement. They envisaged the challenges that may be faced by businesses in different stages and the capabilities required to tackle them.

Ghatak and Tiwari's (2021) study examined the governance practices prevailing in prominent Indian Fast Moving Consumer Goods (FMCG) companies. The study assessed the substance and quality of reporting corporate governance practices in annual reports. The study included four renowned FMCG companies: Hindustan Unilever Ltd., ITC Ltd., Nestle (India) Ltd., and Tata Tea Ltd. The study used different parameters, including statutory and non-statutory requirements stipulated by statutory Clause 49 of the revised listing agreement.

Organizational Culture/People Focus

Sustainability studies also explore meaningful job characteristics for the new

generation. Popaitoon (2022) examined the influence of ESG on employee retention. The study concluded that sustainability policies can enhance Gen Z's willingness to stay.

Kearney Eric and Diether Gebert (2009) discussed transformational leadership, team performance, and the theoretical and practical implications of sustainability practices.

Isaksson and Kiessling (2021) explored the impact of human resources practices and Big Data on green innovation. According to this study, green innovation leads to sustainable performance. A sample of 373 employees from the service sector of Oman were surveyed for this study. The survey indicated the impact of Big Data on human resource practices. It is a novel study as it uses the concepts of global human resources and green human resource management (GHRM) practices. The paper discussed the paradoxical tension of sustainability—whether it was created by the inherent system or influenced by society.

Conclusion

The financial aspects and environmental implications are important parameters for business success. The inclination of employees to stay in sustainable organizations is higher because of emotional connect. The study reviewed theoretical and empirical studies on sustainable practices for business profit. The emerging synergy between corporate sustainability and governance has the potential to flourish as an area of corporate strategy. Corporate sustainability and strategy can be combined to strengthen financial performance. The review suggests that more theoretical and empirical studies are essential for advancing

corporate sustainability as a strategy for business profits. It further indicates that management proclivity and stakeholder support are crucial for the successful implementation of sustainability programs in organizations. Given the changing business scenario and the compulsory mandate by importing countries on reduced carbon footprint, it has become imperative for organizations to implement sustainability practices. There is also large scope for research on sustainability as an integrated component in profit calculations. Organizations must incorporate environmental and social aspects into their product offerings, while also satisfying the short-term profitability interests for shareholders. ☺

References

1. Alhaddi .H (2013), "The Influence of Triple Bottom Line on Strategic Positioning: An Exploratory Case Study on Differentiation Through Image", Doctoral Dissertation. Retrieved from ProQuest (3556124).
2. Alhaddi Hanan (2015), "Triple Bottom Line and Sustainability: A Literature Review", *Business and Management Studies*, Vol. 1, No. 2, pp. 6-10.
3. Ambec S and Lanoie P (2008), "Does it Pay to Be Green?", *A Systematic Overview, Academy of Management Perspectives*, Vol. 22, No. 4, pp. 45-62.
4. Aras G and Crowther D (2009), "Corporate Sustainability Reporting: A Study in Disingenuity!", *Journal of Business Ethics*, Vol. 87, pp. 279-288.
5. Brundtland G H (1987), "World Commission on Environment and Development", Presentation of the

- Report of the World Commission on Environment and Development to African and International and Non-governmental Organizations, June 7, Nairobi, Kenya
8. Dyllick T and Hockerts K (2002), "Beyond the Business Case for Corporate Sustainability", *Business Strategy and the Environment*, Vol. 11, No. 2, pp. 130-141.
 9. Elkington John (1997), "The Triple Bottom Line", *Environmental Management: Readings and Cases*, Vol. 2, pp. 49-66.
 11. Isaksson L and Kiessling T (2021), Corporate Social Responsibility (CSR) and Engineering Management: Performance Implications, *IEEE Transactions on Engineering Management*.
 13. Kearney Eric and Diether Gebert (2009), "Managing Diversity and Enhancing Team Outcomes: The Promise of Transformational Leadership", *Journal of Applied Psychology* Vol. 94, No. 1, p. 77.
 14. Madhani Pankaj M (2015), "A Study on the Corporate Governance and Disclosure Practices of Tangible Assets and Intangible Assets-Dominated Firms and Their Relationship", *The IUP Journal of Corporate Governance*, Vol. 14, No. 2, pp. 7-29.
 15. Nidumolu R, Prahalad C K and Rangaswami M R (2009), "Why Sustainability is Now the Key driver of Innovation", *Harvard Business Review*, Vol. 87, No. 9, pp. 56-64.
 16. Prabawani B (2013), "Measuring SMEs' Sustainability: A Literature Review and Agenda for Research", *International Journal of Management and Sustainability*, Vol. 2, No. 12, pp. 193-207.
 - Popaitoon P (2022), "Fostering Work Meaningfulness for Sustainable Human Resources: A Study of Generation Z", *Sustainability*, Vol. 14, No. 6. <https://doi.org/10.3390/su14063626>
 17. Rogers K and Hudson B (2011), "The Triple Bottom Line", *OD Practitioner*, Vol. 43, No. 4, p. 4.
 18. Smith W K and Lewis M W (2011), "Toward a Theory of Paradox: A Dynamic Equilibrium Model of Organizing", *Academy of Management Review*, Vol. 36, No. 2, pp. 381-403.
 19. Van der Voordt G J and Van der Weijde R P J B (2020), "The Triple Bottom Line: Reporting Tool or Reflexive Framework?", *An Employee Perspective on Corporate Responsibility in Practice*.

Suneeta Hegde*
and Pavithra Salanke**

* Research Scholar, SCMS Dayananda Sagar University, Bengaluru, Karnataka, India; and is the corresponding author. E-mail: suneethahegde-rs-mgr@dsu.edu.in

** Associate Professor, SCMS Dayananda Sagar University, Bengaluru, Karnataka, India. E-mail: Pavithra.s@dsu.edu.in

Reference # 33J-2023-12-04-10

Copyright of IUP Journal of Business Strategy is the property of IUP Publications and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.



Impact of Digital Advertising on Consumer Sentiments in the Indian Footwear Market

Rahul G. Kargal, Research Scholar, and Dr. Suresh R, Professor

School of Commerce and Management Studies, Dayananda Sagar University

Article Type: Article

Article Citation: Rahul G. Kargal and Dr. Suresh R Impact of Digital Advertising on Consumer Sentiments in the Indian Footwear Market. M.S. Ramaiah Management Review. 2023; 14(02), 12-29. DOI: 10.52184/msmr.v14i02.000

Received date: October 10, 2023

Accepted date: November 15, 2023

*Author for correspondence:

Rahul G. Kargal  School of Commerce and Management Studies, Dayananda Sagar University

Abstract

Over the past decade, mobile data penetration in India has skyrocketed, leading to tremendous growth in e-commerce and in the usage of internet and social media. Owing to the vast amount of digital content in circulation, consumer brands are having to get creative with digital advertising to attract consumers. This study strives to examine the nature of relationship between digital advertising and the ensuing sentiments of Indian consumers. For this study, a survey was conducted in the Indian city of Bangalore, followed by a testing of hypothesis using 117 convenient samples using the Chi-Square test. The analysis revealed that brands using digital advertising comprising of the variables such as “audio-visuals”, “storytelling” and recognizable “personalities” evoked sentiments of “attention” and “interest” amongst respondents while creating a “desire” to learn more about the products depicted with an aspiration to “purchase” them. The findings help brands understand the variables that impact consumer sentiment and aids their incorporation in future digital promotional content. The study heightens a marketer’s knowledge of the Indian consumer sentiment and highlights the impact that digital content and advertising have on critical dependent consumer behavior variables.

Keywords: Digital Advertising, Consumer Behavior, Consumer Product, Sentiment Analysis, AIDA Model

1. Introduction

Consumers, when making a purchase action, undergo a wide range of emotions. Their actions and decisions could be the result of a need that they might have experienced or is the outcome of an external stimulus. A variety of factors impact consumer behavior. These range from

psychological and social to personal and cultural factors. Advertisers have attempted to discover rationale behind consumer actions, utilize those learnings, and use all available canvases to lure their target audiences into making purchases. While doing so, both advertisers and researchers have applied the Attention, Interest, Desire, and Action (AIDA) model to devise

marketing campaigns. However, research is required to better understand the numerous variables of a digital advertisement that impact consumer sentiments in an effective manner. This paper investigates just this through a study conducted by observing the impact of a digital advertisement from a global footwear brand on the sentiments of Indian consumers.

1.1. Background

The global digital marketing industry, as per reports (Expert Market Research, 2022), was valued at nearly USD 321 billion in 2022. In India, the digital marketing industry was reported (Expert Market Research, 2022) to be valued at USD 4.5 billion in 2022 with a combined aggregate growth rate (CAGR) of 32.1% between 2023 and 2028. The meteoric growth of mobile data, internet usage and social media in India has played a huge role in the growth of digital marketing in the country. As of 2022, Kemp (2022) reported that India had 658 million internet users, 467 million social media users, and 467 million YouTube users. At the beginning of 2022, the ad reach of YouTube was equivalent to 33.4% of the population of India with 31.2% of the audience in the country being female and 68.8% being male.

As a natural consequence, the Indian e-commerce market is prominent and expected to hit USD 350 billion in the year 2030 as per reports (Indian Brand Equity Foundation, 2022). A host of consumer products, from apparels and mobile phones to footwear and grocery, are purchased everyday by the country's population. While the apparel market is reported to grow by 3.34% till 2027 (Apparel Resources, 2022), the footwear market has been documented to grow at 11% over the next five-years

(Rawell, 2022). The projected growth-rate of the footwear industry in India, therefore, becomes a noteworthy topic for this research.

1.2. Motivation for Study

Kadirov (2015) stated that amongst several tools available for an organization, advertising is the most visible and prominent tool, and is also widely recognized by the consumer. Borth, Chen, Ji, and Chang (2013) insisted that digital advertising helped in developing a connection with the consumer and in turn contributed to brand recall, brand awareness, and helped create a positive brand association. Subsequently, in keeping with the digital advancements across the globe, Saura, Palos-Sanchez, and Rodríguez Herráez (2020) noted that several stakeholders – companies, researchers, and advertisers included – are aware of the need to implement digital advertising strategies to generate profits. Meanwhile, in marketing communications, emphasis is laid on the depiction of a product or service's existence and thereafter, towards building a mutual relationship with the customer (Rowley, 2002).

Developed by E. St. Elmo Lewis in 1898, the AIDA model theory outlines four cognitive phases an individual experiences (Attention, Interest, Desire, and Action) when receiving a new idea or upon the purchase of a new product (Michaelson & Stacks, 2011). Further, Kojima, Kimura, Yamaji, and Amasaka (2010) stated that the model was indeed useful for advertisers to address the steps of psychological transformation that the individual goes through from witnessing an advertisement through to the stage of making a purchase decision. However, Hassan, Nadzim, and Shiratuddin (2015) believed that the probability of a

customer visiting the website after watching a digital advertisement was questionable. This emerges as a problem worthy of investigation for the advertiser as purchase actions take place on the product's website owing to the e-commerce business model employed by brands.

1.3. Research Gap

In addition to the observations of Hassan et al. (2015), there is limited research in the Indian context pertaining to the impact of digital advertisements on the consumer's purchase sentiments. Additionally, this research gap also exists in the footwear industry in India, where despite the projected growth of 11% over the next five-years (Rawell, 2022), there exists a lacuna in understanding the consumer sentiments towards digital footwear advertisements.

Filling this gap is important as a lack of clarity on what variable worked towards positively impacting the consumer's sentiment keeps an advertiser from being able to replicate the success achieved in previous campaigns or to make specific modifications as corrective measures for future advertisements. Additionally, a clear understanding of the variables that worked in an advertisement can help advertisers deliver greater return-on-investments (RoI) and bolster visibility for the brand.

Therefore, in keeping with the above premise, this study seeks to answer the question – “Is there a relationship between select variables of a digital advertisement and the ensuing consumer sentiments of awareness, interest, desire, and action in the Indian footwear industry”? Also, the scope of the study is limited to Bangalore, India.

2. Literature Review

2.1. Studies Detailing the Benefits of Analyzing Consumer Sentiment

Yang, Yang, Jansen, and Lalmas (2017) state that industries that constantly seek the interaction and attention of consumers should understand the complexities involving the target audience and consumer behavior. Likewise, Pedro, Yeh, and Oliver (2012) observed that studying consumer sentiment was vital to measure the opinion of consumers towards brands, products, and services. Additionally, it helped in predicting advertising results and served as a feedback loop to ascertain the effectiveness of an advertisement.

Similarly, Wereda and Woźniak (2019) argued that analysis of brand sentiments can contribute to a better understanding of consumer perceptions. Kim, Hur, and Yeo (2015) believed that defining a brand's reputation was possible by studying consumer sentiment. Likewise, while Calmache and Peyró (2010) suggested that a better understanding of consumer sentiment can help improve consumer experience, Peláez, Martínez, and Vargas (2019) discovered benefits in the areas of developing marketing strategies in the future. Equally, Yuan, Wang, and Qin (2014) and Chen and Zhang (2014) argued that a better understanding of consumer sentiment helps in lead generation and towards the development of better marketing campaigns and product messaging respectively.

2.2. Studies Documenting the Impact of Digital Advertising on Consumer Sentiment

Jadhav, Vyas, and Manekar (2018) noted in their study that the purchase behavior of consumers in Nagpur, Maharashtra was greatly influenced by messages promoted via digital marketing while citing trust as integral to purchase decisions. Meanwhile, Hollebeek and Macky (2019) observed that digital content marketing helped customers engage with brands at various level. At first level, they studied that digital content impacted the emotional and identification behavior of customers. Thereafter, at subsequent levels, their research showed that digital content elicited trust and elevated brand equity amongst consumers.

In South Africa, Reddy (2017) analyzed the impact that digital marketing had on Nike's retail operations in the country. He noted that consumers were significantly influenced by digital marketing. Specifically, digital marketing had enabled consumers to recognize problems, helped them in making subsequent purchase decisions and thereafter, impacted their post-purchase behavior as well.

Also, Luo, Tabassum, and Nayak (2022) documented that the growth of online shopping has enthused retailers and they are only increasing their digital marketing efforts and exploring digital channels such as Tik Tok to draw consumers into new experiences.

2.3. Studies Indicating Advertisers Using AIDA Model to Impact Consumer Sentiment

At the outset Hoek and Gendall (2003) argued that by creating attention and awareness in a consumer, advertising can create a desire and trigger action. Several researchers have similarly studied the relevance of the AIDA model in marketing campaigns across multiple channels and industries. For instance, the advent of television presented Indian advertisers with a large canvas to use the audio-visual format to woo consumers. And television advertising was studied by Rawal (2013) through the lens of the AIDA model to examine how advertisers were marketing products like instant noodles and telecommunication services while taking consumers through the funnel of attention, interest, decision, and action. The researcher observed that the audio-visual medium (the television in this case) was indeed a strong medium to stimulate a purchase decision in the mind of a consumer by messaging via story telling.

Meanwhile, Ullal and Hawaldar (2018) observed that audio-visual broadcast via in-store televisions in Udupi and Mangalore in the Indian state of Karnataka drove customers to action and helped increase purchase volume. A year later, Donthi (2019) used AIDA to study the effectiveness of a promotional strategy employed by Maruti Suzuki automobiles in the cities of Hyderabad and Secunderabad in the Indian state of Andhra Pradesh. Donthi (2019) found that ad-campaigns featuring discount offers proved to be effective across all the AIDA stages. Similarly, the ability of an advertising campaign to create an awareness and desire was studied by Kulkarni,

Attal, and Vasundekar (2020). They noted that the highly popular “*mutual funds sahi hai*” (“mutual funds are right”) campaign promoted by the Association of Mutual Funds in India (AMFI) not only created an awareness but also evoked an interest and desire to learn more about mutual funds as a financial instrument in the Indian city of Aurangabad in Maharashtra.

In parallel, studying the impact of the AIDA model in the digital marketing world has revealed interesting insights. For instance, Jansen and Schuster (2011) studied search engine advertising and discovered that ad-spend on keywords that targeted customers at an awareness level were more cost effective. On the contrary, ad-spend on keywords at the purchase level were more expensive but did not necessarily translate to sales. This learning can help digital marketers focus their ad-spend on messaging at the inquiry level and optimize marketing budgets in better manner. Researchers have also published that a website can trigger attention and action in consumers. Prathapan, Sahadevan, and Zakkariya (2018) studied the Kerala Tourism’s office website to find a significant number of unique visitors and high average session durations – which translate to attention and action – when compared to competitors’ websites.

Given that messaging plays a vital role in capturing the attention and thereafter, creating an interest in the consumer, some advertisers are now using visual metaphors as a critical variable for messaging in their advertisements to entertain consumers (Madupu, Sen, & Ranganathan, 2013). In fact, van Mulken, van Hooft, and Nederstigt (2014) and Burgers, Konijn, Steen, and Iepsema (2015) have found ads containing the variable of visual metaphor were more appreciated and were perceived as more

creative. Phillips et al. (2008) added more weight to the use of metaphor as a variable by suggesting that ads containing them received great emotional response and left consumers with a positive attitude.

Clearly, integrating variables that evoke consumer sentiments of AIDA into an advertisement or marketing campaign can prove to be effective in positively impacting the behavior of a consumer towards the product, service, or brand.

3. Hypothesis

Perkins (2007) explained that a data set that captures a characteristic of a unit is termed categorical data. The literature review yielded that each of the stages of the consumer behavior as documented in the AIDA model were tapped into by advertisers as dependent categorical variables that reflected consumer sentiment (Hoek & Gendall, 2003).

Studies have documented dependent variables that reflected the consumer sentiment in the form of awareness and interest in the brand’s products, desire to purchase, desire to share the ad, and urge to review the products. Similarly, independent variables such as “audio-visuals”, “storytelling” and recognizable “public personalities” or celebrities to amplify the advertorial message to the target consumer have been used in advertisements.

These said independent variables are categorical in nature owing to the two possibilities of the said variables (e.g., audio-visuals, storytelling, and athletes) either being used or not. Similarly, the dependent variables identified are categorical in nature owing to the two possibilities of the consumers experiencing either an elevated sense of perception (towards brand

awareness, brand interest, and purchase sentiment) or those perceptions staying unchanged.

Singh, Balasubramanian, and Chakraborty (2000) studied that audio-visual infomercials were effective in eliciting direct-response measures from consumers. Likewise, Appiah (2006) published that visitors were more favorable to a website that contained audio-visual content representations when compared to websites with plain text and pictures. Yousaf, Amin, Jaziri, and Mishra (2021) noted that audio-visual content on social media led to higher engagement amongst consumers. With these studies as the premise, we hypothesized that:

- There is an association between the use of “audio-visual” variables in a digital ad and the ensuing consumer sentiment of “awareness”
- There is an association between the “watching of the ad” and the resulting sentiment of “sharing the ad”.

Shreedhar (2021) studied the association between “storytelling” in social media ads and consumer engagement. He found that with the right character and content, storytelling on social media ads could help raise engagement amongst those watching the ad. Also, Joshi, Domb, Chanda, and Bais (2022) conducted surveys to study the impact that ads with storytelling had on consumer purchase intention. The researchers found that ads which used storytelling in an entertaining manner significantly impacted the purchase intention of the consumer. Correspondingly, Lundqvist, Liljander, Gummerus, and Van Riel (2013) conducted experiments to study the association of storytelling and consumer behavior. Their study revealed that a well-developed story could help in

the development of positive associations with a brand wherein consumers would be willing to purchase it. These studies led us to hypothesize that:

- There is an association between the “storytelling” format of the ad and the creation of an “interest” in the brand
- There is an association between the “watching of the ad” and the creation of a “desire to purchase” the products advertised.

For long, public personalities and celebrities have been used in advertisements in various capacities. Aggarwal-Gupta and Dang (2009) observed via an experiment featuring respondents in India that celebrity experts when featured in advertisements created a favorable attitude in the minds of consumers towards the ad and the product. In another study, Randhawa and Khan (2014) noted that ads and products endorsed by celebrities created awareness, enhanced product information, and drove customers to purchase the product advertised. Similarly, Punjani and Kumar (2021) conducted a study in India to conclude that when celebrities were used in advertisements, both the consumer’s attitude and purchase intent were positive. Comparable results were reported by Mittal (2017), whose study carried out in Indore, India noted that ads featuring celebrities were effective in changing purchase decisions and enhancing brand image. This way, we hypothesized that:

- There is an association between the personalities displayed in an ad and the creation of an “interest” in the brand
- There is an association between the “watching of the ad” and the resulting “urge to look up” (i.e., review) products advertised.

4. Methodology

4.1. Methodology Approach

Ozdemir, Han, and Dalbor (2022) implemented a quantitative approach in a study and found valuable implications in the understanding of customer sentiments. Similarly, Ersoy, Saygılı, Yilmaz, Uslu, and Selvi (2022) adopted a quantitative approach to analyze data collected through an online questionnaire to study the customer sentiment in Turkey during the COVID-19 pandemic. Kanta, Mohan, and Srivalli (2013) employed the survey method and a quantitative approach to study the samples using hypothesis testing to study consumer sentiments towards marketing activities. Thus, a quantitative approach with primary data, gathered via a survey, was used in this study.

4.2. Research Framework

The objectives of the study, its research questions, method, and results are outlined in Table 1.

After mapping the study's objectives, research questions, method, and the results based on the hypothesis, a research

framework was devised comprising of five phases as indicated in Figure 1.

Phase 1 involved literature review which led to identification of gaps in historical research, followed by development of the research questions. In Phase 2, the objective was outlined followed by creation of hypothesis in keeping with the literature review. This led to the narrowing down of the methodology and data gathering via a survey, all of which were part of Phase 3. Thereafter, Phases 4 and 5 were made up of data analysis, documenting the findings and describing the conclusions of the study respectively.

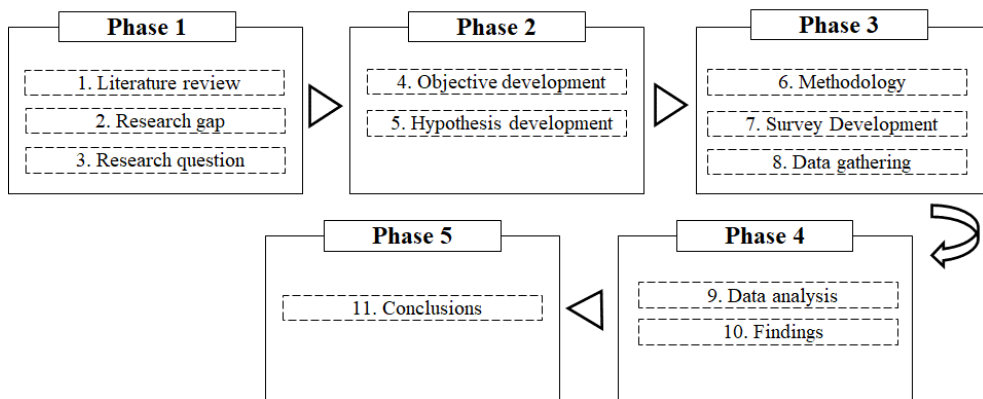
4.3. Survey

As the objective of the study was to observe the relationship between the variables of a digital advertisement and the ensuing consumer sentiment, the construct of the study involved the display of a digital advertisement to a target set of respondents and thereafter, capturing their sentiments upon having watched the advertisement.

In the introductory section, we outlined the growing footwear industry in India. Meanwhile, Nike, is reportedly (Companies

TABLE 1. Research framework.

Objectives of study	Research questions	Method	Possible result
Is there a relationship between select variables of a digital advertisement and the ensuing consumer sentiments of awareness, interest, desire, and action?	• Did the visuals in the ad create an awareness of the brand's products • Did the storytelling format of the ad create an interest in the brand • Did the athlete displayed in the ad create an interest in the brand • Did watching of the ad create a desire to purchase the products • After having watched the ad, did consumer feel like sharing it • After watching the ad, did consumers feel the urge to review the products online	Quantitative study – Survey method	There does exist a relationship between select variables of a digital advertisement and the ensuing consumer sentiments of awareness, interest, desire, and action.

FIGURE 1. Research Framework.

Market Cap, 2022) the footwear brand with the highest global market-cap (USD 189.52 billion). Incidentally, the brand is prevalent in India too, having recorded (Tofler.in, 2022) an operating revenue of over INR 500 crore for the fiscal year ending 31 March 2022. On March 2023, *Nike* released a digital advertorial video featuring the Indian cricketer Smriti Mandhana which has since garnered over 21,000 views (Nike, 2023). In keeping with her popularity, and the strategic use of variables such as “audio-visual”,

and “storytelling” in the ad, it was apt to use this *Nike* digital content for this study by displaying it to test-subjects prior to interviewing them with the questionnaire.

For the study, convenient samples were obtained in June 2023 from Bangalore City, the capital of the Indian state of Karnataka. Reports (Koshi, 2020) indicate that Karnataka is amongst the top-three states in the country which together drive 65% of consumer demand. And with a survey conducted by GrabOn (Daily Pioneer, 2019)

FIGURE 2. Screenshot of the Nike digital ad featuring Smriti Mandhana.

revealing that 33% of online shoppers were in the age group of 26–35, the Bangalore City sample population of 13,608,000 (Macro Trends, 2023) was reduced to the said target age group, from which 117 convenient samples were obtained for the study.

Taherdoost (2019) believed that Likert scale is one of the most widely used scaling methods to collect the required data. Also, Van Laerhoven, van der Zaag-Loonen, and Derkx (2004) observed that a Likert scale be used in surveys owing to the ease of use in responding to questionnaires. Thus, the data collected for this study is in Likert scale of 1 to 5, where 1 refers to “Strongly Disagree”, 2 indicating “Disagree”, 3 referring to “Neither agree nor disagree”, 4 reflecting “Agree”, and 5 citing “Strongly Agree”.

4.4. Research Instruments

Franke, Ho, and Christie (2012) and Ugoni and Walker (1995) argued in favor of using Chi-Square tests to study associations between categorical variables. Likewise, McHugh (2013) credited the Chi-Square tests for its robustness and the ability to derive detailed information. Thus, in keeping with the said precedence, a Chi-Square test for goodness of fit was conducted to analyze the frequencies of the categorical variables.

To proceed further in doing the Chi-Square test for goodness of fit, the frequencies of categories in a particular categorical variable were calculated and termed as observed frequencies. Further, expected frequencies, which is the arithmetic mean of these frequencies, were also calculated. The Chi-Square test statistic is calculated using the following formula:

$\chi^2 = (O_i - E_i)^2 / E_i$; where O_i = observed frequency of i^{th} item and E_i = expected frequency of i^{th} item.

For this study, the said frequencies and calculations were done through SPSS software where it provides the calculated value of Chi-Square, degrees of freedom, and p-value (probability value termed as asymptotic significance value “Asymp. Sig.” in the SPSS software).

The interpretation can be drawn by comparing the calculated value of Chi-Square and tabulated value of Chi-Square at certain degrees of freedom. An interpretation can be drawn using the p-value of the test result generated through SPSS. If the p-value is greater than 0.05, then the hypothesis shall be rejected, otherwise, the hypothesis shall be accepted as the result, at 5% level of significance.

5. Findings

5.1. Demography of Respondents

A review of the samples showed that 44% of the respondents were women while 56% were men. The average age of the convenient sample size used for the study was 23-years of age. Owing to the universal appeal of the brand, all the respondents were aware of Nike. That said, 62% had purchased a Nike product before (38% women and 63% men) and 38% had not done so yet.

5.2. Analysis and Interpretation

The analysis to test the hypothesis via Chi-Square tests revealed observations as indicated below.

- Hypothesis: There is an association between the use of “audio-visual”

TABLE 2. Chi-Square test to study the association between the audio-visuals in the ad and the creation of awareness.

	Observed N	Expected N	Residual
Strongly disagree	3	23.4	-20.4
Disagree	4	23.4	-19.4
Neither disagree nor agree	18	23.4	-5.4
Agree	73	23.4	49.6
Strongly Agree	19	23.4	-4.4
Total	117		

variables in a digital ad and the ensuing consumer sentiment of “awareness”.

TABLE 3. The table depicts the p-value.

	The audio-visuals in the ad created an awareness of the brand's products.
Chi-Square	141.077 ^c
df	4
Asymp. Sig.	.000

The above table shows a Chi-Square value of 141.077^c (df = 4).

With the p-value being <0.05, the test shows that there is an association between the two variables studied. Therefore, we accept the said hypothesis that there is indeed an association between the variable of “audio-visuals” used in the ad and the creation of “awareness” towards the brand’s products in the mind of the respondent.

- Hypothesis: There is an association between the “storytelling” format of the

ad and the creation of an “interest” in the brand.

TABLE 5. The table depicts the p-value.

	The storytelling format of the ad created an interest in the brand.
Chi-Square	103.470 ^c
df	4
Asymp. Sig.	.000

The above table shows a Chi-Square value of 103.470^c.

With the p-value being <0.05, the test shows that there is an association between the two variables studied. Therefore, we accept the said hypothesis that there is indeed an association between the variable of “storytelling” format of the ad and the creation of an “interest” in the brand”.

- Hypothesis: There is an association between the “personality” (i.e., athlete)

TABLE 4. Chi-Square test to study the association between the ad’s storytelling format and the resulting brand interest created.

	Observed N	Expected N	Residual
Strongly disagree	3	23.4	-20.4
Disagree	6	23.4	-17.4
Neither disagree nor agree	17	23.4	-6.4
Agree	64	23.4	40.6
Strongly Agree	27	23.4	3.6
Total	117		

TABLE 6. Chi-Square test to study the association between the athlete displayed in the ad and the resulting creation of brand interest.

	Observed N	Expected N	Residual
Strongly disagree	2	23.4	-21.4
Disagree	7	23.4	-16.4
Neither disagree nor agree	15	23.4	-8.4
Agree	57	23.4	33.6
Strongly Agree	36	23.4	12.6
Total	117		

displayed in the ad and the creation an “interest” in the brand.

TABLE 7. The table depicts the p-value.

	The athletes displayed in the ad created an interest in the brand.
Chi-Square	89.111 ^c
df	4
Asymp. Sig.	.000

The above table shows a Chi-Square value of 89.111^c.

With the p-value being <0.05, the test shows that there is an association between the two variables studied. Therefore, we accept the said hypothesis that there is indeed an association between the variable of the “personality” or celebrity (i.e., athlete) displayed in the ad and the creation of an “interest” in the brand.

- Hypothesis: There is an association between the “watching of the ad” and the creation of a “desire to purchase” the products advertised.

TABLE 9. The table depicts the p-value.

	Watching the ad created a desire to purchase Nike's product.
Chi-Square	71.162 ^c
df	4
Asymp. Sig.	.000

The above table shows a Chi-Square value of 71.162^c.

With the p-value being <0.05, the test shows that there is an association between the two variables studied. Therefore, we accept the said hypothesis that there is indeed an association between the variable of “watching of the ad” and the creation of a “desire to purchase” the products advertised.

TABLE 8. Chi-Square test to study the association between the watching of the ad itself and the resulting creation of purchase-desire.

	Observed N	Expected N	Residual
Strongly disagree	2	23.4	-21.4
Disagree	14	23.4	-9.4
Neither disagree nor agree	35	23.4	11.6
Agree	53	23.4	29.6
Strongly Agree	13	23.4	-10.4
Total	117		

TABLE 10. Chi-Square test to study the association between watching of the ad itself and the resulting sentiment to share the ad.

	Observed N	Expected N	Residual
Strongly disagree	3	23.4	-20.4
Disagree	17	23.4	-6.4
Neither disagree nor agree	36	23.4	12.6
Agree	51	23.4	27.6
Strongly Agree	10	23.4	-13.4
Total	117		

- Hypothesis: There is an association between the “watching of the ad” and the resulting sentiment of “sharing the ad”.

TABLE 11. The table depicts the p-value.

	After having watched the ad, I felt like sharing it.
Chi-Square	66.547 ^c
df	4
Asymp. Sig.	.000

The above table shows a Chi-Square value of 66.547^c.

With the p-value being <0.05, the test shows that there is an association between the two variables studied. Therefore, we accept the said hypothesis that there is indeed an association between the variables

of “watching of the ad” and the resulting sentiment of “sharing the ad”.

- Hypothesis: There is an association between the “watching of the ad” and the resulting urge to “look up” (i.e., review) the products advertised.

TABLE 13. The table depicts the p-value.

	After watching the ad, I felt the urge to look up Nike's products.
Chi-Square	109.282 ^c
df	4
Asymp. Sig.	.000

The above table shows a Chi-Square value of 109.282^c.

With the p-value being <0.05, the test shows that there is an association between

TABLE 12. Chi-Square test to study the association between watching of the ad itself and the resulting urge to review its products.

	Observed N	Expected N	Residual
Strongly disagree	3	23.4	-20.4
Disagree	12	23.4	-11.4
Neither disagree nor agree	22	23.4	-1.4
Agree	67	23.4	43.6
Strongly Agree	13	23.4	-10.4
Total	117		

the two variables studied. Therefore, we accept the said hypothesis that there is indeed an association between the variable of “watching of the ad” and the resulting urge to “look up” (i.e., review) products advertised.

6. Discussions and Conclusion

6.1 Discussions

In keeping with the hypothesis, the respondents were asked in the survey if each of these independent categorical variables (i.e., “audio-visuals”, “storytelling” and the usage of recognizable public “personalities” or an athlete in this case) evoked a sentiment of attention, interest, and desire to learn more about the brand and in parallel, create an interest to purchase the products. About 79% of the respondents agreed (16% strongly agreed) that “audio-visuals” helped create an “awareness” of the brand. Similarly, 78% agreed (23% strongly agreed) that the “storytelling” format helped create an interest in the brand, while 79% (31% strongly agreed) confirmed that “athlete” featured in the ad evoked a sentiment of brand-interest. These observations clearly indicate that the said independent categorical variables are indeed critical to the development of impactful digital advertisements or campaigns.

On the other end of the spectrum, the entertaining nature of the digital advertisement did evoke the desired sentiment on the respondents with 56% of the interviewees expressing a desire (11% strongly agreed) to purchase the products displayed. Meanwhile, 53% agreed (9% strongly agreed) that they felt the need to share the digital advertisement. And finally, 68%

agreed (11% strongly agreed) that they felt the urge to understand more about the products by reviewing them online. Similarly, 75% of the respondents agreed (22% strongly agreed) to have clearly understood the overarching message of the digital ad, which was to celebrate 50-years of the brand. This is a strong testament of the fact that the digital ad – while using the said independent variables – was able to deliver the message in an impactful manner to respondents.

In the analysis and interpretation section, we documented the findings of the Chi-Square test which displayed that owing to the p-value being < 0.05 when each of the hypotheses was tested, we may deduce that there is indeed a relationship between the stimulus of independent variables (i.e., audio-visuals, storytelling, and usage of an athlete) and the dependent variable or resulting consumer sentiment (i.e., brand awareness, desire to purchase the products and share the ad and finally, an urge to review the products more). And these findings are indeed consistent with those observed by Madupu, Sen, and Ranganathan (2013), van Mulken, van Hooft, and Nederstigt (2014), Burgers, Konijn, Steen, and Iepsema (2015), and Phillips et al. (2008), all of whom stated that the said independent variable evoked positive sentiments in consumers.

6.2 Conclusion

The findings of the study show that several variables in a digital advertisement play an integral role in impacting the sentiments of a consumer. Subsequently, the range of sentiments that a consumer goes through when watching a digital advertisement is indeed aligned with the AIDA model and thus, the model continues to be a vital tool

for digital advertisers to devise advertisements and study its impact on consumer sentiment.

The study also throws light on certain critical variables, such as the use of audio-visuals and personalities (or an athlete in this case) to employ storytelling to capture the attention of customers as a starting point. Thereafter, each of the variables work as a cohesive engine, and in unison work, to drive home the brand message with the motive of influencing the consumer towards the goal of purchasing the product. The fact that a total of 75% of the respondents in this study collectively agreed (53% agreed and 22% strongly agreed) that Nike's inspirational message shone through in the advertisement is testimony to the fact that the stated independent variables played an integral role in impacting consumer behavior with their association with the said dependent variables.

Further, with a total of 56% of the respondents (45% agreed and 11 strongly agreed) stating that they have been left with a desire to purchase products from the brand advertised, the study proves that digital advertising – when used with variables such as audio-visuals, storytelling, and recognizable personalities – does carry the potential to positively impact consumer behavior.

Finally, the study enhances findings from several other researchers cited in the literature survey who have identified digital advertising as a potent medium to get branding messages through to their target audiences and in the process, influence them.

6.3 Implications

The findings of this study provide advertisers with a concrete understanding of the impact that the said variables can have on consumer sentiments. They will now be able to develop advertisements with the full knowledge that the said variables evoke positive customer sentiments and heighten the visibility of products advertised. Also, brands in the Indian footwear industry will be encouraged by the findings of the study and will be more willing to use digital advertising as a medium to bolster their return on investment (RoI).

7. Opportunities for Future Research

This study was limited by its sample size, a focused geography and demography, and the use of categorical variables only. That said, this observation opens doors for pan-India studies and several other related studies while using nominal, ordinal, or numeric variables.

Similar studies can also be conducted for other product segments such as apparel or consumer electronics. Additionally, this study can be replicated to assess the impact that advertorial messages might have on consumer sentiment across digital channels such as Facebook, Instagram, and WhatsApp.

Also, future studies can be conducted with focused groups while examining each of the variables individually. Finally, with the advent of Machine Learning and Artificial Intelligence, this study creates opportunities to develop predictive models using the variables identified to influence consumer behavior.

References

- Aggarwal-Gupta, M., & Dang, P. J. (2009). Examining celebrity expertise and advertising effectiveness in India. *South Asian Journal of Management*, 16, 61.
- Apparel Resources (2023). India's apparel retail market amounts to US \$ 96.47 billion in 2023. <https://apparelresources.com/business-news/retail/indias-apparel-retail-market-amounts-us-96-47-billion-2023/>
- Appiah, O. (2006). Rich Media, poor Media: The impact of audio/video vs. text/picture testimonial ads on browsers' evaluations of commercial web sites and online products. *Journal of Current Issues & Research in Advertising*, 28, 73–86. doi:10.1080/10641734.2006.10505192
- Borth, D., Chen, T., Ji, R., & Chang, S.-F. (2013). SentiBank: Large-scale ontology and classifiers for detecting sentiment and emotions in visual content. In Proc. 21st ACM Int. Conf. Multimedia (MM) (pp. 459–460). doi:10.1145/2502081.2502268
- Burgers, C., Konijn, E., Steen, G., & Iepma M. (2015). Making ads less complex, yet more creative and persuasive: The effects of conventional metaphors and irony in print advertising. *International Journal of Advertising*, 34, 515–532. doi:10.1080/02650487.2014.996200
- Calmache, M. R., & Peyró, C. F. (2010). Advertising in the digital age: The microsite as a strategic factor in on-line advertising campaigns. *Comunicar. Media Education Research Journal*, 18. doi:10.3916/c34-2010-03-12
- Chen, C. P., & Zhang, C. Y. (2014). Data-intensive applications, challenges, techniques and technologies: A survey on Big Data. *Information sciences*, 275, 314–347. doi:10.1016/j.ins.2014.01.015
- Companies Market Cap (2022). Largest footwear companies by market cap. (Accessed April 2023) <https://companiesmarketcap.com/footwear/largest-companies-by-market-cap/>
- Donthi, V. (2019). AIDA model: An invisible promotional tool – Maruti Suzuki India Limited perspective. *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, 8, ISSN: 2278-3075. doi:10.2139/ssrn.4261303
- Ersoy, A. Y., Saygılı, M., Yilmaz, M. İ., Uslu, M. E., & Selvi, İ. H. (2022). Consumer sentiment in Turkey, from closure to the new normal. *Sustainability*, 14, 9135. doi:10.3390/su14159135
- Expert Market Research (2022). Global Digital Marketing Market Report and Forecast 2023–2028. Retrieved from: <https://www.expertmarketresearch.com/pressrelease/digital-marketing-market>
- Franke, T. M., Ho, T., & Christie, C. A. (2012). The chi-square test: Often used and more often misinterpreted. *American journal of evaluation*, 33, 448–458. doi:10.1177/1098214011426594
- Hassan, S., Nadzim, S. Z. A., & Shiratuddin, N. (2015). Strategic use of social media for small business based on the AIDA model. *Procedia-Social and Behavioral Sciences*, 172, 262–269. doi:10.1016/j.sbspro.2015.01.363
- Hoek, J., & Gendall, P. (2003). How does sponsorship work. In *the proceeding of the ANZMAC 2003*, 1-3 December, 2003, Adelaide (pp. 9–16).
- Hollebeek, L. D., & Macky, K. (2019). Digital content marketing's role in fostering consumer engagement, trust, and value: framework, fundamental propositions, and implications. *Journal of Interactive Marketing*, 45, 27–41. doi:10.1016/j.intmar.2018.07.003
- India Brand Equity Foundation (2022). E-commerce Industry in India. <https://www.ibef.org/industry/ecommerce#:~:text=%20In%202022%2C%20the%20Indian%20ecommerce,US%24%20350%20billion%20by%202030>
- Jadhav, S., Vyas, D., & Manekar, S. (2018). Digital marketing consequences on urban consumer behavior in Nagpur City,” *Clear International Journal of Research in Commerce & Management*, 9.

- Kim, H., Hur, W.-M., & Yeo, J. (2015). Corporate brand trust as a mediator in the relationship between consumer perception of CSR corporate hypocrisy and corporate reputation. *Sustainability*, 7, 3683–3694. doi:10.3390/su7043683
- Jansen, B. J., & Schuster, S. (2011). Bidding on the buying funnel for sponsored search and keyword advertising. *Journal of Electronic Commerce Research*, 12.
https://www.researchgate.net/publication/228796540_Bidding_on_the_buying_funnel_for_sponsored_search_and_keyword_advertising
- Joshi, S., Domb, M., Chanda, B., & Bais, A. (2022). Evaluating the impact of storytelling ads on consumer purchase intention. *Journal of Service Science and Management*, 15, 10–22. doi:10.4236/jssm.2022.151002
- Kadirov, D. (2015). Private labels ain't Bbona Fide! Perceived authenticity and willingness to pay a price premium for national brands over private labels. *Journal of Marketing Management*, 31, 1773–1798. doi:10.1080/0267257X.2015.1031265
- Kanta, K. N. M., Mohan, G. K., & Srivalli, P. (2013). A study on Consumer Sentiment towards marketing activities. *International Journal on Global Business Management & Research*, 2, 27.
- Kemp, S. (2022), "Digital 2022: India," *Data Reportal*, <https://datareportal.com/reports/digital-2022-india>
- Kojima, T., Kimura, T., Yamaji, M., & Amasaka, K., (2010). Proposals and development of the direct mail method "PMCI-DM" for effectively attracting customers. *International Journal of Management & Information Systems*, 14, 15–21. doi:10.19030/ijmis.v14i5.9
- Koshi, L. (2020). Tier 2 cities, smaller towns now contribute 66% of e-commerce demand in India: Report. *The News Minute*, <https://www.thenewsminute.com/article/tier-2-cities-smaller-towns-now-contribute-66-e-commerce-demand-india-report-131315>
- Kulkarni, M., Attal, G., & Vasundekar, V. (2020). Evaluating effectiveness of AMFI campaigns: a study based on AIDA model. In *Computing in Engineering and Technology: Proceedings of ICCET 2019* (pp. 747-761). Springer Singapore. doi:10.1007/978-981-32-9515-5_70
- Lundqvist, A., Liljander, V., Gummerus, J., & Van Riel, A. (2013). The impact of storytelling on the consumer brand experience: The case of a firm-originated story. *Journal of Brand Management*, 20, 283–297. doi:10.1057/bm.2012.15
- Luo, X., Tabassum, N., and Nayak, B. S. (2022). The AIDA model and the impact of TikTok video streaming on online shopping: A case study of TikTok. In *Modern Corporations and Strategies at Work* (pp. 73-91). Springer, Singapore. doi:10.1007/978-981-19-4648-6_4
- Macro Trends (2022). Bangalore, India Metro Area Population 1950–2023. Retrieved from: <https://www.macrotrends.net/cities/21176/bangalore/population#:~:text=The%20metro%20area%20population%20of,a%203.74%25%20increase%20from%202019.>
- Madupu, V., Sen, S., & Ranganathan, S. (2013). The impact of visual structure complexity on ad liking, elaboration, and comprehension. *Marketing Management Journal*, 23, 58–70.
- McHugh, M. L. (2013). The chi-square test of independence. *Biochemia Medica*, 23, 143–149. doi:10.11613/BM.2013.018
- Michaelson, D., & Stacks, D. W. (2011). Standardization in public relations measurement and evaluation. *Public Relations Journal*, 5, 1–22. <https://prjournal.instituteforpr.org/wp-content/uploads/Standardization.pdf>
- Mittal, M. (2017). Impact of celebrity endorsements on advertisement effectiveness & purchase decision among youths. *International Journal of Marketing and Business Communication*, 6, 17–27.
- McQuarrie, E. F., & Phillips, B. J. (2008). It's not your magazine ad: Magnitude and direction of recent changes in advertising style. *Journal*

- of Advertising, 37, 95–106. doi:10.2753/JOA0091-3367370307
- Nike (2023). Smriti Mandhana | What Are You Working On? (E34) | Nike. YouTube. <https://youtu.be/1v-hmVWpmLU?si=T8SbtEdcfL67BffB>
- Ozdemir, O., Han, W., & Dalbor, M. (2022). Economic policy uncertainty and hotel occupancy: the mediating effect of consumer sentiment. *Journal of Hospitality and Tourism Insights*, 5, 253–273. doi:10.1108/JHTI-08-2020-0149
- Pedro, J. S., Yeh, T., & Oliver, N. (2012). Leveraging user comments for aesthetic aware image search reranking. In Proc. 21st Annu. Conf. World Wide Web (WWW) (pp. 439–448). doi:10.1145/2187836.2187896
- Peláez, J. I., Martínez, E. A., & Vargas, L. G. (2019). Products and services valuation through unsolicited information from social media. *Soft Computing*, 24, 1775–1788. doi:10.1007/s00500-019-04005-3
- Perkins, S. M. (2007). Statistical inference on categorical variables. *Topics in Biostatistics*, 73–88. doi:10.1007/978-1-59745-530-5_5
- Prathapan, M., Sahadevan, S., & Zakkariya, K. A. (2018). Effectiveness of digital marketing: Tourism websites comparative analytics based on AIDA model. *International Journal of Innovative Research & Studies*, 8, 262–273.
- Punjani, K. K., & Kumar, V. R. (2021). Impact of advertising puffery and celebrity trustworthiness on attitude and purchase intent: A study on Indian youth. *Journal of Advances in Management Research*, 18, 738–757. doi:10.1108/JAMR-06-2020-0133
- Randhawa, A., & Khan, J. A. (2014). Impact of celebrity endorsement on consumer buying behaviour. *International Journal of Business Management*, 1, 170–188.
- Rawal, P. (2013). AIDA Marketing communication model: Stimulating a purchase decision in the minds of the consumers through a linear progression of steps. *IRC's International Journal of Multidisciplinary Research in Social & Management*, 1, 37–44.
- Rawell, R. (2022). Top footwear stocks in India 2023 – Sector market size, share market, present status. *Future Prospects. Fisdcom*, <https://www.fisdcom.com/top->
- Reddy, G. (2017). Digital marketing impact on the consumer decision making process in Nike's customer retail operations in South Africa. *Doctoral dissertation, University of Pretoria*. <http://hdl.handle.net/2263/59756>
- Rowley, J. (2002). Information Marketing in a digital world. *Library Hi Tech*, 20, 52–58. doi:10.1108/07378830210444540
- Saura, J. R., Palos-Sanchez, P., & Rodríguez Herráez, B. Digital marketing for sustainable growth: Business models and online campaigns using sustainable strategies. *Sustainability*, 12, 1003. doi:10.3390/su12031003
- Singh, M., Balasubramanian, S. K., & Chakraborty, G. (2000). A comparative analysis of three communication formats: Advertising, infomercial, and direct experience. *Journal of Advertising*, 29, 59–75. 10.1080/00913367.2000.10673624
- Shreedhar, G. (2021). Evaluating the impact of storytelling in Facebook advertisements on wildlife conservation engagement: Lessons and challenges. *Conservation Science and Practice*, 3, e534. doi:10.1111/csp2.534
- Taherdoost, H. (2019). What is the best response scale for survey and questionnaire design; review of different lengths of rating scale/attitude scale/Likert scale. *Hamed Taherdoost*, 1–10. <https://ssrn.com/abstract=3588604>
- The Daily Pioneer (2019). Survey on online shopping sales, reveals 52.1% of the shopper demographic are men. Retrieved from: <https://www.dailypioneer.com/2019/impact/survey-on-online-shopping-sales--reveals-52-1--of-the-shopper-demographic-are-men-.html>
- Tofler (2022). Nike India Private Limited. Retrieved from: <https://www.tofler.in/nike-india-private-limited/company/U36939KA2004PTC034515#:~:text=The%20operating%20revenue%20of%20NIKE%20>

- INDIA%20PRIVATE%20LIMITED%20 is%20in,ending%20on%2031%20 March%2C%202022.
- Ugoni, A., & Walker, B. F. (1995). The Chi square test: an introduction. *COMSIG review*, 4, 61. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2050386/>
- Ullal, M.S., & Hawaldar, I. (2018). Influence of Advertisement on Customers Based on AIDA Model. *Problems and Perspectives in Management*, 16, 285–298. doi:10.21511/ppm.16(4).2018.24.
- Van Laerhoven, H., van der Zaag-Loonen, H. J., & Derkx, B. H. (2004). A comparison of Likert scale and visual analogue scales as response options in children's questionnaires. *Acta paediatrica*, 93, 830–835. doi:10.1111/j.1651-2227.2004.tb03026.x
- van Mulken, M., van Hooft, A., & Nederstigt, U. (2014). Finding the Tipping Point: Visual Metaphor and Conceptual Complexity in Advertising. *Journal of Advertising*, 43, 333–343. doi: 10.1080/00913367.2014.920283
- W. Wereda, & J. Woźniak (2019). Building relationships with customer 4.0 in the era of marketing 4.0: The case study of innovative enterprises in Poland. *Social Sciences*, 8, 177. doi:10.3390/socsci8060177
- Yang, Y., Yang, Y. C., Jansen, B. J., & Lalmas, M. (2017). Computational advertising: A paradigm shift for advertising and marketing? *IEEE Intelligent Systems*, 32, 3–6. doi:10.1109/MIS.2017.58
- Yousaf, A., Amin, I., Jaziri, D., & Mishra, A. (2021). Effect of message orientation/ vividness on consumer engagement for travel brands on social networking sites. *Journal of Product & Brand Management*, 30, 44–57. doi:10.1108/JPBM-08-2019-2546
- Y. Yuan, F. Wang, J. Li, & R. Qin (2014). A survey on real time bidding advertising. In *Proc. IEEE Int. Conf. Service Oper. Logistics Inform. (SOLI)* (pp. 418–423). doi:10.1109/SOLI.2014.6960761

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/383659033>

Sustainable Innovations in Textile and Fashion

Article in Asian Textile Journal · February 2024

CITATIONS
0

READS
7

1 author:



[Purnendu Maji](#)
Dayananda Sagar Institutions

1 PUBLICATION 0 CITATIONS

SEE PROFILE

managing the breaking points placed on the industry's naturally limited asset base, the recent contamination, the resulting negative social effects, and the absence of reasonable product development. The role of scientific research is to point out possible solutions for technological advancement and assess whether or not those developments actually improve things.

Living exercises have been documented as early as 5000 BC. The textile industry has been crafting clothing made from natural fibers to protect wearers from cold or direct sunlight for thousands of years. The textile industry consumes more oil than all of France and produces more plastic waste than Germany's urban waste. This can be attributed to the massive transformations of the last 150 years.

The impact of the textile industry has expanded beyond our closets thanks to modern application, engineered filament innovations, and fast fashion. An impact that has even spread to include contemporary uses such as automobiles, machinery, aircraft, and building supplies. The journey begins in rural areas and oil fields and continues through processing, weaving, dying, finishing, and distribution. Accordingly, people frequently fail to recognize the complexity of the value chain underlying a coat, a bathing suit, or a parachute, to mention a few contemporary textile products. We occasionally think about the manufacturing process when we buy a pair of trousers, but we definitely don't think about the environmental impact when we throw them in the trash.

Lifecycle perspective

The life cycle perspective is a method of handling product and process administration that entails intervening in the plan procedure to avoid a portion of the detrimental environmental outcomes. It combines a variety of methods, such as formalized quantitative control, life cycle assessment (LCA), and generally subjective life cycle thinking. From its



Sustainable innovations in textile and fashion

Purnendu Maji

Dayananda Nagar University, Bengaluru 560001
purnendu.maji@dnun.edu.in

original focus on protecting vitality, life cycle assessment (LCA) has evolved into a strategy that theoretically considers the ecological, social, and financial aspects of sustainability; the latter is known as life cycle costing. The carbon footprint, which is used to globalize, place exchanges and product labels, is

mentioned here, but two important approaches used by the fashion industry and other assembly businesses are Cradle to Cradle and The Natural Step (Holmström, 2003). Many approaches rely on considerations like new recyclability and agendas regarding portions of the provenance of crude materials, but they

In-depth discussion of the numerous innovativeness and parameter matrices pertinent to sustainability in the context of contemporary fashion and textile manufacturing are highlighted.

the most notable LCA indicator. Another is the water footprint, which is particularly relevant for the fashion industry that uses cotton as a raw material (Dominguez et al., 2011).

There are two major elements in the larger chain of life cycle thinking (see

also not involve the use of a particularly quantitative approach strategy to item configuration. The LCA assesses the environmental impact but makes them quicker and less expensive to apply. Rather than focusing solely on the operational management of fields and

Managing the breaking points placed on the industry's naturally limited asset base, the need to prevent contamination, the reduction of negative social effects, and the maintenance of reasonable product prices are important tasks for technological development. The role of scientific advancements is to point out possible directions for technological advancement and assess whether or not those developments actually improve things.

Weaving exercises have been documented as early as 5000 BC. The textile industry has been crafting clothing made of natural fibers to protect wearers from the cold or direct sunlight for thousands of years. The textile industry consumes more oil than all of France and produces more plastic waste than Germany's urban waste. This can be attributed to the massive transformations of the last 150 years.

The impact of the textile industry has expanded beyond our closets thanks to modern upheaval, engineered filament innovation, and fast fashion. An impact that has even spread to include contemporary uses such as automobiles, machinery, aircraft, and building supplies. The journey begins in rural areas and oil fields and continues through processing, weaving, dying, finishing, and distribution. Accordingly, people frequently fail to recognise the complexity of the value chain underlying a coat, a bathing suit, or a parachute, to mention a few contemporary textile products. We occasionally think about the manufacturing process when we buy a pair of trousers, but we definitely don't think about the environmental impact when we throw them in the trash.

Lifecycle perspective

The life cycle perspective is a method of handling product and procedure administration that entails intervening in the plan procedure to avoid a portion of the deal for contaminating ventures. It combines a variety of methods, such as formalised, quantitative controls like life cycle assessment (LCA) and generally subjective life cycle thinking. From its



Sustainable innovation in textile and fashion

Purnendu Maji

Dayananda Sagar University, B
purnendu.maji@dsu.edu

original focus on protecting vitality, life cycle assessment (LCA) has evolved into a strategy that theoretically considers the ecological, social, and financial aspects of supportability; the latter is known as life cycle costing. The carbon footprint, which is used in global atmosphere exchanges and product labels, is

mentioned in the ISO 14040 and ISO 14044 standards. Cradle to Cradle (C2C) (McDowell & Roberts, 2012) is an approach that focuses on considerations like energy efficiency and agendas regarding pollution of the provenance of crude materials, but they

In-depth discussion of the numerous innovativeness and parameter matrices pertinent to sustainability in the content of contemporary fashion and textile manufacturing are highlighted.

the most notable LCA indicator. Another is the water footprint, which is particularly relevant to the fashion industry that uses cotton as a raw material (Sandin et al., 2013).

There are too many elements in the larger church of lifecycle thinking to

do not mandate the use of a particular quantitative appraisal strategy in item configuration. This reduces their exactness or accuracy but makes them quicker and less expensive to apply. Rather than focusing solely on the operational management of fields and

Managing the breaking points placed on the industry's naturally limited asset base, the need to prevent contamination, the reduction of negative social effects, and the maintenance of reasonable product prices are important tasks for technological development. The role of scientific advancements is to point out possible directions for technological advancement and assess whether or not those developments actually improve things.

Weaving exercises have been documented as early as 5000 BC. The textile industry has been crafting clothing made of natural fibers to protect wearers from the cold or direct sunlight for thousands of years. The textile industry consumes more oil than all of France and produces more plastic waste than Germany's urban waste. This can be attributed to the massive transformations of the last 150 years.

The impact of the textile industry has expanded beyond our closets thanks to modern upheaval, engineered filament innovation, and fast fashion. An impact that has even spread to include contemporary uses such as automobiles, machinery, aircraft, and building supplies. The journey begins in rural areas and oil fields and continues through processing, weaving, dying, finishing, and distribution. Accordingly, people frequently fail to recognise the complete value chain underlying a coat, a bathing suit, or a parachute, to mention a few contemporary textile products. We occasionally think of the manufacturing process when we buy trousers, but we definitely do not think about the environmental impact of throwing them in the trash.

Lifecycle perspective

The life cycle of handling, administration, the plan process, and the

the plan process, and the



Sustainable innovations in textile and fashion

Purnendu Maji

Dayananda Sagar University, Bengaluru 560068
purnendu.maji@dsu.edu.in

original focus on protecting vitality, life cycle assessment (LCA) has evolved into a strategy that theoretically considers the ecological, social, and financial aspects of sustainability; the latter is referred to as the carbon footprint. The carbon footprint, or total atmospheric emissions labels, is

mentioned here, but two important approaches used by the fashion industry and other assembly businesses are Cradle to Cradle and The Natural Step (Robert, 2002). Many approaches rely on considerations like item recyclability and agendas regarding portions of the provenance of crude materials, but they

Discussion of the numerous innovativeness of the various matrices pertinent to sustainability in the context of contemporary fashion and textile manufacturing are highlighted.

One of the most notable LCA indicator, however, is the water footprint, which is particularly relevant to the fashion industry that uses cotton as a raw material (Sandin et al., 2013).

There are too many elements in the larger church of lifecycle that

do not mandate the use of a particular quantitative appraisal strategy in item identification. This reduces their exactness accuracy but makes them flexible and less expensive to apply. The approach focusing solely on the management of fields and

Managing the breaking points placed on the industry's naturally limited asset base, the need to prevent contamination, the reduction of negative social effects, and the maintenance of reasonable product prices are important tasks for technological development. The role of scientific advancements is to point out possible directions for technological advancement.

Whether or not those

improve things.

Weaving and dyeing have been documented as early as 3000 BC. The textile industry has been creating clothing made of natural fibers to protect wearers from the heat or direct sunlight for thousands of years. The textile industry of France is more than 100 years old. It is one of the most important industries in the world.

The textile industry has a long history. It is one of the most important industries in the world. It has a long history of innovation and creativity. An impact that has even seen the textile industry evolve into modern textiles, machinery, aircraft, and other supplies. The journey from raw materials and oil fields and continues through processing, weaving, dyeing, finishing, and distribution. Accordingly, people frequently fail to recognise the complexity of the value chain underlying a coat, a bathing suit, or a parachute, to mention a few contemporary textile products. We occasionally think about the manufacturing process when we buy a pair of trousers, but we definitely don't think about the environmental impact when we throw them in the trash.

Lifecycle perspective

The life cycle perspective is a method of handling product and procedure administration that entails intervening in the plan procedure to avoid a portion of the deal for contaminating ventures. It combines a variety of methods, such as formalised, quantitative controls like life cycle assessment (LCA) and generally subjective life cycle thinking. From its



Sustainable innovations in textile and fashion

Purnendu Maji

Dayasanda Sagar University, Bengaluru 560068

purnendu.maji@dsu.edu.in

original focus on protecting vitality, life cycle assessment (LCA) has evolved into a strategy that theoretically considers the ecological, social, and financial aspects of supportability; the latter is known as life cycle costing. The carbon footprint, which is used in global atmosphere exchanges and product labels, is

mentioned here, but two important approaches used by the fashion industry and other assembly businesses are Cradle to Cradle and The Natural Step (Robert, 2002). Many approaches rely on considerations like item recyclability and agendas regarding portions of the provenance of crude materials, but they

In-depth discussion of the numerous innovativeness and parameter matrices pertinent to sustainability in the content of contemporary fashion and textile manufacturing are highlighted.

the most notable LCA indicator. Another is the water footprint, which is particularly relevant to the fashion industry that uses cotton as a raw material (Sandin et al., 2013).

There are too many elements in the larger church of lifecycle thinking to

do not mandate the use of a particular quantitative appraisal strategy in item configuration. This reduces their exactness or accuracy but makes them quicker and less expensive to apply. Rather than focusing solely on the operational management of fields and



Employee Excitement if not spell bound a boon to Employer

Dr. Pallavi¹, Dr. Sai Ganesh² & Dr. Ghousia Khatoun³

¹ Professor & Head of Department, HKBK degree, Bangalore

² Associate Dean, Dayananda School of Business Studies, Bangalore

³ Professor, Tishk International University, Kurdistan Region-Iraq, Erbil

ARTICLE INFO

Article History:

Received:	July	1, 2023
Revised:	August	20, 2023
Accepted:	September	5, 2023
Available Online:	October	10, 2023

Keywords:

Employee Excitement, Work Environment, Work place fun, Employee retention

ABSTRACT

Purpose: The main purpose of this research is to analyze the perception of employees on workplace environment, to identify the factors influencing excitement, to determine how work place fun and excitement plays an important role in attracting, retaining and developing competent employees and to find the relationship between workplace environment and employee excitement.

Theoretical Framework: Transition demands for quality and quality is reliant on employee, employee's work quality improves only when the employees are satisfied, the satisfaction fabricates excitement. Exodus of talent and plummeting is possible through intrinsic motivation. What makes employees excited is one of the famished areas to be balkanized. So, employee excitement is to be erudite. Existing scenario display that limiting situations for employee excitement prevail when vision is not discussed with employees, Lack of clarity in career development, unripe discussions of values, ethics and penchant engagement reviews. Incisive study spouts that excited employee's display emotional bonding, cohesiveness and belongingness. Excited employees need not be retained as it is innate. Commitment and self-actualization are sheer.

Design/Methodology/Approach: In this study, we use a deductive approach, in which the hypotheses are tested by collecting information from IT employees located at Bengaluru city to assess the employee excitement in 2023. Quantitative data is collected through self-designed questionnaire administered to IT sector employees. Questionnaire was prepared by researchers using the factors from literature review. Snow ball sampling method was adopted for selection of respondents with the criteria of minimum two years of experience in the same company.

Findings: Overall results shows that employee satisfaction, production, engagement, commitment, influence are some of the components identified as affecting the quality of work life resulting to disrupted work life balance. Resources provided have seldom effect on the success of any organization. Not to be the square peg in the round hole is the wave of revolution. Healthy work environment and employee excitement are the two highest accolade for quality production. Walk the talk, setting of realistic objectives; ensure that every employee is on board. Banners, buttons, and other promotional materials are to be circulated to ensure that the change is on every employee's mind.

Research, Practical and Social Implications: This study not only helps

to fill the gap in the literature review on this topic, but also serves as an important factor reflecting the quality of work life.

Originality/Value: This study focuses on exhibiting the importance of excitement at work, which not only helps in having a healthy work environment and also works a stress buster at work place.



© 2023 The Authors, Published by AIRSD. This is an Open Access Article under the Creative Commons Attribution Non-Commercial 4.0

Corresponding Author's Email: ghousia.khatoun@tiu.edu.iq

INTRODUCTION

Often, employers' function beyond boundaries to retain the pockets of excellence within the organization. In the recent years, the industry has lavished focused efforts on enriching the employee segment. Significant contributions to enduring perspective called employee retention demonstrated the importance of employee retention. For Marx, in his study state that laudable human history portray that every individual is creative and real in nature. "Creative people enter into definite necessary relations which are independent off their will" (p. 217). Constant innovations need to be nurtured for an organization to achieve success. Broadening the pool of quality employees, exodus of talent and plummeting is possible through intrinsic motivation. Find ways to leverage the enthusiasm and excitement that new hires bring to the workforce. Employer needs to be meticulous, oblivious may lead to forsake the star performers. (Gurumani, 2010). Beck and Wade (2004) contend that instant reward transfers would elate the employees to outshine in their work, ALDamoe *et al.* (2012). James and Mathew (2012) state that it is the work environment that encourages audacity and performance of employees to move in the right direction and remain for laudable duration. Cascio (2003; cited in Mahal, 2012, p. 38), has opined that the initiatives taken by management such as rewarding employees for performing their jobs effectively, ensuring harmonious working relations between employees and managers, and maintaining a safe, healthy work environment (Clifton and Harter, 2003) will help the employees gain more when they build on talents, if a workplace culture does not reflect a positive, holistic, transparent, and supportive environment where employees can focus on their strengths, then employees may prefer leaving the organization. As said by Eskildsen and Dahlgaard, 2000, it is crucial to know what factors influence employee satisfaction. Employer has to come out of the cursory thought of employee retention - as the environment is rapidly transforming from employee satisfaction to employee excitement. Studies on employee excitement are at the nascent stage. What makes employees excited is one of the famished areas to be epitomized. Refurbishment on the areas like work environment, work culture, work engagement, employee engagement, organizational commitment, job satisfaction, corporate social responsibility, superior relationship and leadership qualities are inclined to silence.

Need and Significance of the study

Transition demands for quality and quality is reliant on employee, employee's work quality

improves only when the employees are satisfied, the satisfaction fabricates excitement. Exodus of talent and plummeting is possible through intrinsic motivation. What makes employees excited is one of the famished areas to be balkanized. So, employee excitement is to be erudite. Existing scenario display that limiting situations for employee excitement prevail when vision is not discussed with employees, Lack of clarity in career development, unripe discussions of values, ethics and penchant engagement reviews. Incisive study spouts that excited employee's display emotional bonding, cohesiveness and belongingness. Excited employees need not be retained as it is innate. Commitment and self-actualization are sheer.

Objectives of the Study

The study has considered the following as the objectives

1. To analyze the perception of employees on workplace environment.
2. To study the factors influencing excitement.
3. To determine how work place fun and excitement plays an important role in attracting, retaining and developing competent employees
4. To find the relationship between workplace environment and employee excitement.

LITERATURE REVIEW

Employee stretch in the organization depends on one of the factors being work environment (Zeytinoglu& Denton, 2005). McKeown's in his book named 'Retaining Top Employees', defined employee retention as: "A systematic effort by employers to create and foster an environment that encourages current employees to remain employed by having policies and practices in place that address their diverse needs." 2011. To add on, Winterton in the year 2011, state that along with the healthy environment provide alternate job opportunities as well. The Hay Group study on work environment states that job autonomy (freedom towards the job in all aspects like decision making, process of functioning, timings) will help in retaining the employees (Perez, 2008). Dawal &Taha (2006) showed that job and environmental factors were significantly related to job satisfaction. Not only the environmental factors are to be affecting the productivity, there are various other suggestive new competencies which Strewn the excitement of employees. Chang, et. Al. in the year 2019 stated that it is very much essential to provide enough tools and supplies to establish a secure and encouraging work environment in order to strengthen interpersonal connections at work and increase nurse retention. Atkins says. "To be the best company in the world, we must support programs that go beyond the facility fence". Friedman opined that every employer needs to shift their focus to retention and development as the organization require the talented work force for good program designs. Miller commented on the survey conducted by On Point Consulting, New York, New York, in the year 2007, based on 655 respondent's show that the real source for getting employee support is to clarify the purpose of the change and discussion by managers about the reasons for change. Breough & Frye, 2007 have concentrated on understanding how employees with dual working couples can be benefited, having elderly parents and single parent at home is an responsibility to employees, family support supervisor (i.e., telecommuting, ability to take work home, flextime, and family leave) responsibility of employees towards home (caring for a sick child, taking an elderly parent to the doctor, spending time with a spouse, participating in a school carpool), help in reducing family work conflict and increase job satisfaction. In addition to the existing literature, good guy

awards, (administrative professional today). social work event (3 pieces of PIE, Physical, Intellectual and Emotional), new product launch (everything everywhere preps biggest employee engagement push), happy associates are at the core of customers relations, it is believed that they can make customers happy only when their associates are happy (Soderquist) adds to the excitement. In contrast to the existing notion that heavy pay package keeps employees happy is an old thought as the author narrates that the possible consequences of financial rewards or bonuses does not help in maintaining excitement, and engagement is not guaranteed by bonuses if the employees are dealing with pessimistic bosses or workforce (bonus back fire, De Haas).

In addition, literature review shows that organizations that are transparent and involve their high performing employees in finding solutions will be able to retain these individuals during downturns in the economy (Ongori, 2008). Workspace designs have a profound impact on workers and tend to live with job as long as satisfied (Brill, Weidemann, Olsen, Keable & BOSTI, 2001). One of the attributes under environment is Knowledge having stayed in the company for a considerable period of time the employee becomes a repository of knowledge, need to take care of such employees (Kujur, 2008). Mandhanya, Y in the study stated that flexible timings and work arrangements help employees manage both work and personal life (Perry-smith and Blum 2000: Solomon 1999).Rice, 2010 states that leaders need to transit from clarity to inspiration by communicating the future vision to employees, talk about their careers, speak authentically where employees can get the real sense, discuss values and review on engagement and not performance would rather help the organization. In a study, authors concentrate on Gen Y employees as they posses' an ultimate challenge for the corporations with regard to their retention. They tend to challenge new opportunities and management decisions; strive for more work life balance, and involve in decision making. Gen Y employees are to be retained by providing career development, mentoring, job satisfaction and inclusive style of management (Inclusive style of management is a style of management which is wholesome and encompassing all the benefits that the employees need for) (Aruna & Anitha, 2015).

RESEARCH METHODOLOGY

Materials

This study aimed at collecting information from IT employees located at Bengaluru city to assess the employee excitement. Quantitative data is collected through self-designed questionnaire administered to IT sector employees. Questionnaire was prepared by researchers using the factors from literature review. Snow ball sampling method was adopted for selection of respondents with the criteria of minimum two years of experience in the same company. 150 questionnaires were distributed and 100 questionnaires were useful resulting to 66.66%.

Variables of the study

1. Independent Variables: Employee Excitement
2. Dependent Variable: Work place environment
3. Demographic variables like name of organization, department working for, designation, gender, age, marital status, qualification, total number of years of experience and number of years of experience in the present company were incorporated in the questionnaire.

Hypothesis

H0: There is no significant relationship between Work Environment and Employee Excitement

H1: There is significant relationship between Work Environment and Employee Excitement

Method

SPSS (Statistical Package for Social Sciences) was used for the analysis of data. Objectives of the study were given prominence while analyzing the data. Normality test, Factor analysis, t test and regression were used in the analysis.

RESULTS

I. Demographic Profile

Table 1: Demographic Profile of the Respondents

Demographic	Categories	Percentage
Gender	Male	43
	Female	57
Age	25yrs-35yrs	51
	36yrs-45yrs	29
	46yrs-55yrs	13
	56yrs and above	7
Marriage Status	Married	63
	Unmarried	37
Qualification	Graduate	63
	Post Graduate	31
	Others	6
Annual Income	1-5 lakhs	42
	6-10 lakhs	45
	11-20 lakhs	10
	above 20 lakhs	3
Designation	Junior Engineer	52
	Senior Engineer	37
	Project Manager	8
	Senior Divisional Manager	3

II. Test of Normality

The test statistic (D) provides a measurement of the divergence of sample distribution from the normal distribution, the higher the value of D, the less probable it is then data is normally distributed. The p-value quantifies this probability, with a low probability indicating that your sample diverges from a normal distribution to an extent unlikely to arise merely by chance. Put simply, high D, low p, is evidence that your data is not normally distributed.

Table 2: Kolmogorov-Smirnov Test of Normality – Employee Excitement

Variable	Mean	Median	SD	Skewness	Kurtosis	P value
Employee Excitement	0.68732	0.6975	0.123937	-0.725473	1.506337	.98399

The value of the K-S test statistic (D) is .0918, the p-value is .98399, showing that data is normally distributed.

Table 3: Kolmogorov-Smirnov Test of Normality – Work Environment

Variable	Mean	Median	SD	Skewness	Kurtosis	P value
Work Environment	0.70469	0.717	0.067104	0.067104	0.411696	.79448

The value of the K-S test statistic (D) is .15313, the The p-value is .79448, showing that data is normally distributed.

III Factors influencing Employee Excitement at work station

KMO (Kaiser – Meyer – Olkin) of sampling adequacy is 0.611 (table 5), the KMO ranges between 0&1 with higher values indicating greater suitability and and Bartlett’s test of sphericity is significant [Chi-square χ^2 (231) = 1009, $p < 0.001$], this shows that the sample size is adequate (greater than 0.5) to draw conclusions. Factor analysis is performed to extract the major factors influencing employee excitement, in table 6 about total variance shows that factors extracted with Eigen values more than one are seven factors influencing employee excitement and it has explanatory power of 68.72%, these factors influence employee excitement to a great extent. These factors are identified from rotated component matrix and presented in Table 7. The variables with loading 0.9 are more were selected. So the first factor is loaded with **Job involvement**, 68.72% of employees agrees that the work place is favorable for working. Second factor being **flexible timings**, 62.97% of the employees enjoy the flexible timings provided by the organization. Third factor being **knowledge repository** constitute to 55.58%. 47.22 % of employee opine that they like **work space design** of their respective department, 36.92% of employees believe that their organization **maintains transparency**, 26.19% of the employees agree that their organization sets **realistic objectives** and 13.34% of employees agree that they have **freedom towards decision making**, process of functioning and timings (job autonomy).

Table 4: Showing KMO and Bartlett’s Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.611
Bartlett's Test of Sphericity	Approx. Chi-Square	1009.448
	df	231
	Sig.	.000

Table 5: Showing Total Variance

Component	Total Variance Explained								
	Initial Eigenvalues			Extraction Sums of Squared			Rotation Sums of Squared		
	Loadings			Loadings			Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Job Autonomy	4.738	21.538	21.538	4.738	21.538	21.538	2.935	13.342	13.342
Realistic Objectives	2.515	11.430	32.968	2.515	11.430	32.968	2.828	12.856	26.198
Transparent	2.379	10.813	43.781	2.379	10.813	43.781	2.361	10.731	36.929
Departmental	1.674	7.608	51.388	1.674	7.608	51.388	2.264	10.292	47.220
Infrastructure	1.461	6.642	58.030	1.461	6.642	58.030	1.840	8.366	55.586
Knowledge Repository	1.231	5.596	63.626	1.231	5.596	63.626	1.625	7.386	62.972
Flexible Timings	1.121	5.096	68.722	1.121	5.096	68.722	1.265	5.750	68.722
Walk the Talk	.988	4.492	73.214						
Promotional Campaign	.948	4.308	77.522						
Communication	.791	3.594	81.115						
Career development	.732	3.325	84.441						
Leave Facilities	.602	2.737	87.178						
Good Guy Awards	.564	2.564	89.741						
Involvement in Product	.450	2.045	91.786						
Launch									
Free from Bullying	.395	1.795	93.582						
Social Events	.338	1.535	95.117						
Good day greetings	.307	1.395	96.512						
New Product Planning	.257	1.168	97.680						
Healthy Relationship	.230	1.045	98.725						
Team work	.140	.635	99.360						
Feedback on Exit	.076	.346	99.706						
Interview									
Job opportunities	.065	.294	100.000						

Extraction Method: Principal Component Analysis.

Table 6: Showing Rotated Component Matrix

Rotated Component Matrix ^a							
	Component						
	1	2	3	4	5	6	7
Job Autonomy	-.006	-.077	.122	.793	.159	.086	-.093
Realistic Objectives	.023	.462	.447	.016	.145	.363	.033

Transparent	.125	.113	.141	-.100	.421	.713	-.031
Departmental Infrastructure	.751	.033	.309	.105	.142	-.287	.128
Knowledge Repository	.345	.578	.507	.398	.081	.117	.101
Flexible Timings	.031	.611	.458	.290	-.076	-.088	.166
Job Involvement	.861	.238	-.187	-.161	.087	.015	.053
Walk the Talk	-.050	.125	.869	.007	.120	.079	.075
Promotional Campaign	.442	.006	-.139	-.172	.694	.028	-.087
Communication	.022	.174	.003	.617	-.060	-.268	.407
Career development	.683	.085	.123	.161	.193	.292	.026
Leave Facilities	-.283	-.235	.230	-.007	.635	.129	.103
Good Guy Awards	.054	.635	-.094	.558	-.061	.118	-.231
Involvement in Product Launch	.057	.726	.223	-.311	.015	.278	.136
Free from Bullying	.071	.104	-.071	.029	-.180	.746	-.005
Social Events	.276	-.062	.019	.654	-.208	-.042	-.034
Good day greetings	.149	.114	.778	.040	-.127	-.090	-.195
New Product Planning	.162	.195	-.033	.063	.726	-.080	-.093
Healthy Relationship	.103	.105	-.007	-.007	-.055	.029	.872
Team work	.345	.266	.105	.116	.029	.056	-.352
Feedback on Exit Interview	.692	-.101	.029	.219	-.089	.156	-.052
Job opportunities	.057	.797	.049	-.075	.056	.007	-.005
Extraction Method: Principal Component Analysis.							
Rotation Method: Varimax with Kaiser Normalization.							
a. Rotation converged in 9 iterations.							

Factors influencing Employee's Workplace Environment

KMO (Kaiser – Meyer – Olkin) measures of sampling adequacy is 0.606 (table 5), the KMO ranges between 0&1 with higher values indicating greater suitability and Bartlett's test of sphericity is significant [$\chi^2(231) = 1009, p < 0.001$], this shows that the sample size is adequate (greater than 0.5) to draw conclusions. Factor analysis is performed to extract the major factors influencing work environment, in table 9 about total variance shows that factors extracted with Eigen values more than one are six factors influencing work environment and it has explanatory power of 70.45%, these factors influence work environment to a great extent. These factors are identified from rotated component matrix and presented in Table 10. The variables with loading 0.9 are more were selected. So, the first factor is loaded with **Training Programs**, 70.45% of employees agree that training programs provided by organization help employees to achieve the required skill for performing the job effectively. Second factor being **personal work**, 63.12% of the employees are able to attend their personal work. Third factor being **Cordial relationship** constitute to 54.30%, employees are able to maintain cordial relationship with colleagues in the work place. 45.37 % of employee opine that they get **timely product updates**, 34.90% of employees are **satisfied with policies and practices** of their organization, 24.42% of the employees agree that lot of work empowerment is given to employees to decide about their

own style and pace of work that their organization and 12.78% of employees agree that they have **healthy work environment**.

Table 7: Showing KMO and Bartlett's Test

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.606
Bartlett's Test of Sphericity	Approx. Chi-Square	350.393
	Df	120
	Sig.	.000

Table 8: Showing Total Variance

Total Variance Explained

Components	Initial Eigenvalues		Cumulative %	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance		Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Work Environment	3.214	20.086	20.086	3.21	20.086	20.086	2.046	12.786	12.786
Work Empowerment	1.745	10.906	30.992	1.75	10.906	30.992	1.862	11.638	24.424
Policies and practices	1.657	10.356	41.347	1.66	10.356	41.347	1.676	10.477	34.901
New Product Updates	1.319	8.247	49.594	1.32	8.247	49.594	1.675	10.469	45.37
Cordial relationship	1.247	7.795	57.39	1.25	7.795	57.39	1.429	8.931	54.301
Personal work	1.086	6.786	64.176	1.09	6.786	64.176	1.411	8.819	63.119
Training programs	1.005	6.283	70.459	1.01	6.283	70.459	1.174	7.34	70.459
Employee training opportunities	0.825	5.159	75.617						
Fair compensation	0.811	5.071	80.688						
Recognition	0.653	4.081	84.768						
Employee Provident Fund	0.55	3.44	88.209						
Leave Travel Allowance	0.527	3.294	91.502						
Job rotation	0.459	2.867	94.369						
Sufficient Resources	0.414	2.587	96.956						
Additional responsibilities	0.29	1.814	98.77						
Channel of communication	0.197	1.23	100						
Extraction Method: Principal Component Analysis.									

Table 9: Showing rotation matrix

Rotated Component Matrix^a							
	Component						
	1	2	3	4	5	6	7
Work place environment	.139	-.020	.014	-.173	.762	.205	-.081
Work Empowerment	.632	-.043	.072	-.148	.219	.353	-.034
Policies and practices	.098	-.024	.150	.066	.049	.802	.018
New Product Updates	.199	.734	-.103	.064	.184	-.276	-.110
Cordial relationship	.744	.344	.380	.035	.069	-.069	.124
Personal work	.483	.270	.398	-.198	.042	-.366	-.215
Training programs	-.054	.832	.200	-.154	-.011	.126	.152
Employee training opportunities	.740	-.097	-.020	.418	.004	-.003	.110
Fair compensation	-.128	.440	-.107	.557	.171	.406	-.014
Recognition	-.049	-.013	.301	.616	.386	-.269	.029
Employee Provident Fund	.338	.388	.089	.171	-.078	.255	.460
Leave Travel Allowance	.187	-.114	-.009	.776	-.221	.141	-.034
Job rotation	.030	-.028	.798	.089	.208	.058	.159
Sufficient Resources	.263	.118	.740	-.002	-.223	.171	-.135
Additional responsibilities	.013	-.003	.010	-.059	.094	-.019	.853
Channel of communication	.053	.236	.023	.205	.651	-.123	.269
Extraction Method: Principal Component Analysis.							
Rotation Method: Varimax with Kaiser Normalization.							
a. Rotation converged in 18 iterations.							

IV Relationship between Workplace Environment and Employee Excitement

A paired t-test was conducted test the means of two populations, paired two-sample t-test is performed to determine whether a sample's means are distinct. Data is of unequal sample sizes, so researchers have considered the first 15 samples of both the variables (Employee Excitement and Work Environment).

Table 10: Showing the relationship between Workplace Environment and Employee Excitement

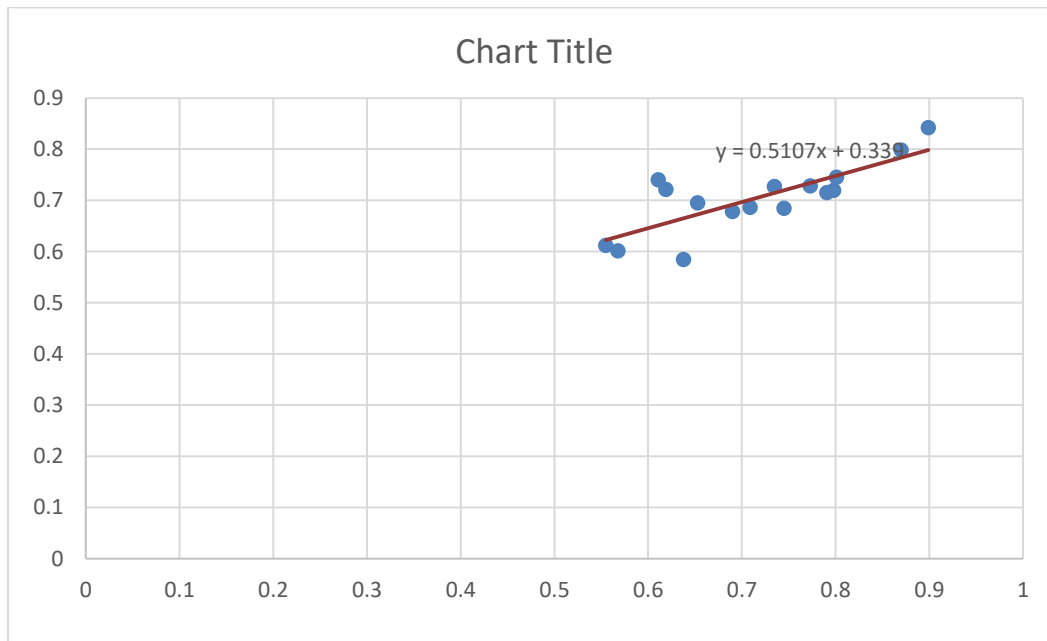
t-Test: Paired Two Sample for Means		
	0.678	0.69
Mean	0.706466667	0.717666667
Variance	0.004770267	0.011396381
Observations	15	15
Pearson Correlation	0.785795261	
Hypothesized Mean Difference	0	
Df	14	

t Stat	-	0.641027964
P(T<=t) one-tail		0.265929271
t Critical one-tail		1.761310136
P(T<=t) two-tail		0.531858543
t Critical two-tail		2.144786688

Multiple R (correlation coefficient) is 0.785 – it measures the strength of linear relationship between two variables (employee excitement and work environment) that varies between -1 and 1 and its absolute value (the distance from 0 to the destination number, regardless the direction) indicates the strength of relationship. Larger the absolute value stronger is the relationship, **showing a relationship between employee excitement and work environment**. 1 denotes strong relationship, -1 denotes strong negative relationship and 0 denotes no relationship.

R^2 – it helps in determining the coefficient and it is an indicator of goodness of fit. R^2 is 0.62 (rounded to two digits) is a good fitness. **It means 62% of the values fit regression model**. 62% of the dependent variables (Y values – Work place environment) are explained by independent variables (X Values – Employee excitement)

Standard Error – is **0.04** which means that it is more certain, smaller the number, the more certain is the regression equation.



Linear equation is used to explain the relationship between the components/features/factors (workplace environment and employee excitement), mainly used for regression.

Results

Results show that female respondents constitute to 57% when compared to male respondents,

51% of the respondents are between the age of 25 and 35 years, followed by 29% between the age of 36 and 45 years. 63% of the respondents are married and are graduates. 45% of the respondents are earning 6 to 10 lakhs P.A. 52% of the respondents serve the organization as Junior Software Engineer, 37% as Senior Software Engineer. Job involvement, 68.72% of employees agree that the work place is favorable for working. Flexible timings, 62.97% of the employees enjoy the flexible timings provided by the organization. Knowledge repository constitute to 55.58%. 47.22 % of employee opine that they like work space design of their respective department, 36.92% of employees believe that their organization maintains transparency, 26.19% of the employees agree that their organization sets realistic objectives and 13.34% of employees agree that they have freedom towards decision making, process of functioning and timings (job autonomy). Training Programs, 70.45% of employees agree that training programs provided by organization help employees to achieve the required skill for performing the job effectively. Personal work, 63.12% of the employees are able to attend their personal work. Cordial relationship constitute to 54.30%, employees are able to maintain cordial relationship with colleagues in the work place. 45.37 % of employee opine that they get timely product updates, 34.90% of employees are satisfied with policies and practices of their organization, 24.42% of the employees agree that lot of work empowerment is given to employees to decide about their own style and pace of work that their organization, 12.78% of employees agree that they have healthy work environment and transparency maintained in the organization, mentoring on career development and leave facilities provided keep the employees more excited at work place.

DISCUSSION

Broadening the changes in the direction of transparency, employee participation in decision making (EPDM), policies and practices, setting realistic objectives and work empowerment savior the organization. Looking at the results of data analysis on employee excitement, it is observed that 68.72% of employees agree that the work place is **favorable** for working but only 12.78% of employees agree that they have **healthy work environment**, this shows that work environment has impact on excitement of an employee. For an employee to be excited it is essential to provide with the (62.97%) **flexible timings**, sourcing employees for effective deliverables. Every organization needs to admire on the **repository of knowledge** (55.58%). Work space design adds to the employee' excitement, 47.22 % of employee opine that they like **work space design** of their respective department. When adored on transparency not every organization supports this trend, there is a need for improving on maintain the transparency within the organization (36.92%) of employees believe that their organization maintains **transparency**, under emphasis on setting realistic objectives, employee participation in decision making (EPDM) helps the organization in reaching the target. Though **training programs** provided constitute to 70.45% still we see the employee dissatisfaction leading to stress and job burnout. **Cordial relationship** constitutes to 54.30% giving space for improvement for employees to maintain cordial relationship with colleagues in the work place to have a healthy work environment. 45.37 % of employee opine that they get **timely product updates** giving space for the companies to increase the awareness repeatedly on product updates, only 34.90% of employees are satisfied with policies and practices of their organization, the companies need to ensure to survey and feedback from employees for improvements in the **policies and**

procedures, 24.42% of the employees agree that lot of **work empowerment** is given to employees to decide about their own style and pace of work that their organization, there is a need for management to understand that this is the era of decentralization and it is right time to give more space and freedom for employee empowerment and 12.78% of employees agree that they have healthy work environment.

Implication of the Study

Over the decades, employee satisfaction, production, engagement, commitment, influence are some of the components identified as affecting the quality of work life. It is most crucial time to increase the awareness of healthy work environment and giving space for Physical Environment (Provide ergonomic tools and furniture to support employees' physical well-being), Natural Light and Ventilation (Whenever feasible, use natural materials to create a cozy ambiance). Spaces that are neat and organized (a well-maintained workspace promotes a productive work climate), Promote diversity and inclusion to ensure that every employee feels appreciated and respected. Establish a clear mission and values statement to convey the company's objectives and core values to employees. Open Communication: Encourage transparent and open communication among team members to build trust. Organize events and activities that foster team cohesion and camaraderie. Collaboration and Teamwork (Collaborative Spaces: Design places that support teamwork and group discussions). Flexibility and Work-Life Balance: To promote work-life balance, provide remote work choices or flexible work schedules. Wellness Initiatives (Offer tools and initiatives emphasizing mental and physical health), Professional Development (Training Opportunities: Make training and skill-building programs an investment in your employees' development), Career Advancement (Establish avenues for professional development and offer prospects for advancement), Recognition and Appreciation (Recognize and incentivize staff members for their accomplishments and services), Feedback Mechanisms: Provide regular routes for employees to provide constructive criticism and appreciation. Technology and Tools: Ensure that staff have the latest tools and technology to accomplish their jobs effectively. Tool Training (Make sure staff members receive training on utilizing new technology), Empowerment and Autonomy (Include staff members in decision-making processes where suitable), Empowerment (asking staff members to accept responsibility for their work and offer suggestions), Safety (Physical Safety: Put safety measures in place to guarantee a safe working environment), Data security (uphold stringent procedures to safeguard private data), Pleasure and Entertainment (Recreational Spaces: Establish spaces for rest and respite, Celebrate Your Successes (Acknowledge and honor your accomplishments). Resources provided have seldom effect on the success of any organization. Not to be the square peg in the round hole is the wave of revolution. Healthy work environment and employee excitement are the two highest accolade for quality production. Walk the talk, setting of realistic objectives; ensure that every employee is on board. Banners, buttons, and other promotional materials are to be circulated to ensure that the change is on every employee's mind.

SCOPE FOR FURTHER RESEARCH

This study may be extended to other geographical locations as this study is limited to Bangalore, this study can be extended with collecting data for few more years and only two variables were

studied, this can be extended with other variable like job satisfaction, attrition, stress and psychological variables.

REFERENCES:

- ALDamoe, F. M. A., Yazam, M., & Ahmid, K. B. (2012). The mediating effect of HRM outcomes (employee retention) on the relationship between HRM practices and organizational performance. *International Journal of Human Resource Studies*, 2(1), 75.
- Aruna, M., & Anitha, J. (2015). Employee retention enablers: Generation Y employees. *SCMS Journal of Indian Management*, 12(3), 94.
- Brad Shuck, M., Rocco, T. S., & Alborno, C. A. (2011). Exploring employee engagement from the employee perspective: Implications for HRD. *Journal of European Industrial Training*, 35(4), 300-325.
- Brandler, S., Roman, C. P., Miller, G. J., & Yang, K. (2007). Handbook of research methods in public administration. CRC press.
- Cascio, W. F. (2006). Managing Human Resources: productivity, quality of work life, profits 7th Edition Tata McGraw-Hill. *Abnormal and Social Psychology*, 62, 401-407.
- Cameron, K., & Dutton, J. (Eds.). (2003). *Positive organizational scholarship: Foundations of a new discipline*. Berrett-Koehler Publishers.
- Dawal, S. Z., & Taha, Z. (2006). Factors affecting job satisfaction in two automotive industries in Malaysia. *Jurnal Teknologi*, 65â-80.
- Dey, S. (2009). Employee retention--A key to organizational growth. *GMJ*, 3(1), 4549.
- Eskildsen, J. K., & Dahlgard, J. J. (2000). A causal model for employee satisfaction. *Total quality management*, 11(8), 1081-1094.
- Friedman, L. (2006). Are you losing potential new hires at hello. *T+ D*, 60(11), 25-27.
- Fromm, E. (1991). Causes for the patient's change in analytic treatment. *Contemporary Psychoanalysis*, 27, 581-601.
- Get Les Mckeown's (2010-11). Retain top employees, published in HBR series, 32.
- Gurumani, V. S. (2010). Invaluable tools for talent retention. *Human capital*, 4, 54-55.
- Breaugh, J. A., & Frye, N. K. (2007). An examination of the antecedents and consequences of the use of family-friendly benefits. *Journal of Managerial Issues*, 35-52.
- James, L., & Mathew, L. (2012). Employee retention strategies: IT industry. *SCMS Journal of Indian Management*, 9(3).
- Kujur Sabina (2008). "Retention Techniques in Corporate India"
- Kamo. M. (2014). How to keep your employees motivated and excited about their job. Productivity Hacks, Startups.
- MANDHANYA, Y. (2015). A STUDY OF IMPACT OF WORKING ENVIRONMENT ON RETENTION OF EMPLOYEES (With special reference to Automobile sector). *Global Management Review*, 9(4).
- McKee, A. (2014). Being happy at work matters. *Harvard Business Review*, 14.
- [Measley, N. \(2015\). Playing it Forward: The Benefits of Fun in the Workplace. http://www.articleweekly.com/nat-measley/fun-in-the-workplace/ retrieved on 2/6/2016\).](http://www.articleweekly.com/nat-measley/fun-in-the-workplace/)
- Miller, T. I. (2007). Performance Matters. *National Research Center, Inc., Boulder, Colorado. Public management*, 2007.
- Mahal, P. K. (2012). HR Practices as Determinants of Organizational Commitment and Employee Retention. *IUP Journal of Management Research*, 11(4).

- Ongori, H., & Shunda, J. P. W. (2008). Managing behind the scenes: Employee empowerment. *The International Journal of Applied Economics and Finance*, 2(2), 84-94.
- Perez, M.(2008). Turnover intent. (Diploma Thesis), International University of Zurich, Zurich.
- Perry-Smith, J. E., & Blum, T. C. (2000). Work-family human resource bundles and perceived organizational performance. *Academy of management Journal*, 43(6), 1107-1117.
- Rice, C (2010). Beyond clarity, it's time for inspiration. *Leadership excellence*, November, 2010.
- Solomon, C. M. (1994). Work/family's failing grade: Why today's initiatives aren't enough. *Personnel Journal*.
- Three pieces of PIE, Physical, Intellectual and Emotional. (<http://www.atkinsglobal.com/en-gb/angles/our-contributors/atkins>)
- Winterton, J. (2004). A conceptual model of labour turnover and retention. *Human Resource Development International*, 7(3), 371-390.
- Zeytinoglu, I. U., & Denton, M. (2006). Satisfied workers, retained workers: Effects of work and work environment on homecare workers' job satisfaction, stress, physical health, and retention (p. 117). Ottawa: Research Institute for Quantitative Studies in Economics and Population, McMaster University.

Impact of Inventory Management Practices on MSMEs: A Regional Study in India

S Ramesh Murthy* and Padmalatha N A**

This study examines the inventory management (IM) practices, reasons, influencing factors and impact of IM on the performance of micro, small and medium enterprises (MSMEs). Primary data was collected using a survey questionnaire among 40+ MSMEs in Baddi Industrial Area, Himachal Pradesh, India. The study reveals that MSMEs generally follow poor IM practices and non-scientific forecasting methods, leading to capital being tied up due to excess inventory or stockouts, delayed delivery, customer dissatisfaction, reduced profits, operational inefficiencies, and diminished competitiveness. Factors such as limited awareness, lack of access to technology and finances, and a shortage of skilled manpower contribute to inadequate implementation of scientific IM practices. The study establishes that poor IM practices and unscientific forecasting practices have an impact on the inventory cost, which in turn impacts the firm's performance. To address these challenges, the study makes many recommendations.

Introduction

Inventories constitute a significant portion of the current assets in any business enterprise (Kruger, 2005). Lack of appropriate inventory management (IM) practices can give rise to a range of problems, including reduced productivity (Palange and Dhatriak, 2021), production of unwanted items, diminished customer commitment (Du *et al.*, 2015) accumulation of costly physical inventories, and frustration (Meyer, 1991). Hence, the cost savings resulting from improved IM practices are substantial (Meyer, 1991). Effective IM and control are crucial for the viability of a firm, as mismanagement of inventory can jeopardize its operations (Sprague and Wacker, 1996; and Holweg *et al.*, 2005). The management of inventories directly impacts a firm's financial strength and competitive position, as the approach taken towards IM affects working capital,

* Research Scholar, Dayananda Sagar University, Bengaluru, Karnataka, India; and is the corresponding author. E-mail: rameshshellm_72@yahoo.com

** Associate Professor, Dayananda Sagar University, Bengaluru, Karnataka, India. E-mail: drpadmalatha-socm@dsu.edu.in

production, and customer service levels (Ng *et al.*, 1993; Vergin, 1998; and Sinha *et al.*, 2023). Inventory is also part of the routines and repeat routines (Saratchandra *et al.*, 2022) while acting as a driver of competitive advantage (Jones and Riley, 1985; and Bhatnagar and Teo, 2009). Therefore, it is imperative that organizations utilize scientific methods in the management of inventory whilst striving to do better than their competitors (Li *et al.*, 2006) in the challenging marketplace.

Micro small and medium enterprises (MSMEs) are defined in various ways across the globe. In India, a micro enterprise in the manufacturing sector is characterized by an investment in plant and machinery not exceeding ₹10 mn. A small enterprise has an investment in plant and machinery greater than ₹10 mn but less than ₹100 mn. A medium enterprise is defined as having an investment in plant and machinery greater than ₹100 mn but not exceeding ₹500 mn. MSMEs are the backbone of the Indian economy, contributing nearly 30% of the country's gross domestic product (GDP), generating employment opportunities for over 110 million people, particularly in rural and semi-urban areas where other job opportunities are limited. They are the largest employer after the agriculture sector and account for almost 50% of India's total exports. The employment opportunity provided by such firms is equally significant, for they lead to better living standards for young people who move from villages to towns and cities.

MSMEs are especially critical for emerging markets on account of their contribution to new employment generation, serving larger original equipment manufacturers (OEMs) and leading to the emergence of economic clusters that support larger industrial clusters. While clusters and the derived economics have been articulated in detail by Porter (1998), on-the ground evidence is manifest in the form of industrial clusters such as the automobile clusters around Chennai, India and Pune, India. Textile clusters have emerged in towns such as Tirupur and Ludhiana. The presence of larger OEMs along with the ancillary industries leads to a healthy self-sustaining industrial ecosystem. The Western world has several such ones—for instance, the auto design firms clustered around Turin, Italy or the automotive cluster in Detroit, US and the machine tools and manufacturing industrial clusters around Cincinnati, Ohio, US. All clusters have developed with a small number of large firms that are supported by several hundreds of smaller firms which are essentially MSMEs.

Despite the acknowledged significance of inventories for a firm's survival, IM practices in several MSMEs are very rudimentary and often use heuristic approaches (Widyastuti, 2018). In the formulation of business strategies, IM is often not considered a critical or strategic activity (Sprague and Wacker, 1996). There are fewer in-depth studies on the IM practices adopted by MSMEs in India. Therefore, this paper aims to fill this gap by examining the state of IM practices amongst MSMEs in the Baddi Industrial Area, Himachal Pradesh, India.

Study Setting

The state of Himachal Pradesh in India is known for tourism and industrial zones. From an industrial zone context, the Indian government set up specific departments that would facilitate and expedite industrial activities. One such body is the Development Commissioner Ministry of Micro Small & Medium Enterprises (DCMSME) (<https://dcmsme.gov.in>). The Baddi region in Solan District of Himachal Pradesh had drawn up an industrial profile of the district during 2014-15 (<https://dcmsme.gov.in/old/dips/District%20Industrial%20Potential%20Solan.pdf>). The document outlines the topography as well as the industrial scenario prevailing in the district. The total geographical area of the district is 1,936 sq. km. Forest area accounts for 11% of the total area.

Baddi has about 3,000 companies that provide raw materials, intermediaries and finished goods to industries such as pharmaceuticals, automobiles, consumer goods, industrial machinery and food processing. Recent work in the district shows that specific zones have been demarcated for expanding the existing manufacturing cluster at Baddi (Sharma, 2023), indicating the resurgence of industrial activity. Baddi-Barotiwala-Nalagarh (BBN) is an industrial hub identified for development as part of infrastructural advancement of the Amritsar-Kolkata Industrial Corridor project. Within the ambit of this larger initiative, the BBN corridor has been developed by National Industrial Corridor Development Corporation (NICDC), a special purpose vehicle for continuous industrial development.

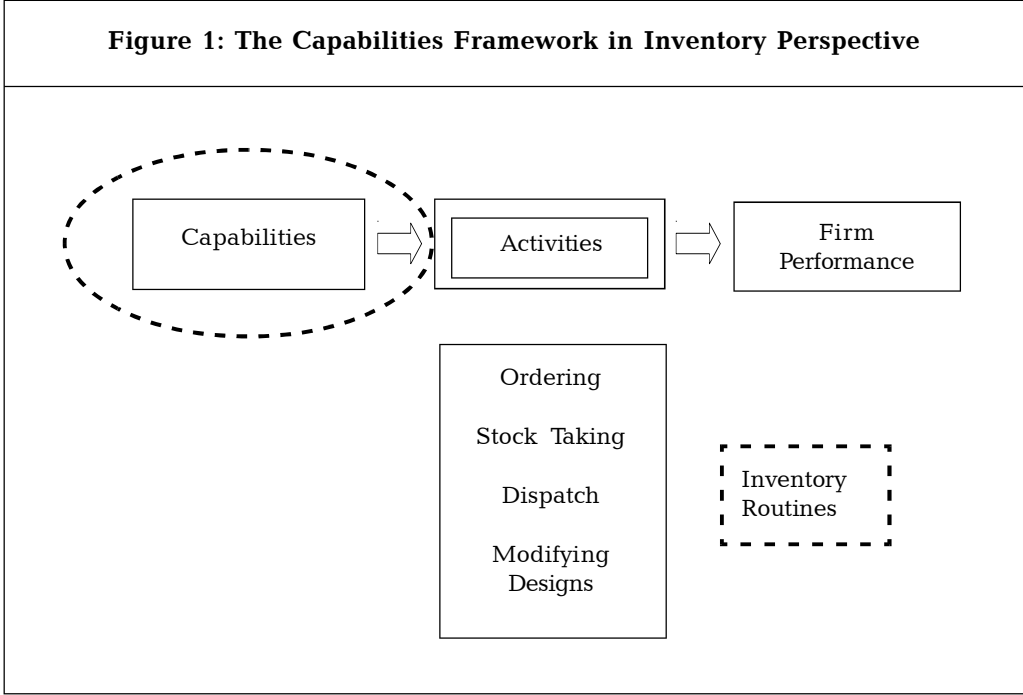
Theoretical Foundations and Literature Review

Certain practices adopted by MSMEs can be beneficial in establishing foundational aspects derived from specific theories. A starting point would be to draw inferences from the resource-based view (Wernerfelt, 1984; and Barney, 1991), wherein the scholars classify all firm resources into tangible and intangible ones. Firms are able to articulate their tangible resources, while struggling to take stock of their intangible ones. In the context of MSMEs, inventory can be said to be a tangible resource that acts as a bargaining point, helping organizations to leverage them for routine business transactions. Hence, inventory may act as an operational lever, enabling organizations to use it as a potent tool, despite its being a part of the repeat routines. The resource-based view laid more emphasis on the firms' being unable to identify the intangibles, whereas in most cases, they can easily list down the tangible resources.

Extending the applications from Porter's (1980) clear classification of a) Cost leadership, b) differentiation and c) focus as the three generic strategies which could lead firms to competitive advantage, Hill and Jones (2011) went on to propose and substantiate their theories on the building blocks of competitive advantage. Their exposition envisioned a) Cost efficiency, b) quality, c) innovation and d) customer responsiveness as the building blocks of competitive advantage. With regard to MSMEs, we can clearly see the application of inventory as a lever that could help firms achieve

cost efficiency, provided effective and scientific IM practices were used. Moreover, for scenarios which called for quick response during uncertain times, inventory buffers could also lead to superior customer responsiveness.

Since most of the MSMEs studied are suppliers to larger OEMs, their focus is directed towards capabilities and activities which would consequently drive towards firm performance. Their repeat routines also align them well with the structural framework proposed by Hill and Jones (2011); the construct can be portrayed in the form of a capabilities framework (Figure 1). Examples of activities could be any business process such as placing a purchase order or despatch against an order received.



The dynamic capabilities perspective (Pisano and Teece, 1984) applied to MSMEs may be construed as a quest for constant improvement in the capabilities of the smaller firms since their demands are volatile and ever-changing. Moreover, since the bargaining power rests with the buyer ecosystem, the smaller firms which tend to be part of the MSME universe need to constantly upgrade their capabilities. On the other hand, a lot of their activities (Figure 1) remain routine, including the activities undertaken as part of IM practices. The dotted line depicting the capabilities ellipse indicates that capabilities have to be constantly refined and honed; firms cannot choose to be complacent.

At the turn of the century, Lawson and Samson (2001) strongly observed that within the umbrella of capabilities, firms need to provide for innovation; they opined that the innovation capabilities need to be enhanced with a view to serving their customer

interests. More recent studies emphasized that MSMEs need to innovate using technology (Gupta and Barua, 2016), while constantly striving to be ahead of competing firms in capabilities (Khurana *et al.*, 2019).

IM has significance for any enterprise because effective practice of IM allows an enterprise to minimize inventory costs and avoid shortage or excess of material resources, leading to cost efficiencies within the firm. Eloranta and Raisanen (1988); and Demberere and Kasongo (2021) argued that poor quality of forecasts is one of the factors contributing to shortage or excess inventory in MSMEs. Chikan (1990) observed that a sound IM system is a decisive factor in a firm's success that may over time act as a key building block of competitive advantage. Natarajan (1991) discussed the relationship between IM and competitive advantage, bringing into focus factors such as cost, delivery and quality; he argued that inventory costs are determined not only by their level of inventory but also by the time the materials spend in the system. Chikan and Whybark (1990) observed that MSMEs are slow to adopt and implement contemporary IM practices. MSMEs are often satisfied with archaic, non-scientific practices such as end-of-year stocktaking, trading and maintaining profit and loss accounts, even though many benefits can be derived from implementing a formal inventory management system. Given that many SMEs lack professional expertise (Kumar *et al.*, 2022) and generally take decisions based on intuition and elementary IM practices (Mohanty, 1985), investments in inventory are not always costed accurately or appropriately. Peel *et al.* (2000) revealed that small firms tend to have a relatively high proportion of current assets, less liquidity, exhibit volatile cash flows, and a high reliance on short-term debt. Similarly, Howorth and Westhead (2003) suggested that small companies tend to focus on some areas of IM where they can expect to improve marginal returns. For small businesses, an efficient IM is a vital component of success and survival (Muchaendepi *et al.*, 2019). Grablowsky (1976) showed a significant relationship between various success measures and the adoption of IM policies. Given the peculiarities of small businesses, Peel and Wilson (1996) stressed the need for efficient inventory management.

There are many factors that cause IM problems in small scale industries. Chan *et al.*, 2017 argued that underproduction, overproduction, stockout situation, delays in the delivery of raw materials, planning, documentation/store records, knowledge of employee/staff skill and funding are some of the reasons for IM-related problems. Rajeev (2008) found that use of heuristics in IM, low emphasis placed on forecasting techniques, random ordering of materials, low levels of training and development, and lesser support from computerized methods as well as low importance given to purchasing and variable lead-time lead to IM problems in the context of machine tool enterprises in Bengaluru, India. Ahmad and Zabri (2016) demonstrated that systematic approach of IM was only utilized by 33% of MSMEs surveyed. The rule of thumb was the most popular IM techniques among respondents; this indicates that convenience and judgement played a role in critical inventory decisions. Owner-managers' attitude

and knowledge in IM have significant influence on IM practice. IM and managerial competence are significantly associated with financial performance of small businesses (Orobia *et al.*, 2020). Lack of knowledge of benefits and competitive advantage results in one fourth of the MSME not implementing any kind of IM practice (Mangla *et al.*, 2018). Apart from technology, factors like human resource, economic condition, organizational culture of SMEs are vital in improving the performance of inventory management. The study indicated that despite being aware of IM practice, most of them base their decision on heuristics (Narayanapillai, 2013).

Several studies have established the positive impact of IM on the performance of the organization (Ahmad and Zabri, 2018). Superior IM practices can lead to enhanced competitive advantage and improved organizational performance (Atnafu and Balda, 2018). IM leads to economy and efficiency, nurtures competitive ability and paves the way for cost reduction (Chalotra, 2013). MSMEs that implemented IM practices, which included reflected frequent stock verification and EOQ-based raw material ordering, achieved lower inventory cost and higher inventory turnover rate (Mangla *et al.*, 2018). Kaewchura (2021) established that inventory control systems had the greatest influence on competitive advantage, followed by inventory control practices and information technology. Narayanapillai (2013) found that variables such as safety stock planning, employee training and better IM practices differentiate the performance of firms from the rest; Buteau (2021) noted that digital technologies could significantly accelerate the growth of MSMEs in India. Therefore, we find that lack of formalized and scientific methods in inventory management leads to increased inventory costs for the firm.

Forecasting and Inventory Cost/Performance

While some studies have looked at digital interventions in the performance of MSMEs (Bhatti *et al.*, 2022), the authors agree that absence of rigorous IM practices has diluted the potential performance; Kumar and Chandra (2023) proposed a hybrid framework to mitigate some prevailing IM problems in the context of pharmaceutical MSMEs, while noting that arcane forecasting methods and frequent intervention of 'experts' led to unstructured decision making. Syntetos *et al.* (2010) discussed the impact of subjectivity observed in forecasting methods as they find that such approaches may end up harming the accuracy of scientific forecasting. The findings suggest that managerial intervention on account of process-specific knowledge may hamper the implementation of rigorous, software-based methods. Upadhye *et al.* (2010) discussed that lean management principles could be used to improve IM practices; they argued that poor quality forecasts contribute to shortage or excess of inventory in MSMEs.

Hypotheses

H₁: Poor IM practices increase the inventory costs (decrease the performance)

H₂: Poor forecasting methods increase the inventory cost (decrease the performance)

Data and Methodology

A structured questionnaire (see Appendix) containing qualitative questions and questions based on a 5-point Likert scale was used to collect data from of 40+ MSME firms in Baddi industrial area.

The questionnaire focussed on collecting data on following points – inventory counting frequency, reordering frequency, inventory carrying costs, safety stock, impact of IM systems, production planning, lead time, physical inventory counting, inventory tracking tools, stockout prevention strategies, raw material sourcing, and substitute material usage during stockouts.

Descriptive analysis was done to establish if the IM practices and forecasting methods are good or poor. The study uses factor analysis to group the observed variables into 3 latent factors, namely, inventory practices, forecasting challenges and inventory cost. It then uses structural equation model to establish the causal relationship among the latent factors and test the hypothesis that poor IM practices and archaic forecasting method negatively impact the inventory costs, which is used as an indicator to measure the performance and competitiveness of the firm.

Reliability of the Instrument

The reliability of the questionnaire was measured using Cronbach's alpha. A coefficient of 0.9850 suggests that the items in the entire set measure the same underlying construct with very high consistency and reliability.

Findings

Descriptive Analysis

The findings highlight the key aspects of IM practices in small-scale industries in the Baddi industrial area of Himachal Pradesh, India. Most surveyed firms (58%) conduct weekly inventory counts, while 28% perform daily counts, and 15% carry out monthly counts. On average, 10 stock-keeping units (SKUs) are counted during inventory. Firms conducting daily inventory counts reorder stock after 6 days, those conducting weekly counts reorder after 8 days, and firms performing monthly counts reorder after 30 days. Firms conducting daily counts maintain safety inventory, while those conducting monthly counts do not, resulting in higher inventory levels and carrying costs for the latter group. Production planning strategies vary among the small-scale industries surveyed. Around 36% plan production for fast-moving SKUs on a make-to-stock basis, while 28% plan production based on customer orders. Excel is the preferred inventory management tool for 60% of the firms, while 33% rely on accounting systems like Tally.

To prevent stockouts, firms employ different strategies. Approximately 26% focus on regular inventory counts and monitoring, while 45% prioritize employee training

and empowerment. Some firms believe monitoring the entire supply chain is crucial for avoiding stockouts. Regarding sourcing practices, 75% of the firms prefer direct sourcing from manufacturers but face challenges such as high minimum order quantities and advance payment requirements. Intermediaries are often used, causing supply chain delays. Sales forecast based on past customer orders are used by 33% of firms, while another 33% collaborate with suppliers for sourcing raw materials. In the event of stockouts, firms borrow materials from friendly manufacturers (50%), arrange rush delivery (5%), wait for stocks to become available (15%), or use substitute materials (30%). The surveyed small-scale industries do not adopt theoretical concepts like economic order quantity (EOQ) and reorder point (RoP), inventory classification methods like ABC Analysis, or inventory optimization techniques or software. Limited evidence of supply chain collaboration with suppliers and customers is also observed.

Based on the descriptive analysis, it is concluded that the MSMEs in Baddi industrial area follow poor inventory management practices and non-scientific/rudimentary/ rule of thumb forecasting methods.

Factor Analysis

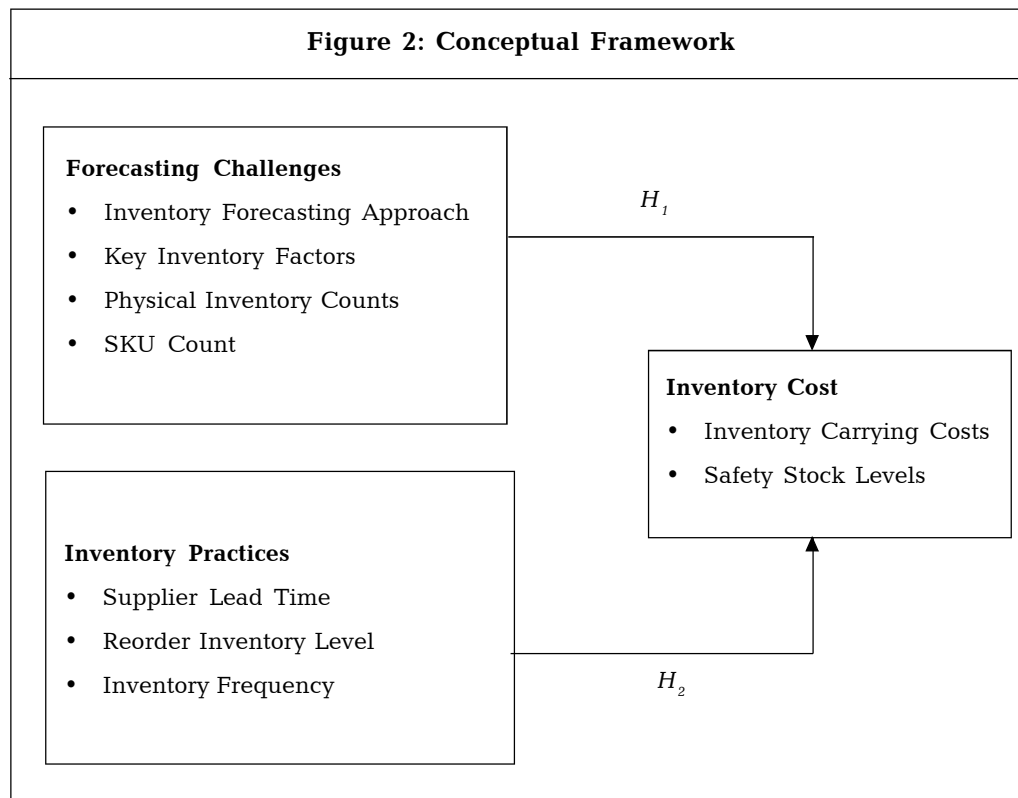
Based on the Kaiser-Meyer-Olkin test results, the overall measure of sample adequacy (MSA) value is 0.628. It can be concluded that the variables in the dataset are suitable for factor analysis.

Principal component analysis (PCA) with varimax rotation was first carried out using JMP-SAS software. The FPCA analysis is shown in Table 1.

Table 1: FPCA Analysis Results			
Variable	Loading		
	Factor 1	Factor 2	Factor 3
Supplier Lead Time	0.99875		
Reorder Inventory Level	0.97984		
Inventory Frequency	0.52068		
Inventory Forecasting Approach		0.63641	
Key Inventory Factors		0.59277	
Physical Inventory Counts		0.49217	
Baddi Area Inventory Challenges		-0.4748	
SKU Count		0.38184	
High Inventory Levels		-0.0613	
Reasonable Carrying Costs			0.37647
Safety Stock Levels			0.3511

Table 1 shows the presence of 3 factors. The first category (Variables 1-3) was categorized as inventory management practices. The second category (Variables 4-8) was classified as forecasting challenges, and the third group (Variables 9-11) was categorized as inventory costs.

Figure 2 represents the conceptual framework of the study.



Structural Equation Model and Hypothesis Testing

From Figure 3 and Table 2, it is established that the p -value of 0.0066 indicates statistical significance, suggesting a significant relationship between poor inventory practices and increase in inventory costs. The RMSEA value of 0.1282 indicates a good fit for the structural equation model. The Comparative Fit Index (CFI) value of 0.7777 is reasonable for a good fit. Hence, H_1 is accepted.

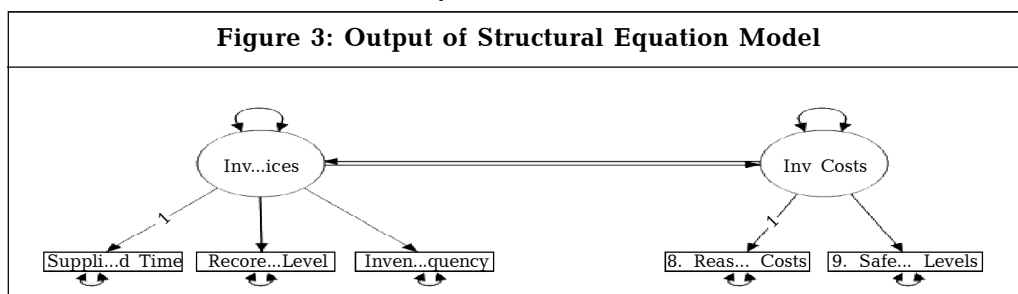


Table 2: Hypothesis Testing (H_1)					
Hypothesis	Relationship	p -Value	CFI	RMSEA	Decision
H_1	Poor Inv Practices→ High Inv Costs	0.0066	0.7777	0.1282	Accepted

Regarding H_2 , from the output of Figure 4 and Table 3, it is established that the p -value of 0.0001 indicates statistical significance, suggesting a strong relationship between poor forecasting practices and increase in inventory costs. But the RMSEA value of 0.2587 suggests a poor fit for the structural equation model and the CFI value of 0.1389 is below the threshold for a good fit. Therefore, the overall fit of the structural equation model is not strong, and the hypothesis is rejected.

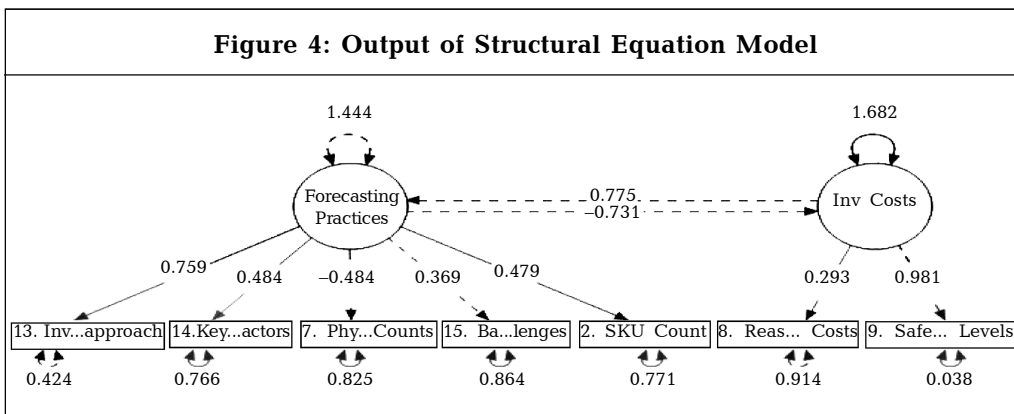


Table 3: Hypothesis Testing (H_2)					
Hypothesis	Relationship	p -Value	CFI	RMSEA	Decision
H_2	Poor Forecasting Practices →High Inv Costs	0.0001	0.1389	0.2587	Rejected

Discussion

The descriptive analysis revealed that the forecasting methods employed by the MSMEs were rudimentary in nature. There were instances of excess inventory or stockouts. However, the results obtained from the structural equation model did not support the notion that poor forecasting methods directly translate into increased inventory costs. To further explore this discrepancy, additional data analysis was performed, and follow-up telephonic discussions were conducted with the respondents. It was discovered that the MSMEs deal with a relatively low number of SKUs. Their end customers are known, they receive annual orders with scheduled shipments, and they rarely encounter sudden orders from unknown customers. As a result, they are able to forecast their inventory needs with a reasonable level of accuracy. However, due to credit terms and

small minimum order quantities (MoQs), these MSMEs are compelled to rely on intermediaries for their supplies. The inconsistency in supply from intermediaries, coupled with sudden changes in prices, forces the MSMEs to avoid holding excessive inventory. Consequently, the observed instances of excess inventory or stockouts are primarily attributed to the behavior of suppliers rather than the forecasting practices of the MSMEs. Therefore, the rejection of H_2 , which suggests a direct link between poor forecasting and inventory issues, is justified.

Conclusion

A comprehensive study conducted on 40 MSMEs in the Baddi industrial area revealed a significant deficiency in IM practices. These enterprises exhibited poor utilization of formal IM practices, characterized by a lack of integration between physical stock and accounting systems. The primary contributors to subpar IM practices were identified as the absence of a cohesive approach, a lack of awareness about IM among entrepreneurs, and a shortage of qualified personnel. Furthermore, various other factors compounded the situation, including working capital constraints, inadequate training and development, stagnation in human resource development, absence of an ERP system and software utilization, and organizational characteristics specific to MSMEs.

The study discovered the absence of formal inventory ordering policies, such as fixed quantity or fixed period ordering policies, in the surveyed SMEs. Instead, a haphazard procurement policy prevailed, indicating a random approach to material procurement. Moreover, reliance on imprecise rule-of-thumb methods for IM, limited emphasis on accurate forecasting, ad hoc material ordering practices, low utilization of computer systems, and a diminished focus on purchasing and variable lead-time were identified.

It was observed that MSMEs did not engage in collaborative purchasing from manufacturers, which could provide them with bargaining power and other benefits such as reduced lead time, lower minimum order quantity, credit facilities, and quantity discounts. The utilization of computers was limited to word processing and Microsoft Excel, with minimal focus on improving employee skills through training and development programs. Human resource development was found to be lacking.

The absence of effective IM practices renders organizations uncompetitive and inefficient, and negatively impacts profitability. Firms often face issues of excess inventory or stockouts, resulting in inventory discrepancies or incorrect products being available at the wrong time and place. This leads to high capital costs or an inability to meet demand, resulting in customer dissatisfaction and long-term consequences for the firm's survival.

Implications: MSMEs are the backbone of the Indian economy, and their competitiveness and profitability are crucial for national growth. It is imperative that MSMEs adopt effective IM strategies to minimize costs, enhance profitability, and

gain a competitive advantage. The government should play a vital role in supporting MSMEs by providing training, mentorship, and exposure to the benefits of modern IM practices. This includes implementing theoretical inventory control concepts like EOQ, ROP, and just-in-time (JIT) systems and utilizing inventory forecasting techniques like trend analysis, moving average, and exponential smoothing. Additionally, MSMEs can benefit from commercial-grade IM software such as Zoho inventory, which enables streamlined inventory tracking, stock monitoring, and insightful reporting. Measuring inventory performance through metrics like inventory turnover ratio and days inventory cover, and employing inventory classification methods such as ABC analysis, FSN analysis, and VED analysis, can help MSMEs prioritize their inventory effectively. Adopting conceptual concepts such as inventory optimization techniques, implementing inventory management software, and fostering supply chain collaboration with suppliers and customers can improve inventory management practices in the studied MSMEs. In addition to the theoretical concepts and conceptual concepts mentioned, there are a few other factors that impact the IM practices of MSMEs like the type of product or service being sold, the size of the business, the industry in which the business operates, the level of competition and the economic climate.

It is important for MSMEs to consider all these factors when developing and implementing inventory management practices. By embracing these solutions, small-scale industries can optimize their inventory, reduce costs, and improve operational efficiency overall.

Limitations and Future Scope: India is a vast country, and the government is setting up industrial clusters in various parts of the country. MSMEs in various clusters have different cultural and social factors. They face challenges which are unique to them. Hence, further studies focusing on different MSME clusters are necessary to understand their IM practices and reasons for not implementing modern IM practices. There is a need for research to understand the impact of lack of resources, inadequate infrastructure, and limited access to finance faced by MSMEs and their impact on IM practices. Future studies should also be done to explore the impact of cultural and social factors, the role of government policies, and the impact of technological advancements on IM practices in Indian MSMEs.

This study has several limitations. Firstly, the questionnaire items used to measure constructs were not standardized, highlighting the need for future research to revalidate measurement scales with more representative observations. Additionally, relying on a single respondent from a firm to assess the overall aspect of inventory management practice of that firm may not accurately reflect the reality as no single person is solely responsible for inventory within a firm. Therefore, future studies should aim to incorporate multiple respondents from each participating enterprise to enhance the research findings. Furthermore, the data collection from a single MSME cluster restricts the ability to generalize the results to the entire sector at a national level, and the findings may not be applicable to medium- and large-scale manufacturing firms. ♦

References

1. Ahmad K and Zabri S M (2016), "Inventory Management Practices Among Malaysian Micro Retailing Enterprises", *Journal of Business and Retail Management Research*, Vol. 11, No. 1, pp. 103-115.
2. Ahmad K and Zabri S M (2018), "The Mediating Effect of Knowledge of Inventory Management in the Relationship Between Inventory Management Practices and Performance: The Case of Micro Retailing Enterprises", *Journal of Business and Retail Management Research*, Vol. 12, No. 2, pp. 83-93.
3. Atnafu D and Balda A (2018), "The Impact of Inventory Management Practice on Firms' Competitiveness and Organizational Performance: Empirical Evidence from Micro and Small Enterprises in Ethiopia", *Cogent Business & Management*, Vol. 5, No. 1, p. 1503219.
4. Barney J (1991), "Special Theory Forum the Resource-Based Model of the Firm: Origins, Implications, and Prospects", *Journal of Management*, Vol. 17, No. 1, pp. 97-98.
5. Bhatnagar R and Teo C C (2009), "Role of Logistics in Enhancing Competitive Advantage: A Value Chain Framework for Global Supply Chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 39, No. 3, pp. 202-226.
6. Bhatti S H, Ahmed A, Ferraris A *et al.* (2022), "Big Data Analytics Capabilities and MSME Innovation and Performance: A Double Mediation Model of Digital Platform and Network Capabilities", *Annals of Operations Research*. <https://doi.org/10.1007/s10479-022-05002-w>, pp. 1-24.
7. Buteau S (2021), "Roadmap for Digital Technology to Foster India's MSME Ecosystem—Opportunities and Challenges", *CSI Transactions on ICT*, Vol. 9, No. 4, pp. 233-244.
8. Chalotra V (2013), "Inventory Management and Small Firms Growth: An Analytical Study in Supply Chain", *Vision*, Vol. 17, No. 3, pp. 213-222.
9. Chan S W, Tasmin R, Aziati A N *et al.* (2017), "Factors Influencing the Effectiveness of Inventory Management in Manufacturing SMEs", *IOP Conference Series: Materials Science and Engineering*, Vol. 226, No. 1, p. 012024. IOP Publishing.
10. Chikan A (1990), "Characterization of Production-Inventory Systems in the Hungarian Industry", *Engineering Costs and Production Economics*, Vol. 18, No. 3, pp. 285-292.
11. Chikán A and Whybark D C (1990), "Cross-National Comparison of Production-Inventory Management Practices", *Engineering Costs and Production Economics*, Vol. 19, Nos. 1-3, pp. 149-156.
12. Demberere J and Kasongo R M (2021), "The Effectiveness of Supply Chain Management Practices on Manufacturing Micro, Small and Medium Enterprises

- (MSME) in Lusaka: A Case of Mandevu and Kalingalinga Markets", *Global Journal of Purchasing and Procurement Management*, Vol. 1, No. 1, pp. 1-21. <https://doi.org/10.1016/j.ijpe.2015.02.013>.
13. Du J, Zhang J and Hua G (2015), "Pricing and Inventory Management in the Presence of Strategic Customers with Risk Preference and Decreasing Value", *International Journal of Production Economics*, Vol. 164, pp. 160-166.
 14. Eloranta E and Raisanen J (1988), "Delivery Performance In Small-To-Medium-Scale Industry", *S. Production and Inventory Management Journal*, Vol. 29, No. 1, p. 50.
 15. Gupta H and Barua M K (2016), "Identifying Enablers of Technological Innovation for Indian MSMEs Using Best-Worst Multi Criteria Decision Making Method", *Technological Forecasting and Social Change*, Vol. 107, pp. 69-79.
 16. Hill C W and Jones G R (2011), *Essentials of Strategic Management*, Cengage Learning.
 17. Holweg M, Disney S, Holmström J and Småros J (2005), "Supply Chain Collaboration: Making Sense of the Strategy Continuum", *European Management Journal*, Vol. 23, No. 2, pp. 170-181.
 18. Howorth C and Westhead P (2003), "The Focus of Working Capital Management in UK Small Firms", *Management Accounting Research*, Vol. 14, No. 2, pp. 94-111.
 19. Kaewchura P (2021), "Role of Inventory Management on Competitive Advantage of Small and Medium Companies in Thailand", *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, Vol. 12, No. 8, pp. 2753-2759.
 20. Khurana S, Haleem A and Mannan B (2019), "Determinants for Integration of Sustainability with Innovation for Indian Manufacturing Enterprises: Empirical Evidence in MSMEs", *Journal of Cleaner Production*, Vol. 229, pp. 374-386.
 21. Kruger G A (2005), "A Statistician Looks at Inventory Management", *Quality Progress*, Vol. 38, No. 2, p. 36.
 22. Kumar D and Chandra D (2023), "A Hybrid Framework to Model Resilience in the Generic Medicine Supply Chain of MSMEs", *Benchmarking: An International Journal*. Vol. 30, No. 6, pp. 2189-2224. <https://doi.org/10.1080/09537287.2022.2131620>
 23. Kumar M, Raut R D, Mangla S K et al. (2022), "The Adoption of Artificial Intelligence Powered Workforce Management for Effective Revenue Growth of Micro, Small, and Medium Scale Enterprises (MSMEs)", *Production Planning & Control*, pp. 1-17.
 24. Lawson B and Samson D (2001), "Developing Innovation Capability in Organisations: A Dynamic Capabilities Approach", *International Journal of Innovation Management*, Vol. 5, No. 03, pp. 377-400.

25. Li S, Ragu-Nathan B, Ragu-Nathan T S and Rao S S (2006), "The Impact of Supply Chain Management Practices on Competitive Advantage and Organizational Performance", *Omega*, Vol. 34, No. 2, pp. 107-124.
26. Mangla S K, Luthra S, Mishra N *et al.* (2018), "Barriers to Effective Circular Supply Chain Management in a Developing Country Context", *Production Planning & Control*, Vol. 29, No. 6, pp. 551-569.
27. Meyer H (1991), "An Eight-Step Approach to Inventory Accuracy: A Case Study at Leviton Manufacturing Company", *Production and Inventory Management Journal*, Vol. 32, No. 2, p. 40.
28. Mohanty R P (1985), "Inventory Problems Under Multiple Constraints: Some Studies", *Engineering Costs and Production Economics*, Vol. 9, No. 4, pp. 355-367.
29. Muchaendepi W, Mbohwa C, Hamandishe T and Kanyepe J (2019), "Inventory Management and Performance of SMEs in the Manufacturing Sector of Harare", *Procedia Manufacturing*, Vol. 33, pp. 454-461.
30. Narayanapillai R (2013), "Inventory Management Practices in Small and Medium Machine Tool Enterprises in India: What Differentiate Between Enterprises?", *Asian Journal of Management*, Vol. 1, No. 01, pp. 05-11.
31. Natarajan R (1991), "Inventory Management-the Big Picture", *Production and Inventory Management Journal*, Vol. 32, No. 4, p. 29.
32. Ng S O E, Partington E C and Sculli D (1993), "A Computer System for Inventory Management of Lighting Products: A Case Study", *Computers in Industry*, Vol. 22, No. 1, pp. 71-79.
33. Orobia L A, Nakibuuka J, Bananuka J and Akisimire R (2020), "Inventory Management, Managerial Competence and Financial Performance of Small Businesses", *Journal of Accounting in Emerging Economies*, Vol. 10, No. 3, pp. 379-398.
34. Palange A and Dhattrak P (2021), "Lean Manufacturing a Vital Tool to Enhance Productivity in Manufacturing", *Materials Today: Proceedings*, Vol. 46, pp. 729-736.
35. Peel M J and Wilson N (1996), "Working Capital and Financial Management Practices in the Small Firm Sector", *International Small Business Journal*, Vol. 14, No. 2, pp. 52-68.
36. Pisano G and Teece D (1994), "The Dynamic Capabilities of Firms: An Introduction", *Industrial and Corporate Change*, Vol. 3, No. 3, pp. 537-556.
37. Porter M E (1998), "Clusters and the New Economics of Competition", *Harvard Business Review: Boston*, Vol. 76, No. 6, pp. 77-90.

38. Porter M E (1980), *Competitive Strategy*, Free Press, New York.
39. Rajeev N (2008), "Inventory Management in Small and Medium Enterprises: A Study of Machine Tool Enterprises in Bangalore", *Management Research News*, Vol. 31, No. 9, pp. 659-669.
40. Saratchandra M, Shrestha A and Murray P A (2022), "Building Knowledge Ambidexterity Using Cloud Computing: Longitudinal Case Studies of SMEs Experiences", *International Journal of Information Management*, Vol. 67, p. 102551.
41. Sharma A (2023), "Himachal Government Identifies 5 Sites for Setting Up Industrial Corridor in BBN Belt", *The Tribune*. Retrieved from <https://www.tribuneindia.com/news/himachal/5-sites-identified-for-setting-up-of-industrial-corridor-in-bbn-belt-467497> Accessed 14 June 2023.
42. Sinha P, Kumar S and Chandra C (2023), "Strategies for Ensuring Required Service Level for Covid-19 Herd Immunity in Indian Vaccine Supply Chain", *European Journal of Operational Research*, Vol. 304, No. 1, pp. 339-352.
43. Sprague L G and Wacker J G (1996), "Macroeconomic Analyses of Inventories: Learning from Practice", *International Journal of Production Economics*, Vol. 45, Nos. 1-3, pp. 231-237.
44. Syntetos A A, Nikolopoulos K and Boylan J E (2010), "Judging the Judges Through Accuracy-Implication Metrics: The Case of Inventory Forecasting", *International Journal of Forecasting*, Vol. 26, No. 1, pp. 134-143.
45. Upadhye N, Deshmukh S G and Garg S (2010), "Lean Manufacturing System for Medium Size Manufacturing Enterprises: An Indian Case", *International Journal of Management Science and Engineering Management*, Vol. 5, No. 5, pp. 362-375.
46. Vergin R C (1998), "An Examination of Inventory Turnover in the Fortune 500 Industrial Companies", *Production and Inventory Management Journal*, Vol. 39, No. 1, p. 51.
47. Wernerfelt B (1984), "A Resource-Based View of the Firm", *Strategic Management Journal*, Vol. 5, No. 2, pp. 171-180.
48. Widyastuti W, Asandimitra N and Artanti Y (2018), "Inhibiting Factors of Inventory Management: Study on Food and Beverage Micro Small and Medium Enterprises", *International Review of Management and Marketing*, Vol. 8, No. 1, pp. 64-67.

Appendix

Questionnaire

1. How often do you take inventory in your business?	
2. How many SKUs do you have as inventory?	
3. At what inventory level, do you reorder?	
4. What is your lead time for receiving inventory from suppliers?	
5. Our inventory levels are frequently too high, leading to excess carrying costs.	
6. Our inventory management system helps us to avoid stockouts.	
7. We regularly conduct physical inventory counts to ensure that our records are accurate.	
8. Our inventory carrying costs are reasonable.	
9. We maintain safety stock levels to ensure that we can meet unexpected demand.	
10. What methods do you use to track your inventory levels?	
11. What is your approach to managing excess inventory?	
12. What steps do you take to ensure accurate inventory counts?	
13. How do you handle stockouts or shortages?	
14. What is your approach to inventory forecasting?	
15. How do you manage inventory storage and organization?	
16. Which concept of inventory system is followed?	
17. Which factors mostly affect your inventory practices?	

Appendix (Cont.)

18.	Which method of procurement you follow for ordering inventory?	
19.	What are the factors that cause delay in controlling inventory practices in your business?	
20.	What are the most common problems you have faced in Baddi industrial area while managing inventory in your business?	
21.	How do you manage your finished goods inventory?	

Reference # 07J-2024-05-03-01

Copyright of IUP Journal of Operations Management is the property of IUP Publications and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.



**International Journal of Biology, Pharmacy
and Allied Sciences (IJBAS)**

'A Bridge Between Laboratory and Reader'

www.ijbas.com

THE ENANTIOSELECTIVE OXIDATION OF HETEROCYCLIC PROCHIRAL SULFIDES TO CHIRAL SULFOXIDES USING THE FUNGAL BIOCATALYSTS

DIVEKAR K¹, REKHA S^{*1}, SUNDARI PS², CHANDRASHEKHAR S³ AND BHAT VN²

1: Department of Pharmaceutical Chemistry, College of Pharmaceutical Sciences, Dayananda Sagar University, Bangalore, Karnataka, India

2: Department of Pharmacognosy, College of Pharmaceutical Sciences, Dayananda Sagar University, Bangalore, Karnataka, India

3: Department of Pharmaceutics, Dr. Ravi Patil College of Pharmacy, Belgaum, Karnataka, India

*Corresponding Author: Dr. Rekha. S; E Mail: rekha.maheshb@gmail.com

Received 19th Oct, 2022; Revised 16th Nov, 2022; Accepted 23rd March 2023; Available online 1st, Dec. 2023

<https://doi.org/10.31032/IJBAS.2023.12.12.7594>

ABSTRACT

Bioconversion of sulfoxidation of sulfides is gaining importance in synthetic chemistry as an alternative tool for the synthesis of enantiomeric sulfoxides.

Different micro organisms belonging to the class of fungi were selected for the study. The selected microorganisms include *Rhizopus stolonifer* MTCC 2198, *Rhizopus stolonifer* MTCC 2591, *Rhizopus stolonifer* MTCC 162, *Aspergillus niger*, *Aspergillus ochraceous*, *Aspergillus flavus*, *Saccharomyces cerevisiae* (Soil isolates) and *Baker's yeast* (Locally purchased).

The substrate chosen for biosulfoxidation was 5-Methoxy-2-[[[4-methoxy-3, 5- dimethyl-2-pyridinyl) methyl]-sulphonyl]-1H benzimidazole.

Among the selected microorganisms used for biosulfoxidation of the above mentioned substrate, *Rhizopus stolonifer* 2591 showed maximum conversion. *Rhizopus stolonifer* 2198 and *Aspergillus ochraceous* showed less conversion while no conversion was observed with *Aspergillus niger*. *Aspergillus flavus*, *Baker's yeast* and *Rhizopus stolonifer* 162. Hence, *Rhizopus stolonifer* 2591 was



Phytochemical Investigation and Evaluation of Antibacterial Activity of *Zizyphus Xylopyrus* (Retz) Willd Leaf Extract

Biswaranjan Das¹, Preeti Mangala², Neha Joshi³, Rahul Subhash Buchade⁴, Rekha S⁵,
Rajarshi Nath⁶, Abinash Kumar Sahu⁷, Arun Mittal⁸

¹Centurion University of Technology and Management, Gopalpur, Balasore, Odisha, India. 756044

²Department of Chemistry, Jyoti Nivas College Autonomous, Karamangala, Hosur Road, Bangalore, Karnataka. 560 095

³Assistant Professor, College of Pharmacy, Graphic Era Hill University, Dehradun Graphic Era Hill University, Bhimtal Campus, Nainital, Uttarakhand, 263136

⁴Department of Pharmaceutical Chemistry, SCES's Indira College of Pharmacy

"Nirumay", S.No.89/2A, New Pune Mumbai Highway, Tatkavade, Pune, Maharashtra, India. Orchid
id: 0000-0002-8825-0922

⁵Department of Pharmaceutical Chemistry, College of Pharmaceutical Sciences,
Dayananda Sagar University, Bangalore. 560078

⁶Department of pharmaceutical chemistry, Bharat Technology, Uluberia, Howrah, & JIS University,
81, Nilgunj Rd, Jagarata Pally, Deshpriya Nagar, Agarpara, Kolkata, West Bengal. 700109

⁷The Pharmaceutical College, Samalpur Vihar, Tingipali, Barpali, Bargarh, Odisha. 768029

⁸SRM Modi Nagar College of Pharmacy, SRMIST, Delhi-NCR Campus, Ghaziabad, Uttar Pradesh,
India. 201204

Article History

Received: 06 September 2023

Revised: 05 October 2023

Accepted: 11 November 2023

CC License
CC-BY-NC-SA 4.0

Abstract

An experiment was carried out to evaluate the antibacterial activity of the *Zizyphus xylopyrus* ethanolic fractions, which was related to the phytoconstituents present. The plant's root powder was extracted using an ethanol extraction procedure that involved several consecutive steps. Following this, the extracted product displayed a distinct scent feature. Tannic acid, phenol, and flavonoids were found, indicating the existence of the required phytochemicals. The flavonoids were isolated using spectroscopic characterization using the ethanolic extract. After then, this extract was used for additional pharmacological testing because in the study, only ethanolic extracts and saponins were used. Based on each sample's results from a variety of qualitative tests, this analysis was carried out. The discovery of new illnesses, especially those brought on by *Enterococcus* and *Staphylococcus* species, has sparked increased interest in the study of therapeutic plants in recent decades. These microorganisms have become resistant to widely used antibiotics and are the cause of a considerable proportion of hospital-acquired illnesses. For example, *S. aureus*, which was once sensitive to a number of antibiotics, is now showing signs of resistance to several medications.

Keywords: *Zizyphus xylopyrus*, Isolate Fraction, phytochemicals, bioactive compounds etc.



Phyto-Pharmacological Effects of Medicinal Plants for the Treatment of Depression

**Rekha S¹, Abhijeet Kumar², Monaf Kafel³, Md Rameez Ahmed K⁴, Sayesh Reji Mathew⁵,
Surya Harshitha S⁶, Muthukumaran T^{7*}**

¹Department of Pharmaceutical Chemistry, College of Pharmaceutical Sciences, Dayananda Sagar University, Bangalore, India

^{2,3,4,5,6}Scholar, College of Pharmaceutical Sciences, Dayananda Sagar University, Bangalore, India

⁷Department of Pharmacology, College of Pharmaceutical Sciences, Dayananda Sagar University, Bangalore, India

***Corresponding Author: Mr. Muthukumaran T**

***Assistant Professor, Department of Pharmacology College of Pharmaceutical Sciences Dayananda Sagar University, Bangalore, Karnataka Email: muthukumaran48@gmail.com, Phone: 8667529693**

Article History

Received: 4 Jan 2024

Revised: 30 Jan 2024

Accepted: 15 Feb 2024

Abstract

Background: Depression is a serious mental illness that has a significant impact on suicidal thoughts. It is ranked as the fourth most significant mental disability globally. Current research is concentrating on increasing the effectiveness of conventional treatments due to highly undesirable effects. Natural goods, herbal plants, and phytochemicals offer a wide range of study opportunities for antidepressant treatments.

Objective: The present study aim at the review of various phyto-Pharmacological effects of medicinal plants for the treatment of depression in a traditional approach

Methods: The methodology includes a thorough search of every electronic source to gather all information on herbal plants, pharmacological effects, and antidepressant mechanisms of phytochemicals from the year 2000 to 2023.

Results: Different plant metabolites were shown to have powerful antidepressant effects, including polyphenols (phenolic acids, flavonoids, lignans, and coumarins), alkaloids, terpenes and terpenoids, saponins and sapogenins. Major group of phytochemicals crucial in evaluating antidepressant effectiveness includes piperine, diterpene alkaloids, berberine, hyperforin, riparin derivatives, ginsenosides, and -carboline alkaloids. A great inhibitor of monoamine oxidase enzymes, an elevation in brain 5-HT and BDNF (Brain-Derived Nicotinic Factor) levels and modulatory effects on the hypothalamus-pituitary-adrenal axis were all demonstrated by piperine. Numerous studies have demonstrated berberine's serotonergic, noradrenergic, and dopaminergic effects, demonstrating the importance of phytochemicals from various sources in the treatment of depression.

Conclusion: All of the medicinal plants listed in this study's thorough review indicated the ability to cure depression using various traditional methods and a variety of processes. In order to discover potential natural, semi-synthetic, or synthetic antidepressants with fewer side effects, the structure-activity

ENHANCED DELIVERY OF HERBAL MEDICATIONS BY USING ETHOSOMES

A. Anita¹, Tanvi Jain², Chetna Saini³, Neha Devi⁴, Neelam Boora⁵, Muruli Krishna Kandukuri¹,
Sohan Lal⁶ and Deepika Aggarwal^{7*}

¹Dayananda Sagar University, Shavige Malleshwara Hill, Kumbhwanmy Layout, Bangalore - 560 078, India.

²Shri Ramswaroop Memorial University, Village - Hadauri, Post - Tindola, Lucknow-Deva Road, Barabanki - 225 103, India.

³Bharat Institute of Pharmacy, Pehlajpur, Babain, Dist. Kurukshetra - 136 156, India.

⁴United Institute of Pharmacy, Rurki, Kurukshetra - 136 156, India.

⁵Faculty of Pharmaceutical Sciences, Motherhood University, Roorkee - 247 661, Haridwar district, India.

⁶Guest lecturer in Botany, Government G.S.G P.G. College, Balod - 491 226, India.

⁷Corresponding author - Deepika Aggarwal, email : deepika.rlic@kuk.ac.in

(Received 11 February 2024, Revised 26 March 2024, Accepted 3 April 2024)

ABSTRACT : The use of herbal medications has been increasing in recent years due to their perceived safety and efficacy. However, the delivery of these medications can be challenging due to their poor solubility and bioavailability. Ethosomes, which are lipid-based vesicular carriers, have been shown to enhance the delivery of various drugs, including herbal medications. In this review, we will discuss the potential of using ethosomal formulations to improve the delivery of herbal medications. We will explore the advantages of using ethosomes, such as their ability to penetrate the skin and enhance drug absorption, and the challenges associated with their formulation and stability. Additionally, we will highlight recent studies that have investigated the use of ethosomes for delivering various herbal medications, including curcumin, resveratrol and quercetin. Overall, the use of ethosomes has the potential to revolutionize the delivery of herbal medications, providing patients with more effective and efficient treatment options. Challenges in the field, such as formulation optimization, regulatory considerations and scale-up, are addressed. Future directions for research and development are outlined, emphasizing advanced formulation technologies, biocompatible materials, personalized medicine and clinical translation.

Key words : Ethosomes, herbal medications, delivery system, optimization, future directions.

How to cite : A. Anita, Tanvi Jain, Chetna Saini, Neha Devi, Neelam Boora, Muruli Krishna Kandukuri, Sohan Lal and Deepika Aggarwal (2024) Enhanced delivery of herbal medications by using ethosomes. *Biochem. Cell. Arch.* 24, 541-552. DOI: <https://doi.org/10.51470/bca.2024.24.1.541>



INTRODUCTION

Traditional herbal medications have been used for centuries across cultures worldwide, offering a plethora of therapeutic benefits derived from natural sources. These remedies, often rooted in traditional knowledge, encompass a wide range of plants, herbs and botanical extracts known for their medicinal properties (Semalty *et al.*, 2007). However, despite their long-standing usage and potential efficacy, the delivery of herbal medications poses significant challenges, limiting their full therapeutic potential (Singh *et al.*, 2008). Throughout history, traditional herbal medications have played a crucial role in healthcare, serving as primary remedies for various ailments. Ancient civilizations such as the Chinese, Indian, Egyptian and Greek cultures extensively documented the use of herbs for medicinal purposes. These remedies

were often passed down through generations, forming the basis of traditional medicine systems (Koli and Lin, 2009). Herbal medications offer diverse therapeutic actions, including anti-inflammatory, antimicrobial, analgesic, and immunomodulatory effects. They are valued not only for their therapeutic efficacy but also for their perceived safety and relatively minimal side effects compared to synthetic drugs. However, the effectiveness of herbal medications is often hindered by challenges related to their formulation and delivery. Despite the rich therapeutic potential of herbal medications, their delivery poses several challenges that impede their efficacy. One of the primary challenges is the poor bioavailability of active herbal constituents (Chaturvedi *et al.*, 2011). Many herbal compounds exhibit low solubility and permeability, resulting in limited absorption and reduced therapeutic

RESEARCH ARTICLE

Design Development and Characterization of Nicardipine Solid Lipid Nano-Particulars

Kotha Kranthi Kumar^{1*}, Vema Kiran², Ram Kumar Choudhary³, Lalchand D Devhare⁴, Sachinkumar Dnyaneshwar Gunjal⁵

¹College of Pharmaceutical Sciences, Dayananda Sagar University Bengaluru, Karnataka, India.

²M.B. School of Pharmaceutical Sciences, Mahan Babu University, Tirupati, India.

³Government Pharmacy Institute, Agamkuan, Patna.

⁴Mamatakar College of Pharmacy, Ghodpeth, Tah.Bhadrayati, Chandrapur, Maharashtra, India

⁵Anuradhabai College of Pharmacy, Sangamner, Maharashtra State, India, Savitribai Phule Pune University

Received: 04th January, 2024; Revised: 16th January, 2024; Accepted: 18th February, 2024; Available Online: 25th March, 2024

ABSTRACT

The present work was designed and characterized nicardipine solid lipid nano-particles and formulated into capsule. The formulation was evaluated and stability also as per the specified limits. The nanoparticles were prepared by solid hydrophilic adsorbents. The obtained ratio of 1:1:1:2 of drugs, soy PC, DMPC, and labrasol shows the highest dissolved in water. The liquid form was converted into a solid product using an adsorbent like anhydrous lactose and aerosil 200. The above results indicated aerosil 200 containing which helped in enhanced dissolve state in water. The results indicated the formulation trial-6 %drug content -100.2, entrapment efficiency 84.13 ± 1.64 , zeta potential measurement 0.789 ± 0.32 , Drug release rate at 3rd hour 81.6% and relative bioavailability of optimized nanoparticle formulation (CNP-6) was significantly increased. As a result, the produced lipid-based formulation shown potential as a method for improving the transfer of lipophilic chemicals that are weakly water-soluble to the aqueous phase, hence improving oral bioavailability.

Keywords: Nicardipine, Soy PC, DMPC, Aerosil 200, Propylene Glycol, Tween-80.

International Journal of Drug Delivery Technology (2024); DOI: 10.25258/ijddt.14.1.12

How to cite this article: Kumar KK, Kiran V, Choudhary RK, Devhare LD, Gunjal SD. Design Development and Characterization of Nicardipine Solid Lipid Nano-Particulars. International Journal of Drug Delivery Technology. 2024;14(1):71-78.

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

The most common method of administration is still oral medication. Because it is convenient and avoids intravenous problems such catheter infection and thrombosis as well as hinders a good therapeutic outcome, oral administration does indeed improve patients' quality of life. Particularly, issues with low gastrointestinal solubility and chemical stability frequently lead to the less therapeutic effect.

Lipid-based Drug Delivery (LBDD)

offers a new approach to drug development can result in significant cost and time savings when it comes to getting a medicine to market.^{1,2}

It is possible to physical mixes and liquids can produced (be included into capsules directly, or changed into as well as tablet form), depending on the excipient^{3,4}(s) chosen and formulation methods. Evidence from the literature suggests that lipid-based effective in increasing the availability of compounds that are low-soluble.⁵

Super-saturating the GI tract's aqueous environment produces oil droplets with a large surface area and increased.

- Expanding membrane letting the tight connection open to let paracellular movement.
- A Solution of solid state is produced inside the carrier after particle size reduction to molecular size.

Advantages

- Increase the bioavailability of medications with limited water solubility or low membrane penetration capability by facilitating gastric absorption.
- Enhancement or modification of medication absorption and release,
- Preventing sensitive active compounds from deteriorating in the digestive system.
- Masking the unpleasant taste of medications taken orally. However, these formulations have several drawbacks, such as component and/or excipient stability when the product is held at a lower temperature.

*Author for Correspondence: kranthikumar.kota@gmail.com

[Home](#) [Journal of The Institution of Engineers \(India\): Series B](#) [Article](#)

An Imaging Prognosis Model for Particle Pollution

ORIGINAL CONTRIBUTION Published: 09 February 2024

Volume 105, pages 647–656, (2024) [Cite this article](#)

Journal of The Institution of
Engineers (India): Series B

[Aims and scope](#)[Submit manuscript](#)

[S. Pushpa Mala](#) [✉](#), [Suhiepha Sameer](#), [M. Sneha Shree](#) & [Sneha](#)

79 Accesses [Explore all metrics](#) →

Abstract

Although the ongoing evolution of evaluation methodologies within the realm of Artificial Intelligence has urged the growth of numerous solution models for environment, a definite solution to accurately predict and forecast the environmental conditions still persists. Currently, evaluating the amount of particle matter (PM) is done using control stations that are set up in specific locations and can only measure air quality to a certain degree. In this paper, IoT and ML techniques are employed to predict PM emissions and concentration levels. The proposed prognosis approach leverages ML algorithms and AI techniques to construct an evolving technique for predicting the concentration of PM_{2.5} from the image data, utilizing data from the regions with the highest observed PM_{2.5}



Few shot learning for cross domain ckd and prediction based on homomorphing filter with tuna swarm optimization

A. Stella¹ · P. Vasanthi Kumari^{1,2}

Received: 4 July 2023 / Revised: 12 January 2024 / Accepted: 21 January 2024

© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2024

Abstract

Chronic Kidney Disease (CKD) involves illnesses that harm your kidneys and lessen their capacity to maintain your health. Most of the supervised machine learning methods are employed to construct in-domain CKD prediction with the use of labelled datasets. However, employing a classifier that has been trained with labelled images for a certain domain to categorize a picture of CKD on a different domain sometimes leads to poor results, while images that are present in the training domain might not appear in the test domain. So, Deep learning approaches are developed for cross-domain CKD prediction. Initially, CT scans for CKD are gathered and pre-processed using homomorphing and frost filters to enhance the picture quality. A frost filter is utilized to eliminate noise from the original image, and a homomorphing filter is utilized to improve the image contrast level of the noise removal image. In a homomorphing filter, reflectance component values change much over the range between (0, 1). So, the optimal value of the reflectance component is selected based on tuna swarm optimization. Gradient vector flow is then used to segment the pre-processed picture. The segmented picture is then used as an input in the classification process. This model was created to identify cross-domain based CKD using a few shot learning model based on the Attentive Squeeze network (ASNet). According to the experimental study, the proposed approach achieves 96% of accuracy. Consequently, the developed model is the best option for detecting cross domain based CKD prediction with better accuracy.

Keywords Cross-domain CKD prediction · Frost filter · Homomorphing filter · Tuna swarm optimization · Gradient vector flow · Few shot learning · ASNet

✉ A. Stella
stella.a@vemanait.edu.in

P. Vasanthi Kumari
vasanthi-bca@dsu.edu.in

¹ Department of Computer Science & Engineering, School of Engineering, Dayananda Sagar University, Kanakpura Road, Udaypura, Bengaluru, Karnataka 560082, India

² Department of Computer Applications, Dayananda Sagar University, Hosur Rd, Kudlu Gate, Srinivasa Nagar, Hal Layout, Singasandra, Bangalore, Karnataka, India

1 Introduction

Chronic Kidney Disease (CKD) is a significant illness brought on by either pathology in the kidneys or decreased kidney functioning. The kidneys are two organs that resemble beans and measure roughly the size of a fist. On either side of the spine, one is located under the ribs [1]. The primary job of the kidneys is to eliminate waste and extra fluid from the body through urine. The kidneys filter 120–150 quarts of blood every day to create 1–2 quarts of urine. The process of excretion and re-absorption that occurs when producing urine is quite complicated [2]. To keep the chemical equilibrium in the body steady, this procedure is required. The kidneys are in charge of regulating the body's salt, potassium, and acidity levels. They also create hormones that have an impact on the operation of other organs [3]. In this case, a hormone produced by the kidneys, among other things which, stimulates the production of red blood cells and regulates the metabolism of calcium [4].

The steady deterioration of kidney cells over an extended period of time is referred to as chronic. Major renal failure caused by this illness results in the kidneys' loss of the ability to filter blood and a significant fluid accumulation in the body. As a result, the body's levels of potassium and calcium salts rise rapidly. High concentrations of these salts cause a number of different health problems in the body [6]. The condition known as CKD, which affects 14% of people globally, is a serious problem. A progressive reduction in kidney function over time is an indication of CKD. Despite the fact that over 2 million people needed kidney transplants or dialysis to survive, this figure may only reflect 10% of those who require medical care. Compared to breast or prostate cancer, chronic renal disease claims the lives of more people [7].

The glomerular filtration rate, which is influenced by creatinine level, gender, race, and age, is the main variable used to identify the phases of CKD. The functioning of the kidneys goes through five phases. Stage 1 of CKD, which is a serious disease brought on by either impaired kidney function or renal pathology. Since it emerges and manifests symptoms in the final stage, diagnosing it in the early stages is challenging. Early diagnosis and discovery are essential for establishing the prognosis for survival [9]. Because the symptoms are not well-presented in the initial phases of the disease, a timely diagnosis is delayed. Therefore, in order to increase the probability of patients surviving, early detection of chronic renal disease is essential [10]. To solve this issue, an automatic prediction system based on artificial intelligence methods is provided.

Most of the supervised machine learning methods [5, 8] are used to construct in-domain chronic kidney disease prediction with the use of labelled datasets. Earlier studies indicated how different CNN models, such as PANet [11], MMNet [12], and CANet [13], have been used for predicting CKD disease. But, cross domain based CKD prediction often results in poor performance. So, Deep learning approaches are developed for cross-domain chronic kidney disease prediction. But achieving better accuracy with reduced time complexity is quite difficult in most of the existing techniques. Hence, for attaining better and accurate prediction of cross domain based chronic kidney disease, deep learning based Few Shot Learning (FSL) with Attentive Squeeze Network (ASNet) is proposed. The major contribution of this research is given below.

- Deep learning based Few Shot Learning with Attentive Squeeze Network is developed for automatic cross-domain Chronic Kidney Disease (CKD) prediction.
- Frost filter and homomorphing filter are utilized for pre-processing the original image to improve the quality of the image.

- The performance of the homomorphing filter is improved by applying tuna swarm optimization for optimal selection of reflectance component.
- Gradient Vector flow is utilized for segmenting the pre-processed image to identify the region of the CKD disease.
- The segmented image is classified, and the disease is recognized using a few shot learning based Attentive Squeeze Network (ASNet) is developed.

The following sections of the study are organized as follows: Section 2 discusses many research publications associated with existing chronic kidney disease detection techniques. Section 3 provides a brief definition of the suggested methodology's description. The outcomes, as well as performance measures of the suggested framework, are described in Section 4. The entire research work is concluded in Section 5.

2 Literature review

To identify cross-domain based chronic kidney disease, several studies using different methods have been conducted. A few of the currently used strategies are reviewed here. Many of them have been explored.

Yildirim [14] constructed a multilayer perceptron using skewed data to forecast chronic kidney disease. Numerous applications, including data mining and decision-support systems which, heavily rely on neural networks. Backpropagation networks are common neural network topologies that may be trained to distinguish different patterns. The learning rate was a key factor that profoundly influences multilayer perceptrons, and sampling strategies may enhance the efficiency of classification algorithms. Backpropagation networks were common neural network topologies that may be trained to distinguish different patterns.

Chittora et al. [4] suggested a prediction of chronic kidney disease. In this method, seven classifier algorithms have been used to identify CKD illness. Complete characteristics, correlation based selection of attributes, wrapper approach, least absolute shrinkage and selection operator regression, synthetic minority over-sampling with complete characteristics, and synthetic minority over-sampling with chosen features which have the least absolute shrinkage and selection operator regression were all used in the computation of the results for each classifier. However, it was extremely expensive.

Maurya et al. [15] established a machine learning approach to assess the patient's kidney health. According to the severity of the illness, machine learning can automatically divide CKD into several phases using the recommended technique, which separates the causes of CKD. The objective was to use medical test results as input for a classification algorithm and a machine learning algorithm to prescribe an optimal diet for CKD patients. However, these methods had no apparent effect on the results.

Borisagar et al. [16] developed a back propagation neural network approach for predicting CKD. This neural network system was trained using a number of training techniques, with disease symptoms serving as its input. This trained neural network system was utilized to identify kidney illness in humans after being trained using backpropagation methods. The backpropagation techniques described here are capable of telling if a person is infected or not. Nevertheless, real-time detection applications do not work well with these methods.

Dritsas and Trigka [17] introduced a machine learning technique for forecasting the probability of developing CKD. Class balancing is done initially to resolve the uneven

distribution of the instances among classes. Next, characteristics are ranked and analyzed, and lastly, many ML models are trained and assessed using a variety of performance measures. But, it yields low accuracy with high complexity.

Singh et al. [18] introduced Deep Neural Network (DNN) to predict and diagnose chronic renal disease early. During testing, every value that was missing in the database was replaced with the average of the corresponding characteristics. With the help of the Recursive Feature Elimination (RFE) method, the crucial characteristics were chosen. Machine learning models received a set of characteristics to aid in classifying data. However, it takes a lot of time, and it was challenging.

Aljaaf et al. [19] developed a machine learning approach for predicting CKD in its early stages. Add the optimum subset of parameters using predictive analytics to direct machine learning to generate a number of predictive models. The greatest performance was obtained using four machine learning classifiers. However, there is a difference in the correlation between blood glucose and the class characteristic due to the overlapped region.

Ebiaredoh-Mienye et al. [20] proposed a machine learning approach that uses filter based feature selection for better CKD prediction. By combining a cost-sensitive AdaBoost classifier with an information gain based feature selection strategy, CKD may be detected. The qualities may be redundant and might make ML algorithms more complex, but it does not share equal weights in the diagnosis of a patient with CKD.

The aforementioned review has a lot of challenges in the prediction of cross domain based CKD disease. It is extremely expensive [4], these methods had no apparent effect on the results [15], real-time detection applications do not work well with these methods [16], it yield low accuracy with high complexity [17], it takes a lot of time and is challenging [18], there is a difference in the correlation between blood glucose and the class characteristic due to the overlapped region [19], they may be duplicated and raise the complexity of the ML algorithms since they may not have equal weights in the diagnosis of a patient with CKD [20]. In order to overcome these problems, cross do main based few shot learning is developed.

3 Proposed methodology

The gradual decrease of kidney function over months or years is known as chronic renal disease. Chronic renal disease is one of the most challenging illnesses to diagnose, and it is recognized by a steady reduction in kidney function. In order to avoid these concerns, the modern medical system developed various health monitoring systems to detect diseases at the initial stage. Prevention is the best method for enhancing the prognosis of chronic renal disease and is also employed to decrease the death rate globally. As a result, it is thought that automated prediction is crucial for determining whether or not a patient has renal disease. To identify chronic kidney disease, several machine learning methods have been utilized. But when there is a significant domain shift between the source domains and the destination domains, knowledge transfer can be extremely difficult. In order to overcome this issue, cross domain based chronic kidney disease using few shot learning is developed. The architecture of the proposed cross domain based disease prediction is depicted in Fig. 1.

To improve the quality of the original picture, CT scans for the chronic renal disease are gathered and pre-processed employing homomorphing and frost filter. Reflectance component values in homomorphing filtering changes much over the range between (0, 1). So, the optimal value of the reflectance component is selected based on tuna swarm optimization. Then the pre-processed image is segmented using gradient vector flow. The segmented

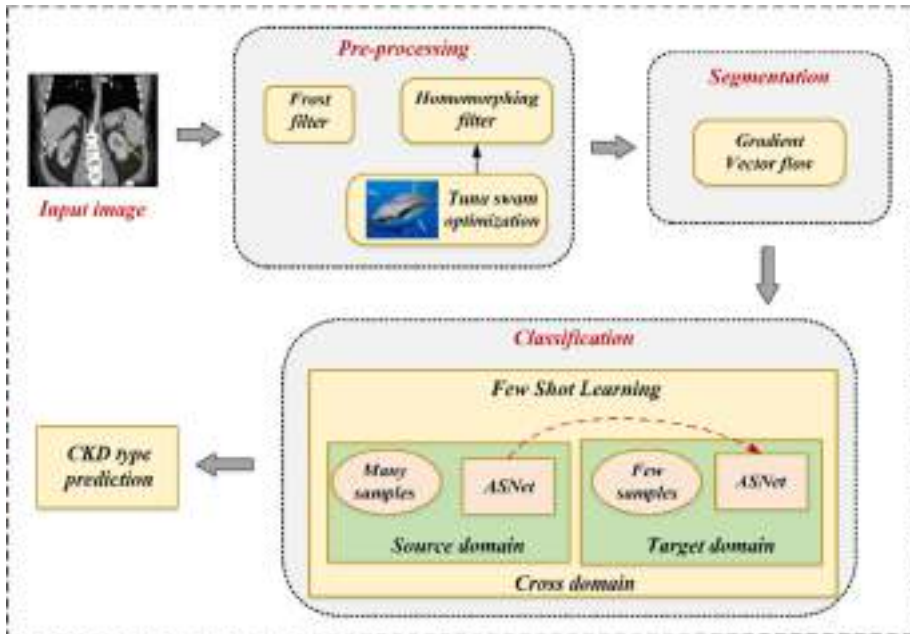


Fig. 1 Architecture of the proposed cross domain based CKD prediction

image is given as an input for the classification process. A classifier is an algorithm that organizes data into labelled informational groupings or categories. In this designed model, an Attentive Squeeze network (ASNet) based integrative few shot learning model is used to detect cross-domain based CKD.

3.1 Image pre-processing

Initially, CT images for chronic kidney disease are collected and pre-processed using a frost filter as well as homomorphing filtering to enhance the image quality.

3.1.1 Frost filter

Frost filter [21] is a linear convolutional filter that is exponentially weighted, adaptive, and capable of maintaining important texture information while decreasing multiplicative noise. The coefficient of variation, or the relationship between the local mean and local standard deviation of a distorted picture, serves as the basis for the filter. The substantially averaged weighted values in the immediate vicinity are used in place of the centre pixel value. Based on the variance of the local noise inside the kernel window, the weights are adjusted proportionally. The mathematical formulation for this filter is explained in Eq. (1)

$$FR = \sum_{m \times m} j \alpha f^{-\alpha|t|} \quad (1)$$

where $\alpha = \left(\frac{4}{m\sigma^2}\right) \left(\frac{\sigma^2}{K^2}\right)$ and $|t| = |Y - Y_0| + |Z - Z_0|$, normalizing constant is represented by parameter j , local variance is denoted by σ , coefficient of variance is denoted by σ , mean

of the image is represented by k , the size of moving kernel window is depicted by m and the variation of modulus from average value in the direction of y and z is represented by $|Y - Y_0| + |Z - Z_0|$.

3.1.2 Homomorphing filter

In order to improve low contrast medical pictures, Homomorphic filtering is a commonly employed technique [22]. Based on the illumination-reflectance framework, this filter operates. The illuminating component and the reflectance model can be employed to separate the picture into two halves. Ranges for the illumination and reflectance components are $0 < i(x, y) < \infty$ and $0 < r(x, y) < 1$, respectively. Because the amount of illumination is constant over the range, illumination components are considered low frequency components. Over the range of $(0, 1)$, reflection component values shift significantly. In the spatial realm, reflectance indicates edges and limits, whereas illumination indicates smoothness. Applying a logarithmic transformation to separate the components of illumination and reflectance. The mathematical formulation for this process is defined in Eq. (2).

$$\ln\{f(y, z)\} = \ln\{f_i(y, z)f_r(y, z)\} \quad (2)$$

where the illumination component is represented by $f_i(y, z)$ and the reflectance component is represented by $f_r(y, z)$. In Eq. (3) the Fourier Transform (F.T.) is employed to process frequency-domain images.

$$FT\{\ln\{f(y, z)\}\} = FT\{\ln\{f_i(y, z)\}\} + FT\{\ln\{f_r(y, z)\}\} \quad (3)$$

The above Eq. (3) can be simplified as Eq. (4)

$$F(u, v) = F_i(u, v) + F_r(u, v) \quad (4)$$

where, $F_i(u, v) = FT\{\ln\{f_i(y, z)\}\}$ and $F_r(u, v) = FT\{\ln\{f_r(y, z)\}\}$. Equation (5) provides the filtered output in the frequency domain.

$$S(u, v) = H(u, v) + F_i(u, v) + H(u, v)F_r(u, v) \quad (5)$$

where the frequency domain filtered output is depicted by $S(u, v)$, filter response in the frequency domain is represented by $H(u, v)$ and frequency domain image is denoted by $F_i(u, v)$. In H.F., choosing the right filter is crucial. The diagnosis of low contrast C.T. imaging requires contrast enhancement, which boosts high frequencies while suppressing low frequencies. For enhancing the contrast of C.T. images, a high pass filter is appropriate. The above goal has been achieved by using a Gaussian filter which is defined in Eq. (6)

$$H(u, v) = (f_h - f_L) \left[1 - e \left\{ -d \left(\frac{C(u, v)}{C_0} \right)^2 \right\} \right] + f_L \quad (6)$$

where slope control is represented by d , high frequency and low frequency gain is denoted by f_h and f_L . The distance between $(0, 0)$ and coordinates (u, v) is defined by $D(u, v)$, cut off frequency is defined by C_0 . To obtain a spatial domain picture, the high pass filtering and inverse Fourier transform are then employed.

$$IFT\{S(u, v)\} = IFT\{H(u, v) + F_i(u, v)\} + IFT\{H(u, v)F_r(u, v)\} \quad (7)$$

Above Eq. (7) can be simplified as in Eq. (8)

$$\ln\{S(y, z)\} = \ln\{h_i(u, v)\} + \ln\{h_r(u, v)\} \quad (8)$$

where the modified illumination and reflection component is defined as $h_i(u, v)$ and $h_r(u, v)$. The augmented picture is then rebuilt using the exponential function described in Eq. (9)

$$h(y, z) = \exp\{\ln\{S(y, z)\} = \ln\{h_i(u, v)\} + \ln\{h_r(u, v)\}\} \quad (9)$$

Contrast enhanced image $h(y, z)$ is given in Eq. (10)

$$h(y, z) = h_i(y, z) \cdot h_r(y, z) \quad (10)$$

where the modified illumination component is represented by $h_i(y, z)$ and reconstructed reflectance component is determined as $h_r(y, z)$. The reflectance component values in this reconstructed picture vary significantly between (0, 1). Thus, the optimal value is chosen utilizing tuna swarm optimization.

3.2 Tuna swarm optimization

Tuna is a predatory fish from the sea called tunni. There are several species of tuna, and they come in a wide range of sizes [23]. The top predators in the ocean, tuna, consume a range of surface and midwater species. Continuous swimmers and tunas have a special and effective swimming style known as the fishtail shape, in which the body remains rigid. Even though a single tuna moves extremely swiftly, it nevertheless reacts more slowly than the little fish. It will thus use the predation based group travel strategy. They hunt for and capture their prey using cunning. These organisms have developed a number of efficient and clever foraging techniques.

Spiral foraging represents the first tactic. Forcing their food into shallow water where they may be more readily attacked, tuna swim in a spiral configuration while eating. Parabolic foraging is the second tactic. Each tuna follows the one before it as it swims, creating a parabolic shape to encircle its prey.

Step 1: Initialization

Initialize the reflectance component based on the population of tuna swarms. Equation (11) contains the mathematical formulas used to represent the initialized procedure.

$$RC = \{RC_1, RC_2, \dots, RC_n\} \quad (11)$$

Boundary conditions: For the reflectance component, LB and UB ranges are [0, 1]

Step 2: Fitness function

Error minimization is the fitness function offered for this optimization approach. The fitness value is computed here using the error. Equation (12) provides the mathematical statement used to express the error function.

$$\text{fitness function} = \text{minimise}(E)$$

$$E = \frac{1}{2} \sum_{n=1}^N (y_n - z_n)^2 \quad (12)$$

In this Eq. (12), y_n stands for the projected value, z_n for the actual value, and E for the Mean Squared Error (MSE).

Step 3: Updation

The value is adjusted after every repetition until it reaches the ideal range. On the basis of Eq. (13) & (14), it can be modified. If $\text{rand} < 0.5$ means then the value gets updated based on Eq. (13) otherwise, it will get updated based on Eq. (14)

$$Y_j^{t+1} = \begin{cases} \beta_1 \cdot \left(Y_{best}^t + |Y_{best}^t - Y_j^t| \right) + \beta_2 \cdot Y_j^t, j = 1 \\ \beta_1 \cdot \left(Y_{best}^t + |Y_{best}^t - Y_j^t| \right) + \beta_2 \cdot Y_{j-1}^t, j = 2, 3, \dots, NP \end{cases} \quad (13)$$

$$Y_j^{t+1} = \begin{cases} Y_{best}^t + \text{rand} \cdot \left(Y_{best}^t - Y_j^t \right) + TF \cdot p^2 \cdot \left(Y_{best}^t - Y_j^t \right), \\ TF \cdot p^2 \cdot Y_i^t, \text{if } \text{rand} \geq 0.5 \end{cases} \quad (14)$$

where, Y_{best}^t is the present optimal individual, Y_i^{t+1} is the i^{th} individual of the $t + 1$ iteration, and β_1 and β_2 are coefficients of weight that regulate how likely it is for individuals to migrate towards the ideal individual and the preceding individual, respectively.

Step 4: Termination

A termination criterion is needed to stop the iterative process of the Tuna-swam optimization algorithm. The architecture for the proposed TSO is given in Fig. 2.

The above architecture depicts the flow diagram for tuna swarm optimization. Pseudocode for homomorphing filtering based on tuna swarm optimization is given in algorithm 1.

Input: Reflectance component ($RC_1, RC_2, \dots, RC_n$)
Begin
Initialize ($RC_1, RC_2, \dots, RC_n$)
While ($t < t_{\max}$)
 Calculate Fitness value = $\min(\text{error})$
 Update Y_{best}^t
 For (each tuna) do
 Update β_1, β_2, P
 If ($\text{rand} < 0.5$), then
 Update the position Y_i^{t+1} using Eqn. (13)
 Else if ($\text{rand} \geq 0.5$), then
 Update position Y_i^{t+1} using Eqn. (14)
 End for
 $t = t + 1$
 End while
 Return the best individual Y_{best}
Output: optimal reflectance component value is selected.

Algorithm 1 : Pseudocode for optimal selection of components in TSVD

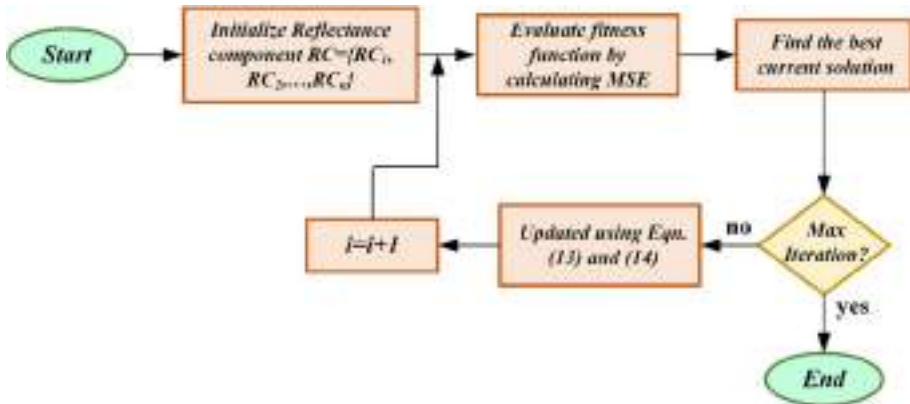


Fig. 2 Flowchart for Tuna Swarm optimization

3.3 Image Segmentation

Image segmentation is a typical method in digital image evaluation and processing that divides an image into a number of regions or segments depending on the properties of the pixels in the image.

3.3.1 Gradient vector flow

Gradient vector flow develops a new vector field that contains information about the positions of object edges throughout the whole image domain by spatially extending the edge map gradient vectors [24]. An elastic contour initialized in the picture domain by the user or the heuristic criteria $P(m) = (P(m), Q(m))$, $m \in [0, 1]$ is used to estimate the object boundary. The differential Eq. (15) modifies the elastic shape.

$$\frac{dX_{(c,t)}}{dt} = F_{int}(X_{(c,t)}) + V_{int}(X_{(s,t)}) \quad (15)$$

where internal force is represented as F_{int} , similar to the one used in traditional snakes, tries to keep the shape's continuity and smoothness and $V = (a(m, n), v(x, y))$ is the GVF field. In order to permit long-range attraction of the shape towards the object border though the contour is located in a uniform region where the gradient is zero, the gradient vector flow field is a regularised form of the edge gradient or image gradient. By decreasing the energy, V can be obtained, and it can be calculated by using Eq. (16)

$$E = \iint \mu(u_x^2 + u_y^2 + v_x^2 + v_y^2) + |\nabla f|^2 |v - \Delta f|^2 dx dy \quad (16)$$

This serves as an illustration of a variation formulation of regularisation. The variable, which is modified in accordance with the amount of noise present in the image, modifies the trade-off between the first and second terms of the integrand. The energy is also dominated by the sum of the gradient's partial derivatives when the edge gradient is low and by the second term when the edge gradient is large. In this case, setting $v = \Delta f$ minimizes the energy. The

GVF field can be demonstrated using the calculus of variations by demonstrating how the pair of Euler representations are derived using Eq. (17) and (18)

$$\mu \Delta^2 u - (u - f_x) (f_x^2 + f_y^2) = 0 \quad (17)$$

$$\mu \Delta^2 v - (v - f_y) (f_x^2 + f_y^2) = 0 \quad (18)$$

where the total mean is denoted as μ , the laplacian operation is denoted as Δ^2 and the initialization of the gradient vector flow snake is automated.

3.4 Combined feature extraction and classification

The segmented image is given as an input for the classification process. In this designed model, based few shot learning based Attentive Squeeze network (ASNet) model is used to detect chronic kidney disease based on extracted features.

3.4.1 ASNet

The core component of ASNet is the attentive squeezing layer which accepts a correlation tensor and outputs a higher level of correlational representation [25]. As input, ASNet receives the pyramidal cross correlation tensors among the query and the feature pyramid of the supporting picture. Pyramidal AS layers get input from pyramidal correlations, which gradually diminish the support image's dimension space. In a bottom-up strategy, pyramidal outcomes are combined to create a final foreground map. Architecture of ASNet is shown in Fig. 3.

In order to create an initial segmentation mask for every support input, the system initially constructs N.K. hyper correlations among the query and every support image. A CNN's stacked convolutional layers, which are fed the input image, are used to form a feature pyramid by combining the intermediate to highest level resultant characteristic maps. The correlation tensors size $H_i^{(l)} \times W_i^{(l)} \times H_j^{(l)} \times W_j^{(l)}$ are calculated by determining the cosine similarity between every pair of characteristic maps, which was constructed using Eq. (19).

$$D^{(l)}(S_i, S_j) = ReLU \left(\frac{G_i^{(l)}(S_i) \cdot G_j^{(l)}(S_j)}{\| G_i^{(l)}(S_i) \| \| G_j^{(l)}(S_j) \|} \right) \quad (19)$$

A hyper correlation pyramid is created by concatenating the tensors from every group along a new channel dimension to organize these L correlation sensors into S , and G are groups of similar spatial sizes.

3.5 Attentive squeeze layer

The AS layer employs strided self-attention to transform a correlation tensor into another using a decreased support dimension. A matrix is created from the tensor, with each column standing for a support pattern. In a hyper correlation pyramid, given a correlation tensor $D \in R^{H_i \times W_i \times H_j \times W_j \times D_m}$, the correlation tensor is reshaped as a block matrix of size $H_i \times W_i$, with every component representing a correlation tensor of $D(Y_i) \in R^{H_j \times W_j \times D_m}$ on the query location Y_i .

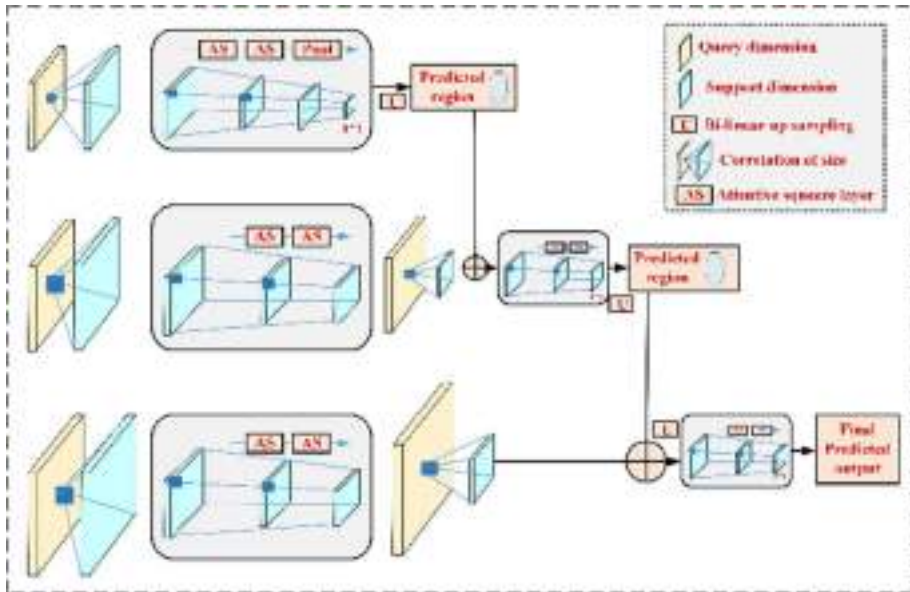


Fig. 3 Architecture of ASNet

$$D^{block} = \begin{bmatrix} D((1, 1)) & \cdots & D((1, W_i)) \\ \vdots & \ddots & \vdots \\ D((H_i, 1)) & \cdots & D((H_i, W_i)) \end{bmatrix} \quad (20)$$

An AS layer analyses the global environment for every support correlation tensor in order to derive a correlational representation with a decreased support dimension while maintaining the query dimension. Use the global self-attention technique for correlational feature transform to grasp each support correlation's structure. All query locations share and process the self-attention weights concurrently.

To control the output size, three convolutions with strides larger or similar to one are utilized. Then, an attention framework is computed using the output target and key correlated depictions, T and K . The following matrix multiplication, which is described in Eq. (21) is used to determine the attentive context.

$$A = TK^T \epsilon R^{H_j' \times H_j' \times H_j' \times H_j'} \quad (21)$$

After utilizing softmax to normalize the attention context, the votes on significant foreground places sum up to one with the masked attention supplied by the support masking annotation X_j , if accessible, to focus more attention on the foreground region described in Eq. (22)

$$A(P_i, P_k) = \frac{\exp(A(P_i, P_k)X_j(P_k))}{\sum_{P_k'} \exp(A(P_i, P_k')X_j(P_k'))} \quad (22)$$

The attention layer is fed to a fully connected layer to predict chronic kidney disease. The mathematical formulation for the output layer is computed by using Eq. (23)

$$D'' = \varphi\left(W_{FF}\left(D_0^j\right)+D_0^j\right) \epsilon R^{H_j' \times W_j' \times D_{out}} \tag{23}$$

By using this few shot learning based Attentive Squeeze network, chronic kidney disease is predicted effectively. Pseudocode for the proposed cross-domain based chronic kidney disease prediction.

4 Result and discussion

The developed cross-domain based few shot learning with an attentive squeeze network model is utilized to detect and recognize chronic kidney disease. The testing is performed with the help of Python 3.8 with CPU: Intel core i5, GPU: Nvidia GeForce GTX 1650, RAM: 16 GB. C.T. images related to kidney diseases are collected through the Kaggle dataset [26]. Overall 12,446 images are present in this input dataset. It has four different classes such as 3709 cyst, 5077 normal, 1377 stone and 2283 tumor samples.

In this designed model, C.T. images are collected and pre-processed to enhance the quality of the image to predict accurately. These pre-processed images are segmented to select the appropriate region of the image. The segmented image is classified using a few shot learning based ASNet. Table 1 shows the simulation parameters for ASNet. The simulation parameter of ASNet and tuna swarm optimization is given in Tables 1 and 2.

Table 1 shows the simulation parameter of ASNet. In this proposed approach, the learning rate of this classifier is represented as 0.001, and the optimizer is referred to as Adam, Epoch set for the proposed approach is 5, the batch size is referred to as 10, and the activation function is referred to as ReLU.

Table 2 shows the parameter of tuna swarm optimization. In this optimization, the number of particles is referred to as 50, the maximum iteration is referred to as 100, the upper limit is specified as -25, and the lower limit is specified as 25. The homomorphing and frost filters are employed to pre-process the input pictures. Then, gradient vector flow is utilized to segment the pre-processed image. The sample pre-processed, and segmented images are shown in Fig. 4.

Figure 4 shows the sample pre-processed and segmented images. By using this approach, the image quality can be improved compared to other existing approaches.

4.1 Performance analysis for noise removal

Noise removal performance is compared with some performance metrics such as Peak-Signal Noise Ratio (PSNR), Mean Square Error (MSE) and Average Gradient (A.G.). The

Table 1 Parameters of ASNet

Parameters	range
Learning rate	0.001
Optimizer	Adam
Epoch	5
Batch size	10
Activation function	ReLU

Table 2 Parameters of tuna-swarm optimization

Parameters	Range
Number of particles	50
Maximum iteration	100
Upper limit	-25
Lower limit	25

proposed Frost Filter (F.F.) was compared with current approaches such as Anisotropic Diffusion (A.D.), Median Filter (M.F.), Bilateral Filter (B.F.) and Gaussian Filter (G.F.) to evaluate the performance of image denoising.

A comparison of PSNR with various proposed and current noise removal approach is shown in Fig. 5. PSNR value for the proposed noise removal frost filter is 48.41 dB, and other existing strategies such as A.D., M.F., B.F. and G.F. and it has a value of 41.2, 36.2, 32.4, and 28.6. Figure 6 shows the comparison of MSE. The developed F.F. filter has 0.0481 value of MSE, and other existing approaches such as A.D. has 0.0898, M.F. has 0.1112, B.F. has 0.1424, and G.F. has 0.1727. A.G. comparison is illustrated in Fig. 7. A.G. value for the proposed F.F. approach is 51.7, but other current frameworks such as A.D. has 46.2, M.F. has 43.46, B.F. has 40.01, and G.F. has 38.87. If the PSNR and A.G. values are low means, then the noise present in the input image was not eliminated properly. So, compared to other current approaches such as A.D., M.F., B.F., and G.F. proposed, F.F. provides better performance.

4.2 Performance analysis for contrast enhancement

Contrast enhancement performance is evaluated and compared with the proposed Homomorphing Filter (H.F.) was compared with current approaches such as Reformed Histogram Equalization (RHE), Adaptive Histogram Equalization (AHE), Global Histogram Equalization (GHE) and Local Histogram Equalization (LHE) based on some performance metrics such as Signal Noise Ratio (SNR), Root Mean Square Error (RMSE) and Correlation Coefficient (CC).

Figure 8 compares the RMSE with various proposed and existing approaches. Proposed H.F. has an RMSE value of 0.076 which is low than current frameworks like A.D., M.F., B.F., and G.F., and has a value of 0.094, 0.132, 0.152, and 0.184. A comparison of CC is shown in Fig. 9. The suggested H.F. has a CC value of 0.83, whereas other current approaches, including A.D., M.F., B.F., and G.F., have CC values of 0.79, 0.76, 0.71, and 0.672, respectively. SNR comparison is shown in Fig. 10. 53.83 dB value is achieved for the proposed H.F., which is high compared to other current approaches such as A.D., M.F., B.F. and G.F., which has a value of 44.21, 39.42, 35.6, and 31.4.

The suggested optimization algorithm's convergence graph is shown in Fig. 11. The suggested optimization's fitness function is calculated using Mean Square Error, which is based on calculating the difference between the expected and observed values as determined by the produced search agents over the whole training set. The fitness for the proposed TSO is 0.2% in the 100th iteration.

Figure 12 displays the confusion matrix for the proposed approach. A confusion matrix is used to verify the classification technique's accuracy. Four different classes (Normal, cyst, stone, tumour) based on CKD are considered to analyze the performance of the

Input image	Pre-processed image		Segmented image
	<i>Frost filter</i>	<i>Homomorphing filter</i>	<i>Gradient vector flow</i>
			
			
			
			
			
			
			
			
			
			

Fig. 4 Sample pre-processed and segmented images

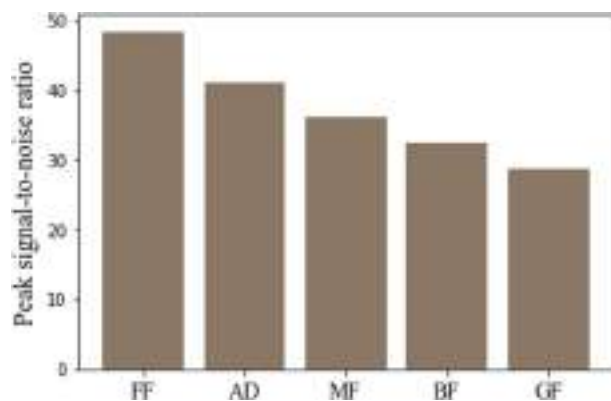
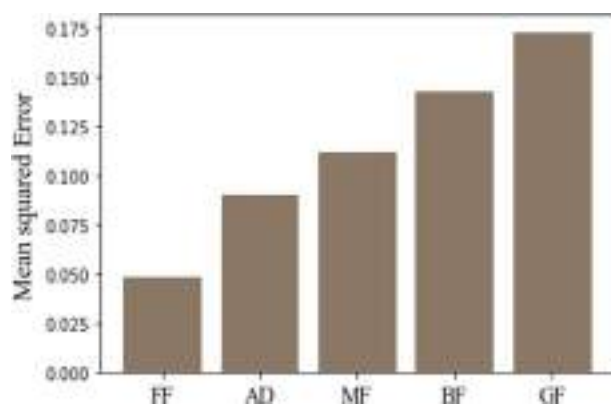
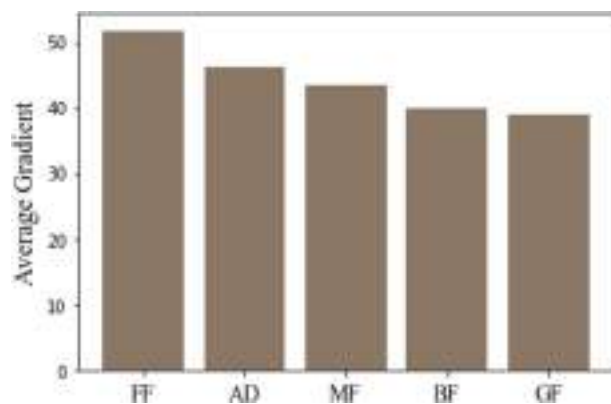
Fig. 5 Comparison of PSNR**Fig. 6** Comparison of MSE**Fig. 7** Comparison of A.G.

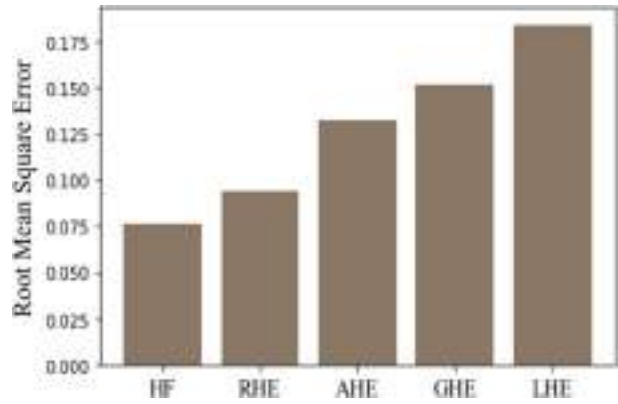
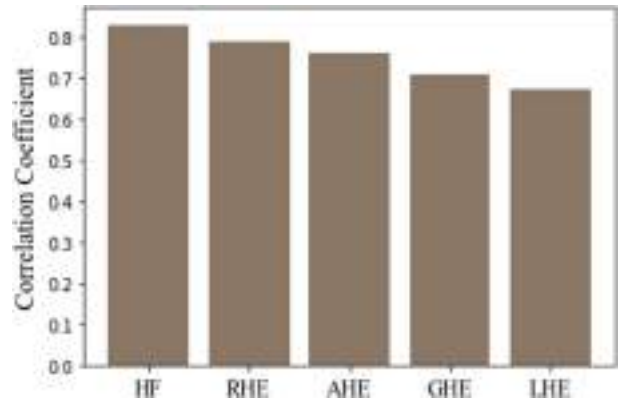
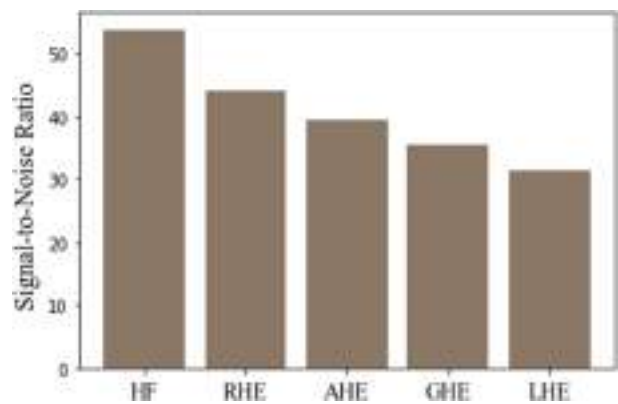
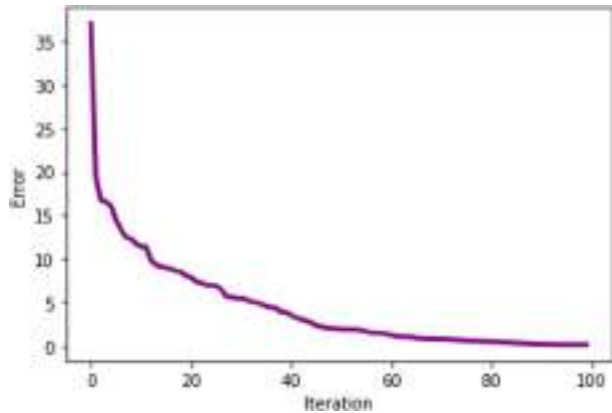
Fig. 8 Comparison of RMSE**Fig. 9** Comparison of CC**Fig. 10** Comparison of SNR

Fig. 11 Convergence for TSO

classifier. The predicted values for class 0 is 7, class 1 is 7, class 2 is 8, and for class 3 is 8 respectively.

Figure 13 displays an AUC and ROC plot of the proposed method. The effectiveness of the model's capacity to distinguish among classes is shown by the ROC curve, which is also a probability curve.

A comparison of accuracy for various training epochs is depicted in Fig. 14. For this proposed classifier, the epoch is 10 means then the accuracy value is 96%. If the epoch value is increased means, then the training accuracy of the proposed model also increased. Similarly, validation accuracy is plotted, which is depicted in Fig. 15. A comparison of loss for various training epochs is depicted in Fig. 16. For this proposed classifier, the epoch is 10 means then the loss value is 4%. If the epoch value is increased means, then the training loss is decreased. Similarly, a validation error is plotted, which is depicted in Fig. 17.

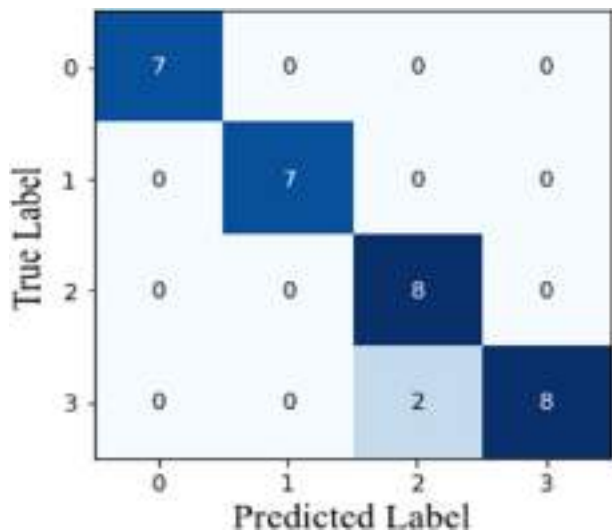
Fig. 12 Confusion matrix plot

Fig. 13 ROC plot

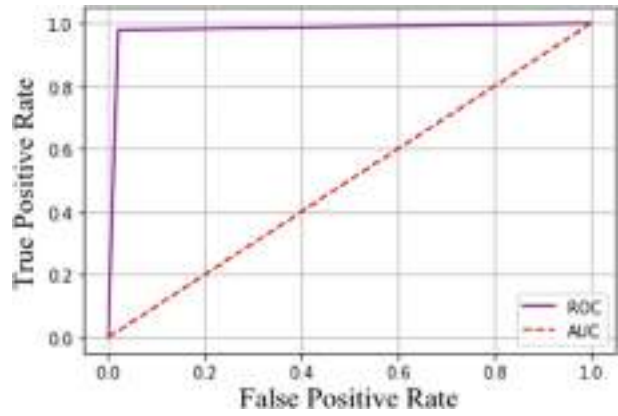


Fig. 14 Training accuracy

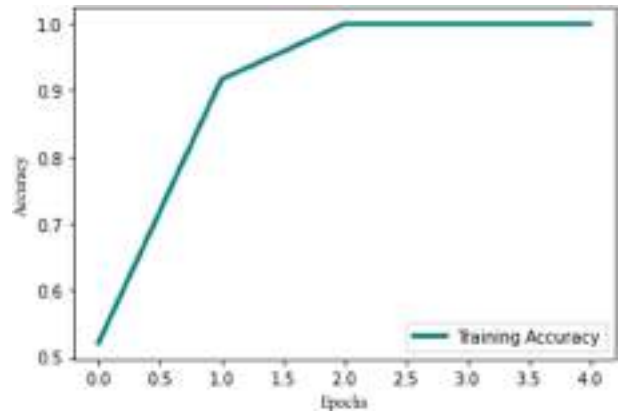


Fig. 15 Validation accuracy

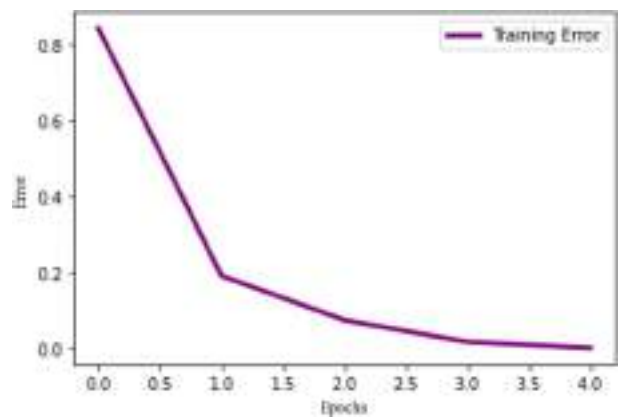
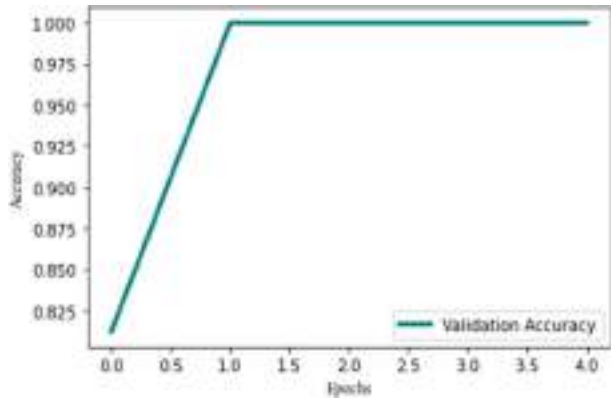
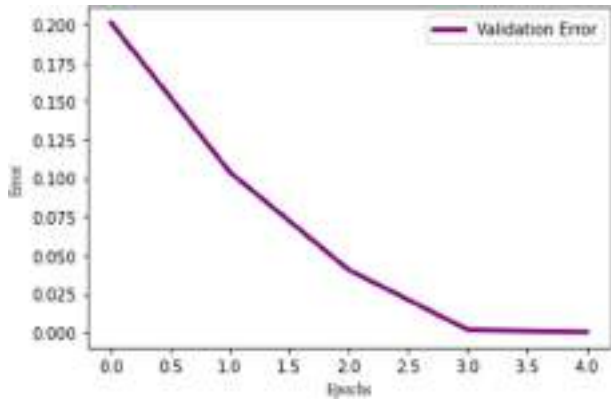


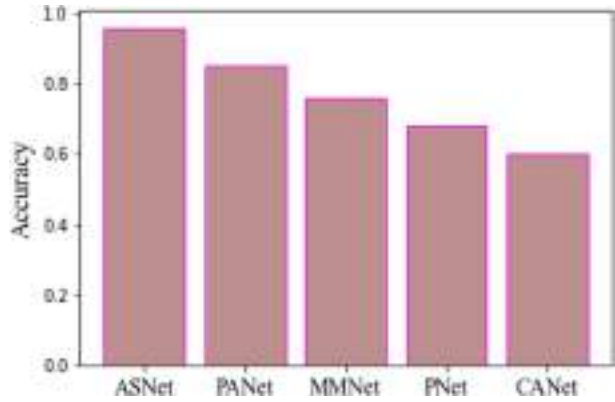
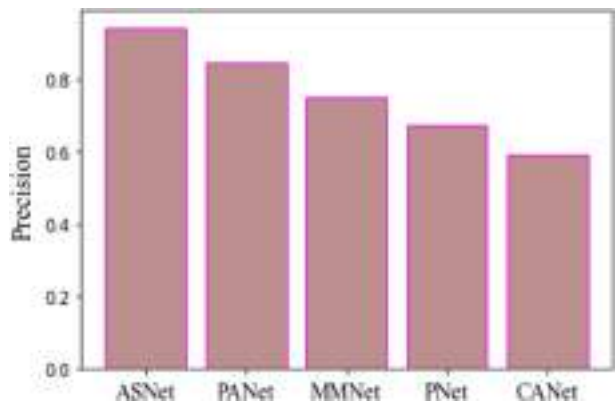
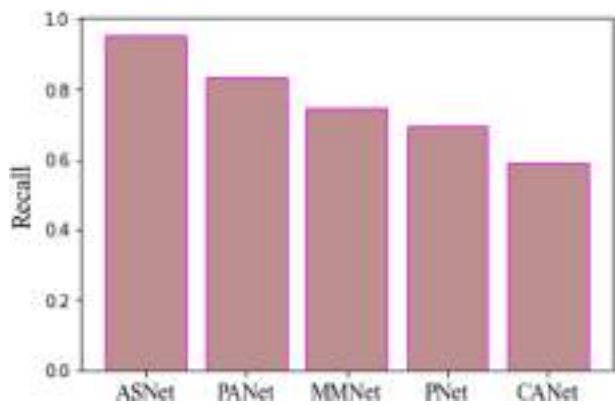
Fig. 16 Training error**Fig. 17** Validation Error

4.3 Comparison analysis

This proposed few shot learning based ASNet is compared with existing classifiers like Prototype alignment Network (PANet), Meta class Memory Network (MMNet), Part aware Prototype Network (PNet) and Class Agnostic Network (CANet). The performance metrics used for comparison between proposed and existing classifiers are accuracy, precision, recall, error, specificity, FOR, F1_Score, FDR, NPV, FNR, kappa, MCC and FPR.

The accuracy evaluation between the proposed approach and different previous approaches are shown in Fig. 18. The accuracy obtained using current approaches like PANet, MMNet, PNet, and CANet are 0.85, 0.76, 0.68, and 0.60, respectively. The suggested ASNet approach has a 96% accuracy rate. Figure 19 shows the comparison of precision metric. The precision value attained for the designed classifier is 0.94, but other current approaches, such as PANet has 0.84, MMNet has 0.75, PNet has 0.67, and CANet has 0.59.

Recall comparison for various proposed and current approaches are depicted in Fig. 20. The recall value is 0.95, which is significantly greater than the recall values of other current techniques like PANet, MMNet, PNet, and CANet, which are 0.83, 0.74, 0.69, and 0.58. Figure 21 shows the comparison of specificity. The specificity value for

Fig. 18 Accuracy comparison**Fig. 19** Precision comparison**Fig. 20** Recall comparison

the proposed approach is 0.97, but other current approaches PANet attain 0.86 MMNet attain 0.77, PNet attains 0.69, and CANet attains 0.61.

The F1-score comparison is shown in Fig. 22. 93% f1-score value achieved for the proposed classifier is 0.95, and other existing approach has a value of 0.84, 0.72, 0.67, and

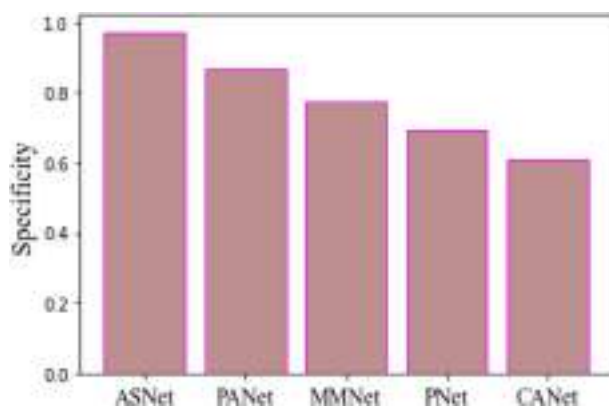
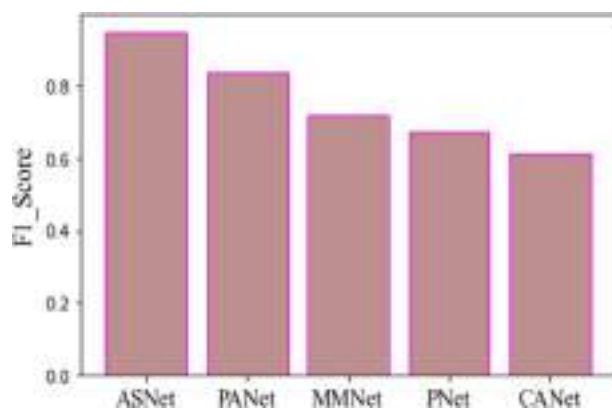
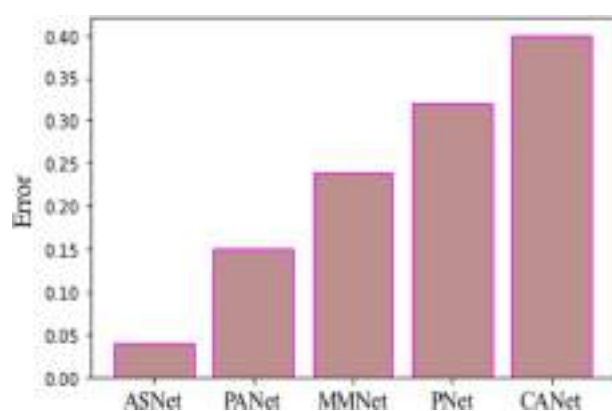
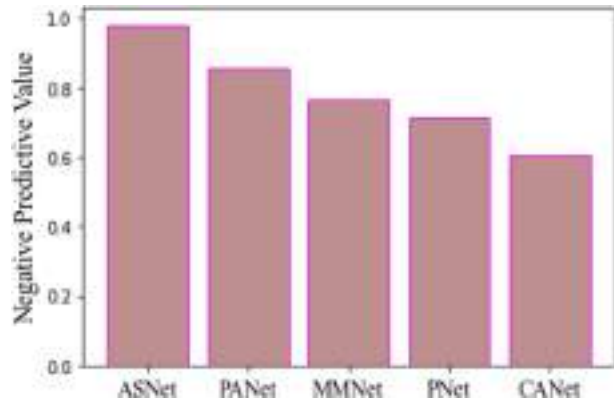
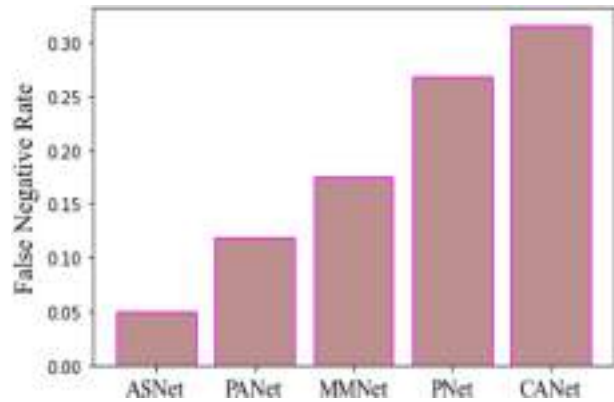
Fig. 21 Specificity comparison**Fig. 22** F1-score comparison**Fig. 23** Error comparison

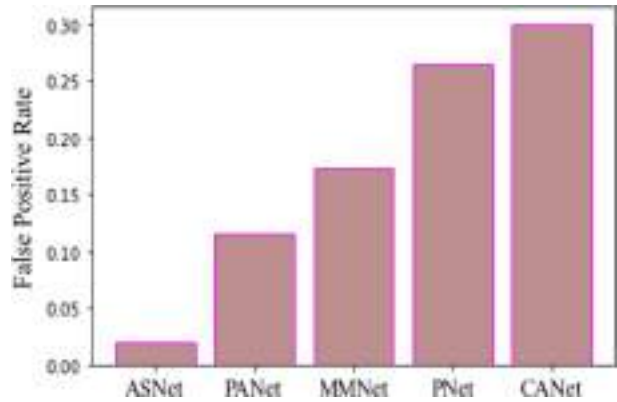
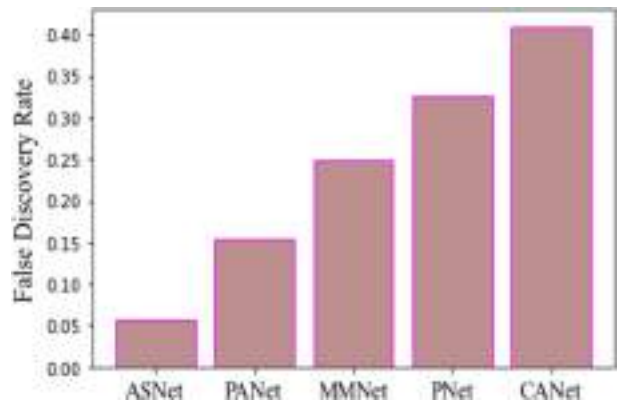
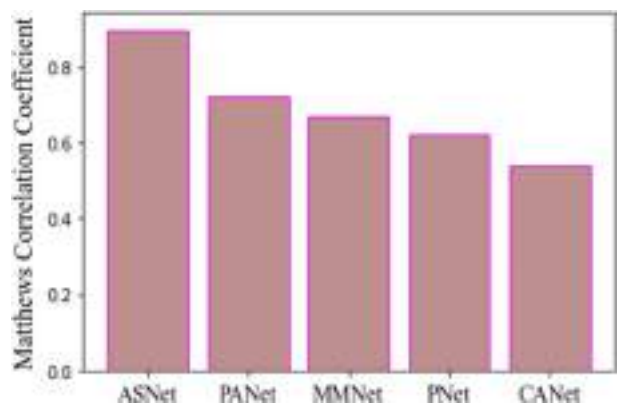
Fig. 24 NPV comparison**Fig. 25** FNR comparison

0.61. Figure 23 shows the evaluation of the error. The error percentages observed by prior techniques like PANet, MMNet, PNet and CANet are 15%, 24%, 32%, and 40%. The % error value obtained for the proposed ASNet approach.

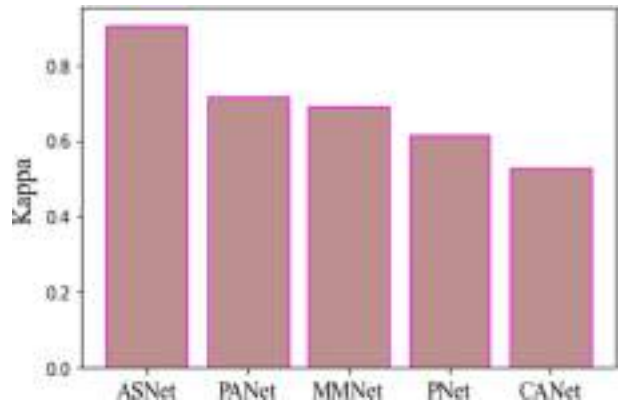
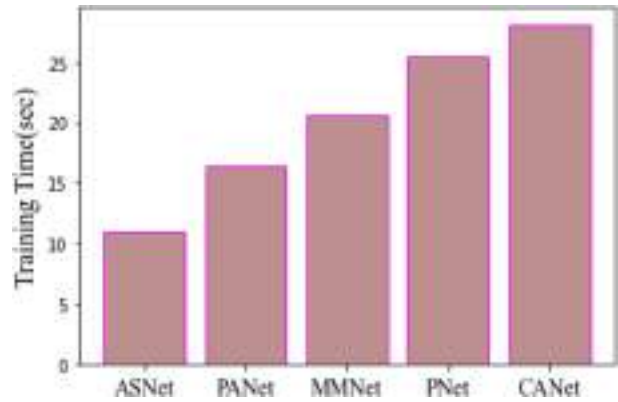
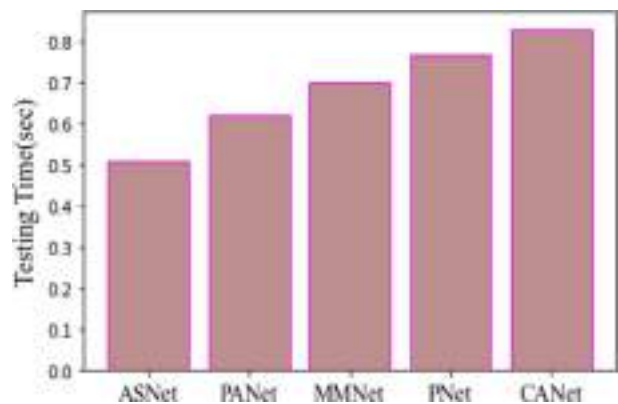
NPV comparisons are illustrated in Fig. 24. The proposed approach has 0.97 of NPV value, but the current approaches, such as PANet, MMNet, PNet and CANet, yield low NPV value that is 0.85, 0.76, 0.71, and 0.60, which shows the effectiveness of the proposed approach in the detection of CKD. A comparison of FNR is shown in Fig. 25. NPV value attained for the proposed and current approaches is 0.05, 0.11, 0.17, 0.26, and 0.31.

A comparison of the FPR metric is shown in Fig. 26. The FPR value achieved for the proposed ASNet is 0.02, but the current approach has 0.11, 0.17, 0.26, and 0.30. FDR comparison is depicted in Fig. 27. The proposed approach yield 0.04 FNR value, but current approaches such as PANet, MMNet, PNet and CANet has 0.11, 0.17, 0.21, and 0.28.

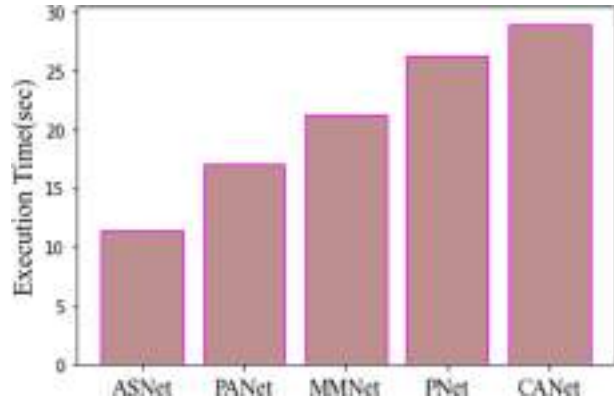
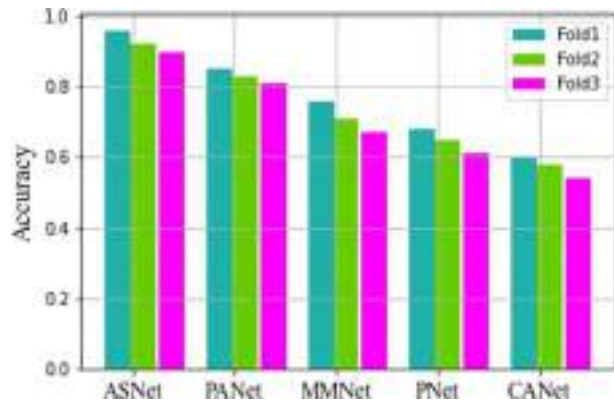
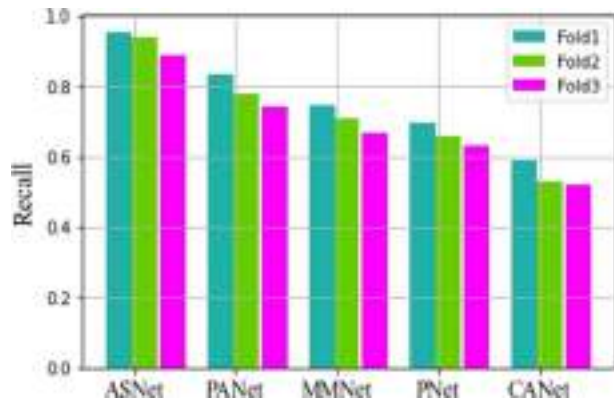
MCC and Kappa comparison is shown in Figs. 28 and 29. The MCC value obtained for the developed framework is 0.89, but other frameworks such as PANet, MMNet, PNet and CANet whose values are 0.72, 0.67, 0.62, and 0.54. The kappa value attained for the proposed ASNet is 0.9057, but other existing approach has a low value that is 0.71, 0.68, 0.61, and 0.52.

Fig. 26 FPR comparison**Fig. 27** FDR comparison**Fig. 28** MCC comparison

Training time comparison is shown in Fig. 30. The proposed approach takes 10.91 s for training, and other current approaches whose values are 16.43 s, 20.57 s, 25.45 s, and 28.12 s. Figure 31 shows the comparison of testing time. Testing time attained for the

Fig. 29 Kappa comparison**Fig. 30** Training time comparison**Fig. 31** Testing time comparison

proposed approach is 0.51 s, but other current approaches PANet has 0.62 s, MMNet has 0.70 s, PNet has 0.77 s, and CANet has 0.83 s. A comparison of execution time is shown in Fig. 32. The proposed approach taken 11.42 s, but other existing approaches such as PANet, MMNet, PNet and CANet taken 17.05 s, 21.4 s, 25.22 s and 28.95 s for execution.

Fig. 32 Execution time comparison**Fig. 33** Cross validation using accuracy**Fig. 34** Cross validation using recall metric

Cross validation by employing accuracy metric is shown in Fig. 33. It explains the performances of proposed and current approaches by considering three different folds. Fold 1 indicates 80% training and 20% testing, Fold 2 indicates 70% training and 30% testing and Fold 3 indicates 60% training and 40% testing. The proposed approach produce better accuracy in Fold 1. Similarly, Fig. 34 shows the cross validation by employing recall

metrics. It has high recall value when considering 80% training and 20% testing samples. This shows that the proposed approach produces better performance.

5 Conclusion

Deep learning based Attentive Squeeze network is developed to recognize the cross domain based CKD prediction using C.T. images. The illness known as CKD significantly impairs the kidney's ability to function normally. In this situation, a protracted period of time might result in worsening kidney function or kidney failure. Therefore, it's important to identify the condition and any distinct stages that the patient may be experiencing. When CKD occurs, it can sometimes lead to consequences, including anaemia, high blood pressure, nerve damage, brittle bones, heart difficulties, or blood vessel issues, among others. Through accurate forecasting, diseases are detected early, and patients' quality of life is improved. The greatest ways to increase survival rates include accurate prognosis, early diagnosis, and effective treatment. The most commonly used automated prediction model for detecting in-domain based CKD is a different machine learning algorithm. Thus, deep learning algorithms are being explored for cross-domain chronic kidney disease prediction. Yet, the majority of the techniques currently in use make it very difficult to get improved accuracy with less time complexity. Generally, to save people's life and decrease the death rate of this patients, a deep learning based automated prediction model is employed. Frost and homomorphing filters are used in the pre-processing of C.T. images for CKD to improve the quality of the original picture. A frost filter is employed to eliminate the noise from the image, and a homomorphing filter is employed to enhance the image contrast level. This filter functions using the illumination and reflectance component. The components of lighting are regarded as low frequency components since the amount of illumination is consistent across the range. And reflectance component values changes much over the range between (0, 1). So, the optimal value of the reflectance component is selected based on tuna swarm optimization. Then the pre-processed image is segmented using gradient vector flow. By spatially extending the edge map gradient vectors, an approach known as gradient vector flow creates a new vector field that contains details on the locations of object edges over the whole picture domain. After that, the segmented image is given as input for the classification process. Classification is done using a few shot learning based ASNet, which classifies whether the patients have chronic kidney disease or not. The motive of this classification approach is to classify target objects in a query image when the target classes are given with a few examples. Additionally, the effectiveness of the proposed approach was verified and evaluated against other methods like PANet, MMNet, PNet and CANet. The proposed approach has 96% of accuracy, 94% of precision, 95% of recall, 97% specificity, 97% of NPV, 95% of f1-score, 89% of MCC, 90% of kappa, 0,02 FPR, and 4% error. And it also yields less training time, testing time and execution time that, is 10.91 s, 0.51 s and 11.42 s compared to the current approach. These performance get varied by using other large size dataset. This graphical representation clearly proves that the suggested method results are significantly better than those of the current methods. In comparison to other methods, the results demonstrated that the proposed few shot learning based ASNet can provide superior results by overcoming the issue of less accuracy and time consuming.

Author contributions The corresponding author claims the major contribution of the paper including formulation, analysis and editing. The co-author provides guidance to verify the analysis result and manuscript editing.

Funding The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Data availability Not applicable.

Code availability Not applicable.

Declarations This article is a completely original work of its authors; it has not been published before and will not be sent to other publications until the journal's editorial board decides not to accept it for publication.

Conflict of interest The authors declared that they have no conflicts of interest to this work. We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

References

1. Mihai S, Codrici E, Popescu ID, Enciu AM, Albulescu L, Necula LG, Mambet C, Anton G, Tanase C (2018) Inflammation-related mechanisms in chronic kidney disease prediction, progression, and outcome. *J Immunol Res* 2018:1–16. <https://doi.org/10.1155/2018/2180373>
2. Pasadana IA, Hartama D, Zarlis M, Sianipar AS, Munandar A, Baeha S, Alam AR (2019) Chronic kidney disease prediction by using different decision tree techniques. *J Phys: Conf Ser* 1255(1):012024 (**IOP Publishing**)
3. Revathy S, Bharathi B, Jeyanthi P, Ramesh M (2019) Chronic kidney disease prediction using machine learning models. *Int J Eng Adv Technol* 9(1):6364–6367
4. Chittora P, Chaurasia S, Chakrabarti P, Kumawat G, Chakrabarti T, Leonowicz Z, Jasiński M, Jasiński Ł, Gono R, Jasińska E, Bolshev V (2021) Prediction of chronic kidney disease-a machine learning perspective. *IEEE Access* 22(9):17312–17334
5. Karthick S, Muthukumaran N (2023) Deep Regression Network for Single-Image Super-Resolution Based on Down-and Upsampling with RCA Blocks. *Natl Acad Sci Lett* pp 1–5. <https://doi.org/10.1007/s40009-023-01353-5>
6. Almansour NA, Syed HF, Khayat NR, Altheeb RK, Juri RE, Alhiyafi J, Alrashed S, Olatunji SO (2019) Neural network and support vector machine for the prediction of chronic kidney disease: A comparative study. *Comput Biol Med* 109:101–111
7. Rady EH, Anwar AS (2019) Prediction of kidney disease stages using data mining algorithms. *Inform Med Unlocked* 15:100178
8. Karthick S, Muthukumaran N (2023) Deep regression network for the single image super resolution of multimedia text image. In 2023 IEEE 5th International Conference on Cybernetics, Cognition and Machine Learning Applications (ICCCMLA) (pp 394–399). IEEE
9. Ogunleye A, Wang QG (2019) XGBoost model for chronic kidney disease diagnosis. *IEEE/ACM Trans Comput Biol Bioinf* 17(6):2131–2140
10. Khamparia A, Saini G, Pandey B, Tiwari S, Gupta D, Khanna A (2020) KDSAE: Chronic kidney disease classification with multimedia data learning using deep stacked autoencoder network. *Multimed Tools Appl* 79:35425–35440
11. Wang K, Liew JH, Zou Y, Zhou D, Feng J (2019) Panet: Few-shot image semantic segmentation with prototype alignment. In: Proceedings of the IEEE/CVF international conference on computer vision, pp 9197–9206. <https://doi.ieeecomputersociety.org/10.1109/ICCV.2019.00929>
12. Wu Z, Shi X, Lin G, Cai J (2021) Learning meta-class memory for few-shot semantic segmentation. In: Proceedings of the IEEE/CVF International Conference on Computer Vision, pp 517–526. <https://doi.org/10.1109/ICCV48922.2021.00056>
13. Zhang C, Lin G, Liu F, Yao R, Shen C (2019) Canet: Class-agnostic segmentation networks with iterative refinement and attentive few-shot learning. In: Proceedings of the IEEE/CVF conference on computer vision and pattern recognition , pp 5217–5226. <https://doi.org/10.1109/CVPR.2019.00536>

14. Yildirim P (2017) Chronic kidney disease prediction on imbalanced data by multilayer perceptron: Chronic kidney disease prediction. In: 2017 IEEE 41st annual computer software and applications conference (COMPSAC) 2:193–198, IEEE
15. Maurya A, Wable R, Shinde R, John S, Jadhav R, Dakshayani R (2019) Chronic kidney disease prediction and recommendation of suitable diet plan by using machine learning. In: 2019 International Conference on Nascent Technologies in Engineering (ICNTE), pp 1–4, IEEE
16. Borisagar N, Barad D, Raval P (2017) Chronic kidney disease prediction using back propagation neural network algorithm. In: Proceedings of International Conference on Communication and Networks: ComNet, pp 295–303, Springer Singapore
17. Dritsas E, Trigka M (2022) Machine learning techniques for chronic kidney disease risk prediction. *Big Data Cogn Comput* 6(3):98
18. Singh V, Asari VK, Rajasekaran R (2022) A deep neural network for early detection and prediction of chronic kidney disease. *Diagnostics* 12(1):116
19. Aljaaf AJ, Al-Jumeily D, Haglan HM, Alloghani M, Baker T, Hussain AJ, Mustafina J (2018) Early prediction of chronic kidney disease using machine learning supported by predictive analytics. In: 2018 IEEE congress on evolutionary computation (CEC), pp 1–9, IEEE
20. Ebiaredoh-Mienye SA, Swart TG, Esenogho E, Mienye ID (2022) A machine learning method with filter-based feature selection for improved prediction of chronic kidney disease. *Bioengineering* 9(8):350
21. Chandra TB, Verma K (2020) Analysis of quantum noise-reducing filters on chest X-ray images: A review. *Measurement* 153:107426
22. Yugander P, Tejaswini CH, Meenakshi J, Varma BS, Jagannath M (2020) MR image enhancement using adaptive weighted mean filtering and homomorphic filtering. *Procedia Comput Sci* 167:677–685
23. Xie L, Han T, Zhou H, Zhang ZR, Han B, Tang A (2021) Tuna swarm optimization: a novel swarm-based metaheuristic algorithm for global optimization. *Comput Intell Neurosci* 2021:1–22. <https://doi.org/10.1155/2021/9210050>
24. Zhu S, Gao R (2016) A novel generalized gradient vector flow snake model using minimal surface and component-normalized method for medical image segmentation. *Biomed Signal Process Control* 26:1
25. Kang D, Cho M (2022) Integrative few-shot learning for classification and segmentation. In: Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition, pp 9979–9990
26. Dataset 1: <https://www.kaggle.com/datasets/nazmul0087/ct-kidney-dataset-normal-cyst-tumor-and-stone>. Accessed 21 Mar 2023

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor (e.g. a society or other partner) holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.



Cost based Random Forest Classifier for Intrusion Detection System in Internet of Things

K. Pramilarani^{a,*}, P. Vasanthi Kumari^b

^a Department of Computer Science and Engineering, Dayananda Sagar University, Bangalore, India

^b Department of Computer Applications, Dayananda Sagar University, Bangalore, India

HIGHLIGHTS

- Effective IDS is developed by proposing an Improved Random Forest Classifier.
- Feature importance based cost matrix is derived for improving the classification.
- The Spark, Kafka and Scikit-learn libraries of Python are used to improve the IDS.
- Maximum variance margin is used to remove the noise values from the input.

ARTICLE INFO

Keywords:

Cost matrix
Cost based Random Forest Classifier
Internet of Things
Intrusion Detection System
Kafka
Scikit-learn
Spark

ABSTRACT

Internet of Things (IoT) is the collection of physical and digital devices that are interconnected using Internet for exchange of information and delivery of services. The Internet of Things (IoT) is an extended application of Internet that is used to offer various services for users in the fields of agriculture, healthcare, education, smart homes and so on in the modern world. The significant issues of the intrusion present in IoT are network disconnection, network hacking and data theft from the source. So the challenging task for worldwide utilization of IoT is to address their security issues, because of the feature imbalance in the different types of attacks. The most essential task for addressing security issues is to predict and classify the intrusion in the network. In this paper, the Cost based Random Forest Classifier (CRFC) is proposed for developing an effective Intrusion Detection System (IDS). The CRFC based classification is improvised by incorporating the cost matrix calculated based on feature importance that helps to improve the process of splitting the features even if there is a feature imbalance. Further, three important libraries of Python namely, Spark, Kafka, and Scikit-learn are used in this IDS to improve the classification performances. In that, Spark is used to implement the distributed environment, Kafka is used for streaming the data and Scikit is used to implement CRFC. There are two datasets known as NSL-KDD and UNSW-NB15 that are used to evaluate the performance of the proposed CRFC-IDS method. The CRFC-IDS method is analyzed on the basis of accuracy, precision, recall, F1-Measure, Area Under the Curve (AUC), False Acceptance Rate (FAR) and Matthews Correlation Coefficient (MCC). The existing approaches OCSVM and DBF are used for comparison with the CRFC-IDS method. The accuracy of CRFC-IDS for NSL-KDD dataset is found to be 99.957%, which is highest when compared to OCSVM and DBF.

1. Introduction

The Internet of Things (IoT) integrates different smart devices that lead to the development of a large-scale network [1,2]. The tiny internet-linked smart devices embedded with sensors and actuators perform as facilitators for an effective connection with users [3]. IoT devices generate a huge amount of data that demand a large storage

space and computing resources [4]. Gartner computed that the usage of IoT would reach 26 billion units in 2020, while Statista's recent study discloses that its usage will be increased to 75.44 billion by 2025 throughout the world [5]. IoT systems are advantageous for various applications in the fields of environmental monitoring, home automation, smart cities, agriculture and farming, logistics and supply chain management, healthcare, digital twins design, public safety, smart

* Corresponding author.

E-mail addresses: Pramiselva2020@gmail.com (K. Pramilarani), vasanthi-bca@dsu.edu.in (P. Vasanthi Kumari).

<https://doi.org/10.1016/j.asoc.2023.111125>

Received 6 May 2023; Received in revised form 9 November 2023; Accepted 27 November 2023

Available online 5 December 2023

1568-4946/© 2023 Elsevier B.V. All rights reserved.

energy grids, quality of life for citizens and so on [6,7]. The intruders attack IoT devices as these devices transfer a huge amount of data with external resources because of inadequate security and defense. Thereby, a large amount of property loss is caused when IoT is affected by attacks. Therefore, the development of proper IDS which focuses on ensuring the security of IoT is crucial [8,9].

An IDS is utilized for securing the device's communication process, as well as detecting any intrusion in the network. The IDS observes and transmits the alarm to the system administrator when a malicious attack is identified in the network [10,11]. The main objective of this research is to identify the intrusions existing in the network using machine learning classifier. In recent times, the machine learning classifier is commonly used for performing the detection of intrusion [12]. Machine learning is a famous data-driven approach which is efficient in approaching and resolving engineering problems, specifically those that are extremely complex and nonlinear [13]. Since the effectiveness of conventional IDS is affected because of a large amount of data flow over the network, it is required to solve and handle the cyber-attacks with a huge amount of data flow. The three solutions that are used to handle the high data traffic in the network are; developing dedicated hardware, using big data approaches and using feature selection approaches. In particular, the big data approach named Spark is effectively used to handle large-scale network data traffic [14,15]. Generally, spark is considered one of the big data processing tools which used as a core component in each big data architecture [16]. Spark examines the datasets in a parallel manner using many nodes, and prioritizes speed [17]. The problem statement of this work is specified as follows: The higher false alarm rate and high traffic load are considered as important issues in the IDS, because it leads to cause the misclassification while detecting the intrusions. A high false alarm ratio means that the IDS is generating a large number of false positives, incorrectly classifying normal traffic as intrusions. A high traffic load makes it more challenging for the IDS to identify intrusions, as legitimate network activity may blend with potential malicious behavior. This leads to a decrease in recall because some true intrusions may be missed during the classification.

The contributions are listed as follows:

- CRFC is used to perform effective classification among the normal traffic and attack classes according to the cost matrix that is computed based on feature importance. Further, the attack classes are also classified for performing precise identification so as to secure the IoT network from threats. The CRFC automatically adapts to different attacks such as DoS, Probe, R2L and U2R based on the data and attack distribution. Hence, the CRFC's tree structures are generated based on the new adaptation to various attacks, providing the reliable intrusion detection information.
- Three important python libraries such as Spark for distributed environment implementation, Kafka for data streaming and Scikit-learn for CRFC design, are included.

The remaining paper is sorted as follows: Section 2 provides information about existing researches available on IDS. A detailed explanation of CRFC based IDS is provided in Section 3, and the results are presented in Section 4 along with the comparative analysis. Further, Sections 5 and 6 provides the discussion and conclusion.

2. Related work

The related work about existing researches available on IDS are given in this section along with their advantages and limitations.

Alazzam et al. [18] developed Intelligent Lightweight IDS which obtained a low false alarm rate while achieving a higher detection rate. The developed Network IDS (NIDS) was an integration of two key subsystems which operated in parallel, where each subsystem was trained by using the One-Class Support Vector Machine (OCSVM). Here, one

system was trained through normal packets and the other one was trained using attack packets. Further, the outcomes from both subsystems were integrated for offering the best prediction for each packet transmitted via the network. However, the higher false alarm affected the performance of anomaly detection subsystem using OCSVM.

Sarhan et al. [19] analyzed the efficiency of three different Deep Learning (DL) approaches used to predict the attack vectors with three Shallow Learning (SL) approaches. The considered DL models were deep feed forward, Convolution Neural Network (CNN) and recurrent neural network whereas the SL models were decision trees, Logistic Regression (LR) and naive Bayes. Further, three different Feature Extraction (FE) approaches such as auto-encoder, principal component analysis, and linear discriminant analysis were explored along with the classification models. From these different classifier and FE combinations, no single integration was the best in all the benchmarks which were ToN-IoT, CSE-CIC-IDS2018 and UNSW-NB15.

Alkadi et al. [20] developed Deep Blockchain Framework (DBF) for providing security based on distributed discovery of intrusion and privacy-based blockchain for IoT networks. The bidirectional long short-term memory was used to predict cyberattacks from the data migration in the network. Smart contracts and blockchains were used to suggest the privacy-preserving approach deployed to enable immutable data transfer and movement among multi-cloud services. But, DBF's performances were affected when traffic overload occurred because of heavy network traffic.

Alferaidi et al. [21] presented the distributed integrated deep learning IDS for the Internet of Vehicles according to the Apache Spark framework. The features and data were obtained on the basis of the combination of deep-learning CNN and improved Long Short-Term Memory (LSTM) using the cluster. The developed deep CNN-LSTM was used to detect the intrusion through the recognition of abnormal behavior and large-scale car network data traffic. However, the detection capacities of classifiers were required to be considered for further improving the prediction.

Baniasadi et al. [22] generated a training algorithm namely Neighborhood Search-Based Particle Swarm Optimization (NSBPSO) for tuning the parameters of deep architecture. The exploration and exploitation of particle swarm optimization were improved by using the NSBPSO algorithm. The merits of NSBPSO were used for optimal training of deep architecture to achieve the best accuracy. However, a huge amount of epochs were required to achieve the highest accuracy while detecting the intrusion.

Zeeshan et al. [23] presented the architecture of Protocol Based Deep Intrusion Detection (PB-DID) to identify intrusions in IoT. In PB-DID, a data packets was generated from IoT traffic based on the evaluation of features of Bot-IoT and UNSWNB15 datasets. This new dataset creation depended on the transmission control protocol and flow. The issues of over-fitting and imbalanced datasets were avoided in PB-DID during classification. However, this model was required to consider more attack classes for an effective analysis.

Bouya-Moko et al. [24] developed optimization-based deep learning to detect intrusions using Spark. The Fuzzy Local Information and Bhattacharya-based C-Means (FLIBCM) was used to divide the data, while class-wise information was used to choose the imperative features. Next, oversampling was used to augment the data and perform further. The Deep Maxout Network (DMN) was used to conduct the classification using augmented data in which Student Psychology Water Cycle Caviar (SPWCC) was used to choose the appropriate weights of DMN. The classification using DMN was evaluated only for individual classes, however, the overall analysis needed to be done among normal and attack classes to evaluate the efficiency.

Devprasad et al. [25] developed lightweight IDS based on the context adaptive classification through the ranking approach of Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). In this IDS, the first level statistical feature selection was done using chi-square, in combination with bat algorithm that was used to choose more relevant

features. Further, the ensemble voting classifier was used as per the choice selected by TOPSIS. The classification performances were affected because of the less amount of features selected during feature selection.

Mohamed and Ejebali [26] presented deep State-Action-Reward-State-Action (SARSA), a reinforcement learning for classifying the imbalanced and modern traffic network. SARSA was integrated with Deep Neural Network (DNN) for interacting with the input data where traffic was examined for detecting attacks. Specifically, the deep SARSA agents with automated trial-error policy were used to predict the attacks. The process of learning was stable due to the usage of on policy strategy in deep SARSA agents. However, the SARSA-DNN performed numerous computations because of its complex architecture.

Alqahtani, A.S [27] developed Firefly-Swarm-Optimized LSTM (FSO-LSTM) to predict the various types of attack along with increased amount of data entries. The spatial and temporal correlated features of IoT network and the optimized LSTM was utilized for predicting the attacks in IoT. The firefly algorithm used in the LSTM was used to minimize computational overhead and it was improved the prediction accuracy. The developed FSO-LSTM was required to feature importance for further enhancing the prediction.

Wang, S et al. [28] presented the IDS using ResNet, Transformer and spatial Bi-directional LSTM (BiLSTM) namely Res-TranBiLSTM which considered both the temporal and spatial features of network traffic. The data imbalance degree was avoided by using a Synthetic Minor Overriding Technique (SMOTE)-Edited Nearest Neighbor (ENN) approach. The temporal features of network traffic were preserved by using a BiLSTM. The Res-TranBiLSTM was provided less prediction accuracy for normal class, hence it denoted a higher false alarm rate because of concealment of the original features.

Therefore, the problems found in the related works are the degradation in performances due to higher false alarm rates and high traffic load. Some researchers considered only a less number of attack classes during the analysis. To overcome these, the CRFC-based classification is developed for achieving the precise classification between the normal traffic and attack classes. Here, efficient Python libraries such as Spark, Kafka, and Scikit are used with CRFC for further improving the classification.

3. CRFC-IDS method

In this research, effective intrusion detection is developed using CRFC with Spark, Kafka and Scikit libraries. The key processes of the CRFC-IDS method are 1) Dataset acquisition, 2) Preprocessing and 3) Classification. The cost matrix incorporated in the CRFC is used to avoid misclassification considering the feature importance. The splitting criteria of CRFC is enhanced based on the computed cost matrix which helps achieve reliable prediction even when it is processed with imbalanced features. Therefore, precise classification among normal traffic and attacks is achieved by using the CRFC-IDS method. Fig. 1 shows the block diagram of the CRFC-IDS method.

3.1. Data acquisition

For study purposes, two different datasets namely, NSL-KDD [29] and UNSW-NB15 [30] are considered for evaluating IDS. The NSL-KDD dataset is extended from KDD 99 [31] by resolving the intrinsic issues in KDD 99 such as data imbalance and redundancy. The labels of the NSL-KDD are generally divided as Normal and Attack, while the Attack is additionally divided into four categories which are U2R, probe, DoS and R2L. Here, the data types are similar to KDD 99, but the dissemination of data is different. Moreover, the NSL-KDD dataset has ~120,000 labeled samples. On the other hand, the UNSW-NB15 is created by IXIA PerfectStorm tool. The UNSW-NB15 has high amount of modern attack types (i.e., 9 types) and more user behaviors than the KDD 99 and NSL-KDD. Therefore, the UNSW-NB15 totally has 257,673 records from



Fig. 1. Block diagram of CRFC-IDS method.

normal and attack traffic. UNSW-NB15's features are separated into five classes: basic, flow, content, time and additional generated features. The relationship between the normal traffic and attack types [32] for both the NSL-KDD and UNSW-NB15 is shown in Table 1.

3.2. Preprocessing

Data preprocessing suitably converts the input data to optimize data acquisition and the further processes. The preprocessing approaches considered in this IDS are the maximum variance margin and min-max algorithm. In maximum variance margin, the variance for all the data samples in the stream is calculated, then the mean value is considered as threshold. The samples within the threshold are streamed for further process and the remaining are determined as noise values. The determined noise values are eliminated from the stream of data. After noise removal, the data are further preprocessed by the min-max algorithm. In general, there is a huge difference between the minimum and maximum values of the dataset, therefore data normalization is used for reducing the algorithm's complexity and its relevant processes. The normalization operation depends on data scaling that has the min-max algorithm which can transform the data's current range to bring between the range $[-1, 1]$ and $[0, 1]$. Eq. (1) expresses the min-max algorithm.

$$x = \frac{(D - D_{\min})(\max - \min)}{(D_{\max} - D_{\min}) + \min} \quad (1)$$

Where D is input; $(\min, \max)$ is a specified range of input; an initial range of input is $(D_{\min}, D_{\max})$ and preprocessed output is x . The preprocessed data is given as input to CRFC to perform an effective classification.

3.3. Cost based Random Forest Classifier

The preprocessed data is given as input to the CRFC for classification purposes. The conventional RFC [33,34] is modified as CRFC by

Table 1
Attack and normal traffic proportions of the dataset.

Dataset	Type	Percentage (%)
NSL-KDD	Normal traffic	55.06
	Attack	44.94
UNSW-NB15	Normal traffic	53.56
	Attack	46.54

considering the cost function for avoiding misclassifications. The CRFC has the capacity for eliminating the high variance or bias during the identification and it is easy to design in an effective and precise way. The CRFC is used to maintain accuracy, even if a huge amount of data is missing during the analysis. The emergence of more trees i.e., Forests is used to improve the accuracy of CRFC. Each tree that exists in the forest provides the classification (i.e., vote) while predicting a new observation.

The classification of CRFC is chosen depending on a huge amount of votes from all the trees of the forest. Each fundamental tree is divided over only a random subset of available independent variables from bootstrapped sample data for creating the CRFC. For instance, the training data for each tree is randomly chosen with replacement. A forest with dissimilar trees is generated, because each tree utilizes distinct independent variables and training data. The bagging modification is used to build and average the huge amount of trees for achieving approximately unbiased models to reduce the variance. The schematic diagram of CRFC is shown in Fig. 2. The algorithm to develop the random forest with N amount of trees is denoted below:

For every $n = 1, 2, \dots, N$

- Use Bootstrap to develop the sample X_n .
- Use sample X_n to build the decision tree b_n .
- Based on the criteria, select the best attribute and perform the split in the tree until the sample data is exhausted.
- Tree is constructed until there are no higher than $n_{\min}$ objects at each leaf, or until tree achieves a significant height.
- From n initial ones, choose m amount of random features for each part to discover the best partitioning between the trees.

The final regression algorithm $f(x)$ is as expressed in Eq. (2).

$$f(x) = \frac{1}{N} \sum_{i=1}^N b_i(x) \quad (2)$$

Where, the regression tree is denoted as $b_i(x)$, and N defines amount of trees. The suggested amount of random features at regression tasks is $m = n/3$, where n defines the number of initial features. The correlation between the trees and the overfitting issue is avoided by using the random subspace method.

In CRFC, the Gini index condition based on the cost matrix is used for constructing the trees that are used to compute the condition of splitting according to the node's impurity. The impact of misclassification error from the cost used in the Gini value is used to provide equal level Gini value during the prediction that helps to eliminate misclassification. The CRFC chooses an appropriate splitting variable by making each node as pure as possible. Consider a portion of data reaching the g th node is A_g and amount of data points belonging to the class C_i is denoted as A_g^i . Therefore, the Gini index of node g (GI_g) is expressed in Eq. (3).

$$GI_g = 1 - \left(\sum_{i=1}^c (p_g^i)^2 \times Cost_g^i \right) \quad (3)$$

Where, p_g^i is relative frequency of i th class that is expressed in Eq. (4) and the cost matrix used for avoiding the misclassification is denoted as $Cost$ which is expressed in Eq. (5).

$$p_g^i = \frac{A_g^i}{A_g} \quad (4)$$

The smaller value of Gini index of node g denotes higher purity which implies that the node has higher observations from a single class i . Therefore, the decrement in the Gini index is essential while splitting the node.

Various levels of consequences occur because of the various misclassifications. For example, the misclassification of R2L as Normal is more dangerous than the misclassification of DoS as Normal. The cost value computed for CRFC to avoid misclassification is expressed in Eq. (5). Further, the regression value ($C_{ij}(x)$) is computed using the Eqs. (6)

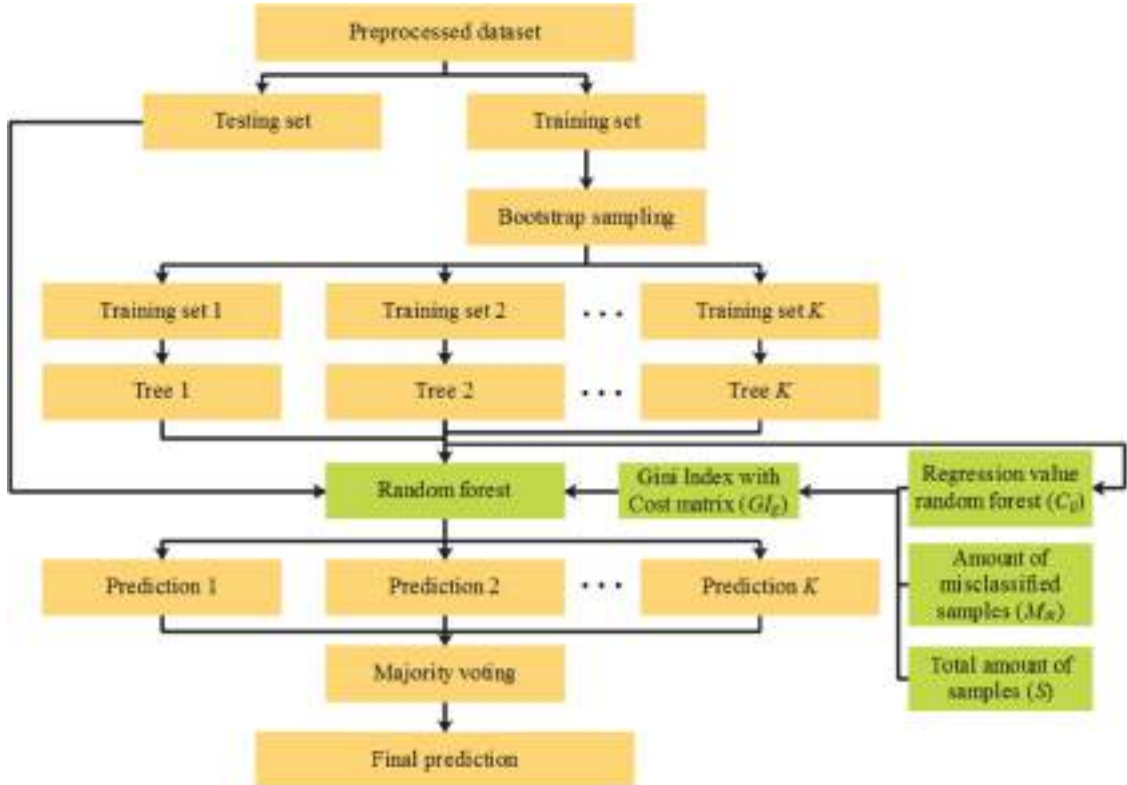


Fig. 2. Schematic diagram of CRFC.

and (7). The incorporation of cost regression is to eliminate the error caused by misclassification.

$$Cost = \frac{M_{ik} \times C_{ij}(x)}{S}, i, k = 1, 2, \dots, N \text{ and } j = 1, 2, \dots, F \quad (5)$$

$$C_{ij}(x) = \begin{bmatrix} f(x_{(0,0)}) & f(x_{(0,1)}) & \dots & f(x_{(0,i)}) \\ f(x_{(1,0)}) & f(x_{(1,1)}) & \dots & f(x_{(1,i)}) \\ \vdots & \vdots & \ddots & \vdots \\ f(x_{(i,0)}) & f(x_{(i,1)}) & \dots & f(x_{(i,i)}) \end{bmatrix} \quad (6)$$

Eq. (6) is further modified to identify a smallest minimum value as expressed in Eq. (7).

$$C_{ij}(x) = \operatorname{argmin}_{1 \leq (i,j) \leq N} \{C_{ij}(x)\} \quad (7)$$

Where, amount of samples in i th class misclassified as samples of k th class is denoted as M_{ik} ; F denotes the number of features; regression value is denoted as $C_{ij}(x)$, and the total amount of samples is denoted as S .

In that, the cost value is computed based on the importance of features from CRFC. The derived cost value is used to enhance the splitting of features even as the CRFC processes with less amount of data. The computed cost value denotes the features weightage that indicates the importance for a specific target or specific attack type. Subsequently, this cost matrix is used as weightage value for enhancing the condition of splitting criteria even when the data has imbalanced features. Therefore, the developed CRFC predicts the intrusion not only based on the probability of trained data, but also depends on the feature importance which helps to enhance the IDS. The developed CRFC automatically adapts to different types of attacks such as DoS, Probe, R2L and U2R because it depends on both the data and attack distribution. This kind of adaption is used to define the tree structures of CRFC that helps to provide the reliable intrusion detection. So, there is no probability of random decision due to the improvisation of splitting criteria based on the cost matrix.

3.3.1. Scikit-learn

Scikit-learn [35] is used to implement the proposed CRFC for performing classification. Scikit-learn is generally an open-source Python library that offers support to design machine learning approaches. This Scikit-learn depends on the SciPy and NumPy which are Python libraries for performing the scientific calculation. Scikit-learn has become famous because of the extensive usage of Python, and ML is used to feature the Scikit-learn. An effective operation over computing resources is achieved by optimizing an ML approach. Scikit-learn has excessive support with quality assurance, bug tracking and documentation. Additionally, the demonstration of input/output data is uniform in Scikit-learn.

3.3.2. Spark and Kafka

Spark [16] is used to implement the distributed environment to perform the CRFC for ensuring an effective IDS. Kafka is used to perform data streaming from the distributed environment of Spark. Spark is considered a big data processing tool which is one of the key components of each architecture of big data. The data saved in the repository or data consumed systems are analyzed by Spark. Apache Spark was developed by AMPLab at UC Berkeley in 2009, and it is suitable for an extensive usage on many cases. The common libraries developed at Spark processing engine are MLlib, Spark Streaming, and Spark SQL for machine learning and GraphX to perform computations of the graph. The supported programming languages of Spark are Scala, Python, R and Java. The cluster over Hadoop YARN and Mesos/ Kafka can operate Spark. Spark supports both batch and stream processing.

4. Results and discussion

This section shows the performance analysis of the CRFC-IDS

method. The implementation and execution of the CRFC-IDS method are done using Python 3.6 software. The system is configured with 1 TB memory Windows 10 operating system, 128 GB RAM and 22 GB RAM. There are two different datasets NSL-KDD and UNSW-NB15 considered for evaluating the CRFC-IDS method. The parameters such as accuracy, precision, recall, F1-Measure, AUC, FAR and MCC are expressed in Eqs. (8)–(14).

$$Accuracy = \frac{TP + TN}{TN + TP + FN + FP} \times 100 \quad (8)$$

$$Precision = \frac{TP}{TP + FP} \times 100 \quad (9)$$

$$Recall = \frac{TP}{TP + FN} \times 100 \quad (10)$$

$$F1 - measure = \frac{2Precision \times Recall}{Precision + Recall} \times 100 \quad (11)$$

$$AUC = \frac{1}{2} \times \left(\frac{TP}{TP + FN} + \frac{TN}{TN + FP} \right) \times 100 \quad (12)$$

$$FAR = \frac{FN}{TP + FN} \quad (13)$$

$$MCC = \frac{TP \times TN - FP \times FN}{\sqrt{(TN + FN)(TP + FP)(TN + FP)(TP + FN)}} \times 100 \quad (14)$$

Where, TP, TN, FP , and FN denotes true positive, true negative, false positive, and false negative, respectively.

4.1. Performance analysis for the NSL-KDD dataset

The performance of the CRFC-IDS method for the NSL-KDD dataset is analysed with different classifiers namely, Logistic Regression, Stochastic Gradient Decent (SGD), and Gradient Boosting Decision Tree (GBDT). Further, the performances are analysed in two different cases such as the classification of each attack type and the classification between attack and normal traffic. Tables 2 and 3 show the class-wise performance analysis of CRFC-IDS method for NSL-KDD dataset. Further, the graphical illustration of class-wise accuracies is shown in Fig. 3. This result shows that the classification performances of CRFC-IDS are improved in comparison with the Logistic Regression, SGD, and GBDT. The CRFC improves the classification based on the computation of cost value considering the feature importance. The computed cost value of CRFC is used to avoid misclassification between the classes. Specifically, the cost value enhances the splitting criteria of the features

Table 2

Class-wise performance analysis of CRFC for NSL-KDD by precision, recall and F1-Measure.

Classifiers	Class	Precision (%)	Recall (%)	F1-Measure (%)
Logistic Regression	DoS	98.8664	84.0817	91.3141
	Probe	89.9055	93.6726	90.6301
	R2L	90.6992	66.2278	68.4704
	U2R	90.0077	73.6049	79.3200
SGD	DoS	99.3025	85.3808	90.8089
	Probe	89.7688	93.8999	92.7259
	R2L	91.7424	66.9790	69.5014
	U2R	91.0981	74.7199	79.0912
GBDT	DoS	98.0988	85.2485	92.1446
	Probe	89.5955	94.0874	91.9322
	R2L	91.4651	66.8666	69.5316
	U2R	90.3520	74.3020	79.3280
CRFC	DoS	99.7295	85.1171	92.2279
	Probe	90.1443	94.6827	92.2915
	R2L	89.7700	66.2348	68.3121
	U2R	91.7707	73.8606	80.2394

Table 3

Class-wise performance analysis of CRFC for NSL-KDD by accuracy, FAR, AUC and MCC.

Classifiers	Class	Accuracy (%)	FAR (%)	AUC (%)	MCC
Logistic Regression	DoS	93.0557	0.2254	98.2369	0.7051
	Probe	93.4866	0.1738	98.2809	0.6194
	R2L	84.4864	0.3047	68.2858	0.0207
	U2R	99.1295	3.0488	97.8991	0.4132
SGD	DoS	93.0325	0.2296	97.5794	0.7117
	Probe	93.5729	0.1853	97.5820	0.6285
	R2L	84.6192	0.3076	68.2521	0.0277
	U2R	99.5559	3.0500	98.8614	0.4184
GBDT	DoS	92.8570	0.2375	97.9307	0.7149
	Probe	93.8985	0.1947	98.4016	0.6317
	R2L	84.4894	0.3149	68.2058	0.0323
	U2R	99.2658	3.0567	98.8267	0.4317
CRFC	DoS	92.7601	0.2408	97.8937	0.7207
	Probe	94.0715	0.2034	97.7318	0.6440
	R2L	84.0152	0.3219	68.4624	0.0350
	U2R	99.5184	3.0606	98.2772	0.4344

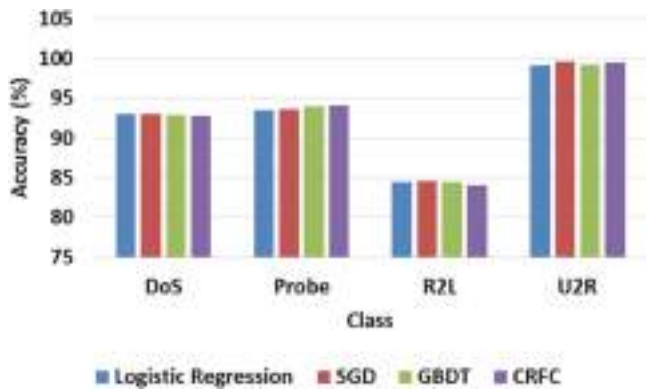


Fig. 3. Accuracy performances for class-wise prediction of NSL-KDD for different classifiers.

that are used to achieve reliable intrusion detection between different attacks such as DoS, Probe, R2L and U2R.

Tables 4 and 5 show the overall analysis of the CRFC-IDS method for the NSL-KDD dataset with different classifiers. The performances are analysed between the normal traffic and attack classes. All the attack types such as DoS, Probe, R2L and U2R are collectively considered as attack class. The accuracy comparison for CRFC-IDS with different classifiers is shown in Fig. 4. The developed CRFC-IDS achieves higher classification than Logistic Regression, SGD and GBDT. The average classification accuracy of CRFC is found to be 99.957%, whereas the Logistic Regression obtains an accuracy of 84.2589%, while the SGD obtains 98.1028% and the GBDT obtains 98.4662%. The misclassification among the normal traffic and attack classes is avoided by computing the cost value based on feature importance in the CRFC.

4.2. Performance analysis for UNSW-NB15 dataset

The performances of CRFC for UNSW-NB15 dataset are analyzed with different classifiers such as Logistic Regression, SGD, and GBDT. Tables 6 and 7 show the analysis of CRFC with different classifiers for

Table 4

The overall analysis of CRFC for NSL-KDD by precision, recall and F1-Measure.

Classifiers	Precision (%)	Recall (%)	F1 Measure (%)
Logistic Regression	89.7872	83.4399	86.2769
SGD	98.6980	98.9920	98.6721
GBDT	99.2897	98.5352	99.2434
CRFC	98.7589	98.6801	98.8110

Table 5

Overall analysis of CRFC for NSL-KDD by accuracy, FAR, AUC and MCC.

Classifiers	Accuracy (%)	FAR (%)	AUC (%)	MCC (%)
Logistic Regression	84.2589	0.3138	92.7424	0.5751
SGD	98.1028	0.5334	98.4267	0.3296
GBDT	98.4662	0.2792	99.8913	0.7217
CRFC	99.957	0.2519	100.00	0.2674

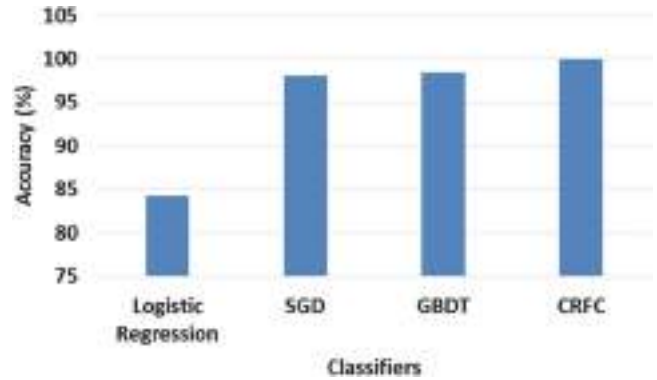


Fig. 4. Average classification accuracy of NSL-KDD dataset for different classifiers.

Table 6

Analysis of CRFC for UNSW-NB15 by precision, recall and F1-Measure.

Classifiers	Precision (%)	Recall (%)	F1 Measure (%)
Logistic Regression	91.7872	88.4399	90.2769
SGD	98.898	99.292	98.8721
GBDT	99.4897	98.7352	99.5434
CRFC	98.9589	98.9801	99.311

Table 7

Analysis of CRFC for UNSW-NB15 by accuracy, FAR, AUC and MCC.

Classifiers	Accuracy (%)	FAR (%)	AUC (%)	MCC (%)
Logistic Regression	92.4506	0.9578	90.4880	0.5326
SGD	98.8348	1.2062	94.5561	0.1889
GBDT	99.6037	0.3478	99.7907	0.3164
CRFC	99.953	0.2232	99.8151	0.2766

UNSW-NB15 dataset. Further, the accuracy comparison of CRFC with the UNSW-NB15 dataset is shown in Fig. 5. This analysis shows that the CRFC outperforms the Logistic Regression, SGD and GBDT. The CRFC exhibits better classification based on the incorporated cost value. The

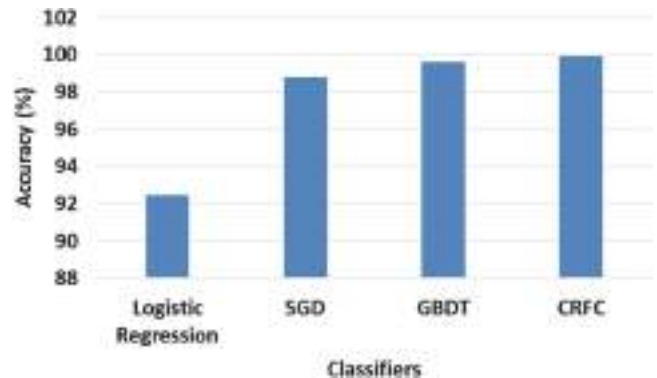


Fig. 5. Average classification accuracy of UNSW-NB15 dataset for different classifiers.

classification using CRFC is enhanced by using both the probability of trained data and enhanced splitting criteria taking into consideration the feature importance.

4.3. Comparative analysis

The comparative analysis for CRFC-IDS with existing research is shown in this section. Existing research approaches such as OCSVM [18] and DBF [20] are used to evaluate the CRFC-IDS method. Two datasets, NSL-KDD and UNSW-NB15 are considered for comparison. Tables 8 and 9 show the comparison of NSL-KDD and UNSW-NB15 dataset respectively. The accuracy comparison for CRFC-IDS is shown in Fig. 6. This comparison shows that the developed CRFC-IDS method outperforms the OCSVM [18] and DBF [20] for both datasets. The developed CRFC-IDS method overcome the issues created by higher false alarm ratio and high traffic load. CRFC minimizes false alarms in IDS by assigning higher misclassification costs to false positives, and it adapts to high traffic loads by adjusting Gini index condition based on cost matrix, making a balance between alerting and reducing false alarms. The false alarm ratio and traffic load is significantly impact on the accuracy and F1-measure of an IDS. For example, the accuracy of CRFC-IDS for the UNSW-NB15 dataset is 99.953%, whereas the OCSVM [18] obtains 99.3% and DBF [20] obtains 99.41%. The cost matrix formulation based on feature importance, is incorporated in CRFC for avoiding the misclassification among the attack types and normal classes. Therefore, the classification performances of CRFC-IDS are further increased by using the Spark, Kafka and Scikit-learn libraries.

5. Discussion

This section provides the brief discussion about the results achieved from CRFC-IDS developed for IoT. At first, the results of CRFC is evaluated with different classifiers including Logistic Regression, SGD and GBDT. The performance of CRFC-IDS are analyzed by using two different datasets NSL-KDD and UNSW-NB15. Specifically, the class wise performance is evaluated for the NSL-KDD dataset. From this analysis, it is cleared that the CRFC achieves better performance when compared to the logistic regression, SGD and GBDT. Moreover, the CRFC-IDS is compared with the OCSVM [18] and DBF [20] in the section of comparative analysis. The proposed CRFC-IDS achieves better performance than the OCSVM [18] and DBF [20] for both the datasets. For example, the accuracy of CRFC-IDS for NSL-KDD dataset is 99.957%, whereas the OCSVM [18] obtains 99.8%. The CRFC provides better IDS by incorporating the cost matrix to create the trees which are used to compute the condition of splitting according to the node's impurity which helps to avoid the misclassification during the analysis.

6. Conclusion

In the recent decades, a huge amount of data broadcasting makes the detection of intrusion difficult in IoT. Therefore, an effective IDS is developed using the CRFC to classify the attack classes from normal traffic. At first, the maximum noise margin and min-max approach is used to preprocess the data. Then the preprocessed data is given as input to the CRFC where a feature importance-based cost matrix is included for precise classification. The developed CRFC is adapted to various attack types such as DoS, Probe, R2L and U2R by considering the data and attack distribution. This adaption is used for defining the CRFC's tree structures which provides the reliable intrusion detection.

Table 8
Comparison for NSL-KDD dataset.

Method	Accuracy (%)	F1-measure (%)
OCSVM [18]	99.8	99.4
CRFC-IDS	99.957	98.811

Table 9
Comparison for UNSW-NB15 dataset.

Method	Accuracy (%)	F1-measure (%)
OCSVM [18]	99.3	99.2
DBF [20]	99.41	NA
CRFC-IDS	99.953	99.311

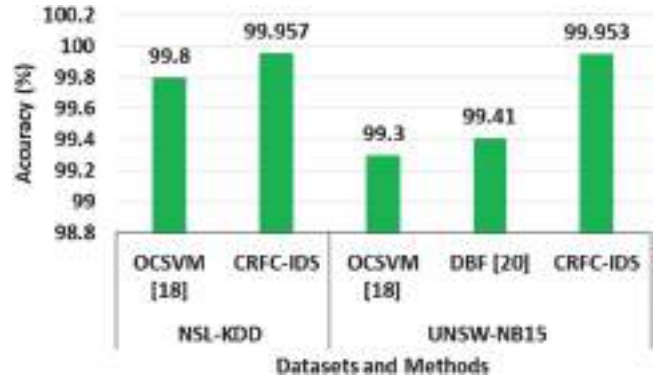


Fig. 6. Comparison of accuracy.

Moreover, the CRFC does not provide any random decision because of the improvisation of splitting criteria based on the cost matrix. Additionally, the Spark, Kafka and Scikit-learn Python libraries are used for a distributed environment and CRFC design for further improving the classification performances. From the results, it is concluded that the CRFC-IDS provides better performance than the OCSVM and DBF. The accuracy of CRFC-IDS for the NSL-KDD dataset is 99.957% which is highest, when compared to the OCSVM and DBF. As a further extension, the pruning and hyperparameter optimization can be incorporated when the IDS is processed in Big data with a variety of classes/ subcategories. In the future, deep learning approaches are fit to be used for improving the performance of IDS.

Funding

This research received no external funding.

Ethics approval

I/We declare that the work submitted for publication is original, previously unpublished in English or any other language(s), and not under consideration for publication elsewhere.

Consent to participate/informed consent

Not applicable.

Consent for publication

I certify that all the authors have approved the paper for release and are in agreement with its content.

CRediT authorship contribution statement

K. Pramilarani: Conceptualization, Implementation, Resource acquisition, Data collection, Writing – original draft, Report writing. **P. Vasanthi Kumari:** Project administration, Validation, Visualization, Formal analysis, Writing – review & editing. All authors approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The datasets generated and/or analysed during the current study are available in the [NSL-KDD] and [UNSW-NB15] repositories: NSL-KDD = <https://www.kaggle.com/datasets/hassan06/nslkdd?select=KDD-Train1.jpg>; UNSW-NB15 = <https://research.unsw.edu.au/projects/unsw-nb15-dataset>.

References

- [1] L. Nie, W. Sun, S. Wang, Z. Ning, J.J.P.C. Rodrigues, Y. Wu, S. Li, Intrusion detection in green internet of things: a deep deterministic policy gradient-based algorithm, *IEEE Trans. Green. Commun. Netw.* 5 (2021) 778–788, <https://doi.org/10.1109/TGCN.2021.3073714>.
- [2] Y. Kayode Saheed, A. Idris Abiodun, S. Misra, M. Kristiansen Holone, R. Colombo-Palacios, A machine learning-based intrusion detection for detecting internet of things network attacks, *Alex. Eng. J.* 61 (2022) 9395–9409, <https://doi.org/10.1016/j.aej.2022.02.063>.
- [3] M.H. Nasir, J. Arshad, M.M. Khan, Collaborative device-level botnet detection for internet of things, *Comput. Secur.* 129 (2023), 103172, <https://doi.org/10.1016/j.cose.2023.103172>.
- [4] Y. Wu, L. Nie, S. Wang, Z. Ning, S. Li, Intelligent intrusion detection for internet of things security: a deep convolutional generative adversarial network-enabled approach, *IEEE Internet Things J.* 10 (2023) 3094–3106, <https://doi.org/10.1109/JIOT.2021.3112159>.
- [5] V. Morfino, S. Rampone, Towards near-real-time intrusion detection for IoT devices using supervised learning and apache spark, *Electronics* 9 (2020) 444, <https://doi.org/10.3390/electronics9030444>.
- [6] M.B. Gorzalczy, F. Rudzinski, Intrusion detection in internet of things with MQTT protocol—an accurate and interpretable genetic-fuzzy rule-based solution, *IEEE Internet Things J.* 9 (2022) 24843–24855, <https://doi.org/10.1109/JIOT.2022.3194837>.
- [7] M.M. Alani, A.I. Awad, An intelligent two-layer intrusion detection system for the internet of things, *IEEE Trans. Ind. Inf.* 19 (2023) 683–692, <https://doi.org/10.1109/TII.2022.3192035>.
- [8] R. Zhao, G. Gui, Z. Xue, J. Yin, T. Ohtsuki, B. Adebisi, H. Gacanin, A novel intrusion detection method based on lightweight neural network for internet of things, *IEEE Internet Things J.* 9 (2022) 9960–9972, <https://doi.org/10.1109/JIOT.2021.3119055>.
- [9] D.C. Attota, V. Mothukuri, R.M. Parizi, S. Pouriyeh, An ensemble multi-view federated learning intrusion detection for IoT, *IEEE Access* 9 (2021) 117734–117745, <https://doi.org/10.1109/ACCESS.2021.3107337>.
- [10] M. Vishwakarma, N. Kesswani, DIDS: a deep neural network based real-time intrusion detection system for IoT, *Decis. Anal. J.* 5 (2022), 100142, <https://doi.org/10.1016/j.dajour.2022.100142>.
- [11] H. Lu, T. Wang, X. Xu, T. Wang, Cognitive memory-guided autoencoder for effective intrusion detection in internet of things, *IEEE Trans. Ind. Inf.* 18 (2022) 3358–3366, <https://doi.org/10.1109/TII.2021.3102637>.
- [12] M. Aslam, D. Ye, A. Tariq, M. Asad, M. Hanif, D. Ndzi, S.A. Chelloug, M.A. Elaziz, M.A. Al-Qaness, S.F. Jilani, Adaptive machine learning based distributed denial-of-services attacks detection and mitigation system for SDN-enabled IoT, *Sensors* 22 (7) (2022) 2697.
- [13] J. Chen, H. Huang, A.G. Cohn, D. Zhang, M. Zhou, Machine learning-based classification of rock discontinuity trace: SMOTE oversampling integrated with GBT ensemble learning, *Int. J. Min. Sci. Technol.* 32 (2) (2022) 309–322.
- [14] Z. Wang, J. Liu, L. Sun, EFS-DNN: an ensemble feature selection-based deep learning approach to network intrusion detection system, *Secur. Commun. Netw.* 2022 (2022), 2693948, <https://doi.org/10.1155/2022/2693948>.
- [15] O. Azeroual, A. Nikiforova, Apache spark and MLib-based intrusion detection system or how the big data technologies can secure the data, *Information* 13 (2022) 58, <https://doi.org/10.3390/info13020058>.
- [16] R. Alghamdi, M. Bellaiche, Evaluation and selection models for ensemble intrusion detection systems in IoT, *IoT* 3 (2022) 285–314, <https://doi.org/10.3390/iot3020017>.
- [17] A.A. Hagar, B.W. Gawali, Apache spark and deep learning models for high-performance network intrusion detection using CSE-CIC-IDS2018, *Comput. Intell. Neurosci.* 2022 (2022), 3131153, <https://doi.org/10.1155/2022/3131153>.
- [18] H. Alazzam, A. Sharieh, K.E. Sabri, A lightweight intelligent network intrusion detection system using OCSVM and Pigeon inspired optimizer, *Appl. Intell.* 52 (2022) 3527–3544, <https://doi.org/10.1007/s10489-021-02621-x>.
- [19] M. Sarhan, S. Layeghy, N. Moustafa, M. Gallagher, M. Portmann, Feature extraction for machine learning-based intrusion detection in IoT networks, *Digit. Commun. Netw.* (2022), <https://doi.org/10.1016/j.dcan.2022.08.012>.
- [20] O. Alkadi, N. Moustafa, B. Turnbull, K.-K.R. Choo, A deep blockchain framework-enabled collaborative intrusion detection for protecting IoT and cloud networks, *IEEE Internet Things J.* 8 (2021) 9463–9472, <https://doi.org/10.1109/JIOT.2020.2996590>.
- [21] A. Alferaidi, K. Yadav, Y. Alharbi, N. Razmjoo, W. Viriyasitvat, K. Gulati, S. Kautish, G. Dhiman, Distributed deep CNN-LSTM model for intrusion detection method in IoT-based vehicles, *Math. Probl. Eng.* 2022 (2022), 3424819, <https://doi.org/10.1155/2022/3424819>.
- [22] S. Baniasadi, O. Rostami, D. Martín, M. Kaveh, A novel deep supervised learning-based approach for intrusion detection in IoT systems, *Sensors* 22 (2022) 4459, <https://doi.org/10.3390/s22124459>.
- [23] M. Zeeshan, Q. Riaz, M.A. Bilal, M.K. Shahzad, H. Jabeen, S.A. Haider, A. Rahim, Protocol-based deep intrusion detection for DoS and DDoS attacks using UNSW-NB15 and Bot-IoT data-sets, *IEEE Access* 10 (2022) 2269–2283, <https://doi.org/10.1109/ACCESS.2021.3137201>.
- [24] B.E. Bouya-Moko, E.K. Boahen, C. Wang, Fuzzy local information and bhattacharya-based C-means clustering and optimized deep learning in spark framework for intrusion detection, *Electronics* 11 (2022) 1675, <https://doi.org/10.3390/electronics11111675>.
- [25] K.D. Devprasad, S. Ramanujam, S.B. Rajendran, Context adaptive ensemble classification mechanism with multi-criteria decision making for network intrusion detection, *Concurr. Comput. Pract. Exp.* 34 (21) (2022), e7110.
- [26] S. Mohamed, R. Ejbal, Deep SARSA-based reinforcement learning approach for anomaly network intrusion detection system, *Int. J. Inf. Secur.* 22 (1) (2023) 235–247.
- [27] A.S. Alqahtani, FSO-LSTM IDS: hybrid optimized and ensembled deep-learning network-based intrusion detection system for smart networks, *J. Supercomput.* 78 (7) (2022) 9438–9455.
- [28] S. Wang, W. Xu, Y. Liu, Res-TranBiLSTM: an intelligent approach for intrusion detection in the Internet of Things, *Comput. Netw.* 235 (2023), 109982.
- [29] M. Tavallaee, E. Bagheri, W. Lu, A.A. Ghorbani, A detailed analysis of the KDD CUP 99 data set, in: 2009 IEEE Symposium on Computational Intelligence for Security and Defense Applications, IEEE, Ottawa, ON, Canada, 2009, pp. 1–6, <https://doi.org/10.1109/CISDA.2009.5356528>.
- [30] N. Moustafa, J. Slay, UNSW-NB15: a comprehensive data set for network intrusion detection systems (UNSW-NB15 network data set), in: 2015 Military Communications and Information Systems Conference (MilCIS), IEEE, Canberra, ACT, Australia, 2015, pp. 1–6, <https://doi.org/10.1109/MilCIS.2015.7348942>.
- [31] S.J. Stolfo, Wei Fan, Wenke Lee, A. Prodromidis, P.K. Chan, Cost-based modeling for fraud and intrusion detection: results from the JAM project, DISCEX'00. Proceedings DARPA Information Survivability Conference and Exposition, IEEE Comput. Soc., Hilton Head, SC, USA, 2000, pp. 130–144, <https://doi.org/10.1109/DISCEX.2000.821515>. DISCEX'00.
- [32] X. Larriva-Novo, V.A. Villagrà, M. Vega-Barbas, D. Rivera, M. Sanz Rodrigo, An IoT-focused intrusion detection system approach based on preprocessing characterization for cybersecurity datasets, *Sensors* 21 (2021) 656, <https://doi.org/10.3390/s21020656>.
- [33] F. Ouyang, B. Guo, L. Ouyang, Z. Liu, S. Lin, W. Meng, X. Huang, H. Chen, H. Qiu-gen, S. Yang, Comparison between linear and nonlinear machine-learning algorithms for the classification of thyroid nodules, *Eur. J. Radiol.* 113 (2019) 251–257, <https://doi.org/10.1016/j.ejrad.2019.02.029>.
- [34] D. Chumachenko, I. Meniaïlov, K. Bazilevych, T. Chumachenko, S. Yakovlev, Investigation of statistical machine learning models for COVID-19 epidemic process simulation: random forest, K-nearest neighbors, gradient boosting, *Computation* 10 (2022) 86, <https://doi.org/10.3390/computation10060086>.
- [35] D. Marković, D. Vujčić, S. Tanasković, B. Đorđević, S. Randić, Z. Stamenković, Prediction of pest insect appearance using sensors and machine learning, *Sensors* 21 (2021) 4846, <https://doi.org/10.3390/s21144846>.

A Deep Auto Imputation Integrated Bayes Optimized Transfer Learning Model with Hybrid Skill-Levy Search Algorithm (DAI-BOTS) for Call Drop Prediction in Mobile Networks

G. V. Ashok^{1,*} and P. Vasanthi Kumari²

¹Department of Computer Science and Engineering, Dayananda Sagar University, Bangalore, Karnataka, India

²Department of Computer Applications, Dayananda Sagar University, Bangalore, Karnataka, India

Email: gvashok1877@gmail.com (G.V.A.); vasanthi-bca@dsu.edu.in (P.V.K.)

*Corresponding author

Abstract—The most intriguing research areas in mobile communication networks recently is call drop prediction. Several artificial intelligence algorithms are created for this goal in earlier research projects; however, they struggle with the problems of large system complexity, poor efficiency, and lack of accuracy. Therefore, the goal of this research work is to create a cutting-edge framework, named as, DAI-BOTS for predicting mobile call drops using clever deep learning algorithms. Here, the special Deep Auto-Encoder based Data Imputation (DAE-DI) technique is used to generate the imputed data with normalized characteristics after data gathering. Then, a hybrid Skill Search based Levy Flight Optimization (S2LFO) method is created to select the most demanding features from the imputed data to lessen the classifier's training and testing complexity. In addition, for precise call dropout prediction, the Bayes Optimized Transfer Learning Network (BOT-LN) classification algorithm is used. In this work, there are four distinct and emerging datasets such as Call Detail Record (CDR), Synthetic Minority Over-sampling Technique (SMOTE), Cell to Cell and IBC Telco used to assess the call drop prediction results of the proposed DAI-BOTS mechanism. In addition, this study also uses a few other publicly available open-source datasets for system validation, including SMOTE, Cell to Cell, and IBM Telco. Furthermore, the results of the DAI-BOTS system are compared based on a number of evaluation factors, taking into consideration the most recent state-of-the-art model techniques.

Keywords—mobile networks, call drop prediction, data imputation, feature optimization, machine learning, classification

I. INTRODUCTION

In present times, the telecommunications industry has grown to be one of the most important in industrialized nations [1, 2]. As a result of technological advancements and a rise in operators, the intensity of competition has

increased. In order to survive in this cutthroat market, businesses must employ a variety of strategies, with the three primary goals being to increase customer retention, promote existing customers, and acquire new ones. The emergence of 5G technology and changing preferences among consumers provides a plethora of opportunities for telecommunications (telecom) enterprises [3]. The telecom market is currently seeing intense competition and a high rate of customer turnover as a consequence of the tremendous economic opportunities that have recently arisen [4]. Telecom operators must create effective marketing strategies based on comprehensive customer data in order to cut abandonment of clients and boost business income. While acquiring new clients receives a lot of attention, this strategy is currently outdated in the fiercely competitive telecom sector [5, 6]. It is well known that getting new customers costs far more than maintaining existing ones. Churn control in the telecom sector becomes important in this situation. The cost of getting a new customer is substantially more than the cost of keeping an existing one, stated by the telecom service providers [7, 8]. In order to reduce customer churn, telecom carriers are directing their marketing efforts into focused client retention initiatives. One of the primary goals of churn management is to create accurate churn forecasting systems that can pinpoint customers who are likely to leave [9]. The main concept is to use a variety of information sources to build a profile of a client, including call routines contract details, invoices, payment, calls from customer service, and personality traits, and then forecast the likelihood that he or she would leave based on features.

Most people's life will be centered on the services offered by mobile wireless networks in the coming years, hence the demand for higher-quality services is only going to rise. The user would pay additional money if they had had to phone back to wrap up the conversation besides to the annoyance that a disrupted call would have caused. Call drops are generally avoidable by service providers if they take particular stages, eventually including distributing traffic across multiple frequencies, removing

interference, and expanding the area of coverage [10–12]. Therefore, the only ways to increase the level of service in mobile networks within the already available spectrum are by fortifying the structure of networks and use innovative techniques for preventing call dropouts. The growing popularity of cellular networks today is expected to result in an enormous spike in network traffic. The length of phone calls is growing, which is a concerning trend. Call dropouts are frequently seen in networks—calls that are “dropped” without any of the parties intentionally disconnecting the phone calls [13, 14]. As a result, the only way to improve mobile network reliability of service within the boundaries of the spectrum at hand is to invest in network infrastructure upgrades and call drop reduction technologies.

Several existing models have been employed to address the challenge of call drop prediction in mobile networks. Common approaches include traditional machine learning techniques such as Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Decision Tree (DT), Logistic Regression (LR), Random Forest (RF), Ensemble Learning (EL), Extreme Gradient Boost (XGB), AdaBoost, and more. These models often rely on various feature engineering and optimization techniques to enhance prediction performance.

In the previous research works [15, 16], several types of learning techniques are developed for determining when calls will drop on mobile networks. Typically, machine learning has been effectively used in numerous fields, including computer vision, healthcare diagnosis, and other domains, and is a key enabler for artificial intelligence. Computers may now learn without explicit programming because of the science of machine learning [17]. In simple terms, there are three types of machine learning techniques: reinforcement-based, unsupervised, and supervised. With the help of specified sample inputs and their desired outcomes, which make up the labeled data set, the learning agent’s goal in supervised learning is to acquire a general rule translating inputs to outputs.

Unsupervised learning involves a machine attempting to draw various patterns using its input without the use of labeled data. The application of deep learning [18, 19] has progressed recently, gaining more potent representational skills due to the development of quick, enormously parallel graphic processors and the substantial expansion of data. Still, it has drawbacks [20] like inefficient call drop detection, lower accuracy, not capable of handling large dimensional data, and high time complexity. The proposed study will therefore make use of an efficient and powerful ML for call drop prediction. The major goal of this study is to create a new Artificial Intelligence (AI) [21, 22] model combined with data imputation and optimization model to more accurately forecast call dropouts in mobile networks.

The main objectives of this paper are given below:

- The purpose of this research work is to develop a novel and sophisticated framework for mobile call drop prediction with the use of intelligent deep learning algorithms.

- After data acquisition, the unique Deep Auto-Encoder based Data Imputation (DAE-DI) technique is applied to generate the imputed data with normalized attributes.
- Then, the hybrid Skill Search based Levy Flight Optimization (S2LFO) technique is developed to choose the most required and pertinent features from the imputed data for reducing the training and testing complexity of classifier.
- The Bayes Optimized Transfer Learning Network (BOT-LN) classification algorithm is implemented for an accurate call dropout prediction.
- A real-time dataset called CDR and, some other public open-source datasets such as Synthetic Minority Over-sampling Technique (SMOTE), Cell to Cell and IBM Telco are used in this study for system validation.

The following sections make up the remaining portions of this work: A thorough literature analysis on the various machine learning and deep learning methods utilized in mobile networks for call drop prediction could be accessed in Section II. The proposed DAI-BOTS model is concisely thoroughly explained in Section III. By using the public open-source call record data, Section IV verifies and assesses the performance and comparative outcomes of the proposed model. Section V summarizes the findings, results, and future scope of the whole endeavor.

II. LITERATURE REVIEW

The present section examines various artificial intelligence techniques that support reliable communication in wireless and mobile networks by lowering call dropout rates. The obstacles and constraints of the earlier investigations are also examined for better understanding.

Khan *et al.* [23] utilized a standard Artificial Neural Network (ANN) algorithm for mobile call prediction by using the information of usage patterns, demographic data, and billing details. This study’s major goal is to develop a Multilayer Perceptron Neural Network (MLP-NN) model that is capable of predicting telecom dropout by analyzing information gained from the telecommunications industry in accordance with variables. The requirement to anticipate and manage loss of customers has increased as the cellular business has grown. Proactive detection of loyal clients who wish to do business elsewhere can help in locating them and exposing them to preventative measures in an effort to keep them. Consequently, building trustworthy and accurate churn models is necessary for practitioners as well as telecom firm owners. To find a promising strategy for maintaining consistent customer baselines, telecom churn prediction has turned as an emerging technological challenge that provides an early warning system for consumers who are shifting over.

Ahmad *et al.* [24] applied a common machine learning technique on telecom data to forecast churn. The greatest benefit of this analysis is the advancement of a churn forecasting model that aids telecom companies in identifying customers who are most likely to switch. The model developed in this work uses machine learning

techniques on a platform that gathers a lot of data and creates a novel method for figuring out features. In this instance, many data mining strategies for churn prediction are discussed, including preprocessing, feature transformation, selection, and classification. Businesses are attempting to create ways to anticipate potential customer migration because it directly affects their profitability, particularly in the telecom industry. To reduce client shifts, it is critical to understand the causes of it. This study aims to design and implement a framework for predicting churn to help telecom carriers pinpoint clients who are among the most inclined to experience churn. Pustokhina *et al.* [25] applied an Optimal Weighted Extreme Machine Learning (OWELM) technique for the identification and classification of customer churn prediction. Here, the SMOTE analysis is also carried out to handle an imbalanced dataset for accurately determining the class labels. Standardization and class labeling are first applied to the consumer data, and the imbalanced dataset is then dealt with the SMOTE approach. The WELM model is subsequently utilized to assign class labels to the applied data.

Ullah *et al.* [26] implemented a new churn prediction mechanism with the use of RF classification technique for improving customer relationship management in telecom sector. There are numerous data analysis and machine learning algorithms available that may be used to evaluate the customer data as a result of new advances in the area of big data. These methods examine the data to determine the causes of customer retention. These strategies can be used by CRM to boost their profit. The recommended work uses the information gain and ranking based feature selection approaches to choose the key attributes. Additionally, the authors classified churn and non-churn on two sizable datasets from the telecom industry adopting an array of machine learning approaches. Furthermore, the researchers claimed that when compared to other machine learning algorithms, the RF method provided better precision. Bahra *et al.* [27] deployed a vector auto-regression model for an effective handover management in mobile networks. Initially the authors used a mobility model constructed using statistical approaches along with deep learning techniques to gather user mobility patterns. To determine a user's potential trajectory, they also used an auto-regression model and a Gated Recurrent Unit (GRU). Here, the amount of pointless handover signaling messages has been decreased down, and the handover process is streamlined utilizing the predicted outcomes. Furthermore, studies have been carried out using the movement data collected from actual users. According to the model's findings, the suggested VAR-GRU mobility paradigm exhibits a smaller prediction error when compared to other approaches. The authors also looked into the expenses associated with handling and transferring handovers under both predictive and non-predictive circumstances.

Fujo *et al.* [28] implemented a deep back-propagated ANN classification technique for customer churn prediction in telecom industry. In the suggested framework, the missing data handling, over sampling, and

transformation operations are performed while preprocessing the given data. Then, the feature engineering and exploratory data analysis processes are also carried out for improving the accuracy of churn prediction. Here, the data transformation is performed with the operations of label encoding, one hot encoding, and normalization. In addition, the correlation matrix formation and variance thresholding methodologies are applied in this study for feature selection. However, the suggested technique limits the main problems of inefficient churn prediction and high time complexity. Erunkulu *et al.* [7] utilized a standard ANN technique for identifying and predicting mobile call drops in the GSM networks. In this study, five different Quality of Service (QoS) parameters are considered for call drop prediction, which includes framework error rate, bit error rate, time, received signal quality and strength. These parameters are considered as the input parameters for classification, where the transformation operations are applied on the input. During classification, the weight values are adjusted according to the error rate of actual output and targeted result. However, the accuracy of the suggested technique is low, which affects the performance efficiency of the entire system.

Wu *et al.* [20] constructed an integrated customer analysis framework for an effective churn management in telecom industry. In this study, there are 6 different classifications such as LR, DT, NB, RF, AB and SMOTE used for churn prediction. After that, the factor analysis is separately performed with the use of Bayesian and LR approaches, and the customer segmentation is performed with the use of K-means technique. According to the predicted results of these techniques, the customer behavior analysis also validated in this study. Yet, the major challenges of this paper are high time cost, and complexity in classification. Hussain *et al.* [29] applied a data-driven deep learning approach for maximizing the QoS in 5G mobile networks. Here, the CDR data has been utilized to improve the security level of mobile communication. Moreover, the standard Adam optimization model is used in this study for predicting the normal and anomaly calls with faster response time. Rizwan *et al.* [30] implemented an AI enabled CDR model for enhancing the service management in mobile communication networks. In this study, the familiar CDR data is used to predict the specific type of cell performance. This framework comprises the modules of data preprocessing, clustering, pattern identification, root cause diagnosis, visualization, and classification. However, the computational complexity of the suggested framework is high, which affects the overall performance of the communication system.

Kolli *et al.* [31] utilized a hybrid set of features for accurately predicting churns from the mobile communication networks. The authors intend to analyze the behavior of customers with the use of individual profile information and social links. Nevertheless, the suggested model is not effective in churn prediction, since it fails with the major problems of lower performance rate and inefficient data handling. Gursoy *et al.* [32] conducted a case study to examine the churn behavior of customers in

the telecom sector. Here also, the CDR data has been used for churn prediction, which comprises the information relevant to the phone usage of subscribers. In addition, the authors suggested a new prototype model for developing an effective churn prediction mechanism. The standard methods are therefore less effective at detecting service disruptions at small cells. With the advent of new technologies, it is projected that the number of design and optimization parameters would significantly rise. Expanding network administration parameters and identities may dramatically increase the likelihood of parameter misconfiguration. The recommended method employs threshold functions to constantly track downlink signal properties in order to determine whether a cell deviates from the acceptable level established by expert systems. A number of approaches have been developed in Ref. [33, 34] for lowering call dropouts in mobile networks, according to the study's findings. Tragically, most of the techniques have the following drawbacks:

- Ineffective results brought on by changeable dependencies.
- Time-consuming dataset training process.
- Lower efficiency.
- Extremely sensitive to noisy data.
- Unsuitable for handling large-dimensional datasets since the nature of the dataset has a substantial effect on how accurate the classifier performs.

In order to prevent call dropouts in a mobile network, the proposed research aims to develop a novel and sophisticated deep learning model.

III. PROPOSED METHODOLOGY

This section provides the complete explanation for the proposed framework, known as, Deep Auto Imputation based Bayes Optimized Transfer Learning model integrated with skill-Levy search algorithm (DAI-BOTS). The unique contribution of this work is the design and development of novel framework for call drop prediction in mobile networks. For this purpose, advanced and sophisticated algorithms are implemented in this study. Call dropouts often have a substantial impact on both voice and online consumers as well as service providers' income [13]. The work that needs to be done and the connections that need to be maintained with different company customers are both impacted by unexpected call drops. They undermine consumer confidence in telecom service providers [14]. There are several scenarios or use cases that can result in a call being lost.

The clear workflow model of the proposed system is shown in Fig. 1, which comprises the following modules:

- ✓ Input telecom data acquisition
- ✓ DAE-DI based data cleaning
- ✓ S2LFO based feature selection
- ✓ BOT-LN classification
- ✓ Performance testing and validation

In the proposed work, three different telecom datasets such as, real time CDR, and open source SMOTE, Call-to-Call and IBM-Telco have been used for system design and development. After telecom data collection, the novel

DAE-DI mechanism is applied to generate the imputed data for improving the overall process of call drop prediction. It is a deep learning architecture model that transforms the raw data into a balanced form for gaining high accuracy. Consequently, the S2LFO technique is applied to choose the most required and useful features from the imputed data for minimizing the training as well testing complexity of classification. Moreover, the BOT-LN classification algorithm is utilized to accurately predict the call drops with high accuracy and performance results. By using the combination of these methodologies, the overall call drop prediction system is greatly improved in the proposed system.

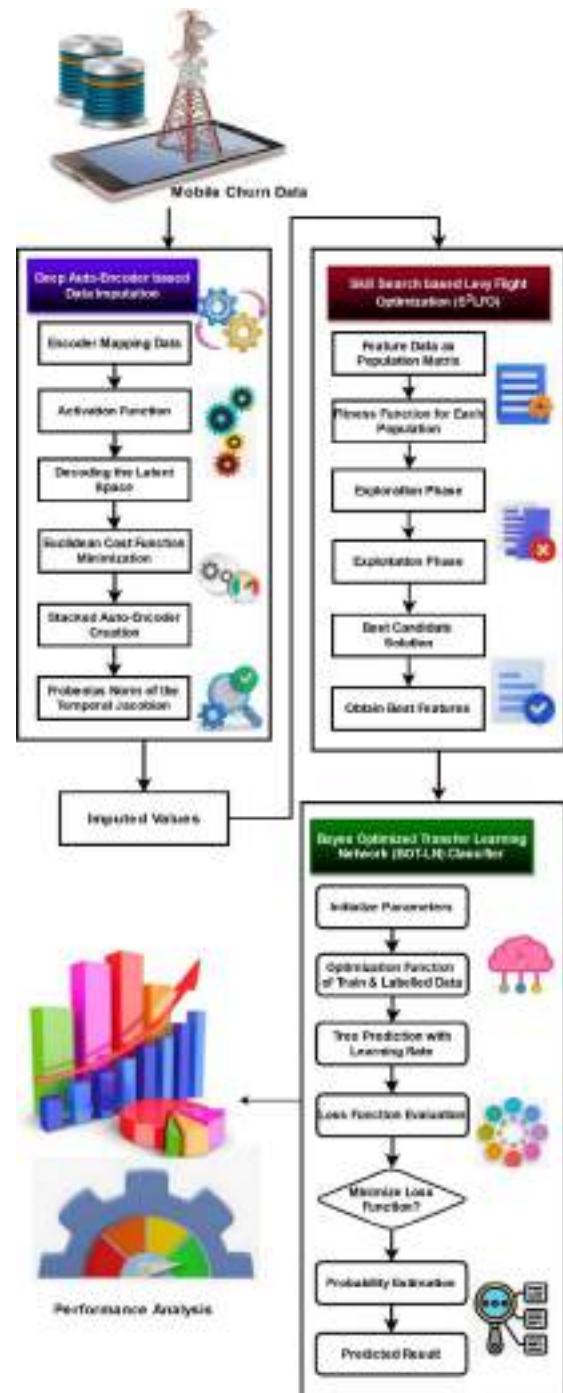


Fig. 1. Flow of the proposed DAI-BOTS model.

A. Data Imputation

Typically, data preparation is an important stage of information discovery activities, which is involved in this framework. It necessitates a number of stages, including the transformation of data as well as information reduction. The efficacy and reliability of learning algorithms will be hampered if raw data is transformed into poor-quality data [35]. As a result, by following proper procedures for data preprocessing and selecting appropriate learning algorithms, the acquired data can be accurately examined. Telecom datasets include a number of problems that need to be solved, including values that are missing, non-numerical features, conflicting feature scales, etc. As a result [36], it is crucial to preprocess the data before applying a learning model. In this study, four different types of datasets are adopted for system performance assessment and evaluation, which includes CDR, Cell2Cell, and IBM Telco, in which Cell to Cell has 58 attributes and 71,047 occurrences.

The data is accessible through Kaggle and the “Centre for Customer Relationship Management Duke University’s” website. IBM Telco is the second set of data used in the study for performance assessment and validation. Since the dataset includes a variety of customer-related information, a consistent link has been established between the churn rate and the customer’s behavior. Many academics have used the IBM Telco data set to predict customer turnover, which is available in Kaggle and has 21 attributes and 7044 rows. We have created a system that makes use of cutting-edge tools and technologies to obtain real-time data from a specific company or service provider, which is typically difficult to perform. The points of entry where the feature file can be initialized are constructed using the coded methods and functions. The following fields are considered when creating CDR data, however if more are required, the framework can help with their production.

In previous studies, the different types of imputation mechanisms are used for data normalization and cleaning. For instance, attribute-based clustering, distance-based clustering, and some others are used for transforming the raw input dataset into a balanced form. However, the conventional approaches have the major limitations of reduced speed of processing, presence of outliers, and redundant information. Therefore, the proposed work aims to implement a novel as well as intelligent mechanism, named as, DAE-DI for dataset imputation. This technique comprises both encoder and decoder units, where the input is mapped into the latent space with the use of encoder. In this stage, the input telecom data $\mathcal{J}^d$ is taken as the input for processing, and the imputed data $\hat{\mathcal{J}}_s$ is delivered as the resultant data. Here, the data mapping is performed at first as represented in the following equation:

$$H^s = \delta(E_r \mathcal{J}^d) \quad (1)$$

where, E_r indicates encoder, D_r represents the decoder, and $\delta(\cdot)$ represents the activation function tanh. Consequently, the decoder D_r is projected into the latent space H^s back to the input space as illustrated in below:

$$\mathcal{J}^d = D_r H^s = D_r \times \delta(E_r \mathcal{J}^d) \quad (2)$$

Moreover, the Euclidean cost function is minimized at the time of training as defined in the following equation:

$$\underset{D_r, E_r}{\operatorname{argmin}} \|\mathcal{J}^d - D_r \times \delta(E_r \mathcal{J}^d)\|_F^2 \quad (3)$$

where, η is the regularization coefficient, and the regularizer K can include simple Tikhonov penalties on the encoder and decoder as well as intricate assumptions like sparsity and position deficits. Typically, several variants of auto-encoders are used for imputation, here the stacked auto-encoder has been used by nesting one with other as represented in the following model:

$$\underset{D_r, E_r}{\operatorname{argmin}} \|\mathcal{J}^d - D_r \times \delta(E_r \mathcal{J}^d)\|_F^2 + \eta K(E_r, D_r) \quad (4)$$

Furthermore, Froebenius norm of the temporal Jacobian is estimated with the expectation matrix value as represented in the following form:

$$\hat{\mathcal{J}}_s'' = \sum_{j=1}^L \mathbb{E} \left(\sum_{t=1}^B |\sigma(\mathcal{J}^d)|^2 \right) \quad (5)$$

where, L indicates the network layer, $\sigma(\mathcal{J}^d)$ denotes the variance of formed by Jacobian matrix, B is the dimension of feature data, and $\mathbb{E}(\cdot)$ indicates the expectation matrix values. Finally, the featured data is generated with the imputed values as defined in the following model:

$$\hat{\mathcal{J}}_s'' = D_r \times \rho[E_r(K)] \quad (6)$$

where, $\rho(\cdot)$ is the sigmoid activation function applied at the encoder layer, in the neural network. By using this data imputation algorithm, the raw telecom dataset is transformed into the featured data, which is further used for call drop prediction operations. The following Algorithm 1 gives the step-wise functioning of the proposed DAE-DI model.

Algorithm 1: Deep Auto Encoder based Data Imputation (DAE-DI)

Input: Input Data $\mathcal{J}^d$;

Output: Imputed data $\hat{\mathcal{J}}_s''$;

Procedure:

- Step 1: An auto-encoder comprise both encoder E_r and decoder D_r units, where the encoder maps the imputed data $\mathcal{J}^d$ into the latent space (H^s) by using Eq. (1);
 - Step 2: Then, the decoder D_r projects the latent space H^s back to the input as shown in Eq. (2);
 - Step 3: The Euclidean cost function is minimized at the time of training by using Eq. (3);
 - Step 4: The stacked auto-encoder has been created by nesting one with another as represented in Eq. (4);
 - Step 5: The Froebenius norm of the temporal Jacobian matrix is formulated as shown in Eq. (5);
 - Step 6: Finally, the imputed values for all the featured data $\hat{\mathcal{J}}_s''$ is represented in Eq. (6).
-

B. Hybrid Skill Search Based Levy Flight Optimization (S2LFO) Algorithm

Since the effectiveness of the call drop prediction system heavily depends on the dataset’s features, feature

selection is typically one of the most crucial operations. Therefore, it is more important than ever to take the best features from the available data. For call drop prediction in the mobile network application systems, numerous feature selection mechanisms based on optimization techniques have been proposed in previous studies. However, the majority of approaches have drawbacks related to time requirements, local optimums, and sophisticated mathematical modeling, as well as increased time consumption. Therefore, the proposed study aims to apply a new hybrid algorithm, named as, S2LFO for feature selection. In this method, the most recently developed Skill Search Optimization (SSO) as well as Levy Flight Optimization (LFO) techniques are integrated together for dataset dimensionality reduction.

One of the novel contribution of this work is the hybridization of these methodologies for feature selection. The SSO is motivated by people's efforts to acquire better abilities. The folks or members seek to learn new things in order to develop their talents. The method starts by randomly initializing the members. Along with the worst and best members, the fitness values are adjusted while the process of iteration. Exploration and exploitation are the two steps that SSO performs for updating the population of members. The skill-learning process is carried out by professionals in the very first stage, whilst the subsequent stage rely on events and personal efforts. The primary goal of the exploration phase is to move the algorithm members with the assistance of other members in order to find the overall solution in the area of searching. When the exploring power is raised, the first ideal area is correctly recognized. In contrast, the exploitation phase concentrates on local search, which aids in the convergence of better solutions. The Hybrid S2LFO algorithm selects Levy Flight Distances through a random process during optimization. This exploration phase is vital for the algorithm to effectively navigate the search space and discover optimal solutions. The specific values for Levy Flight Distances are not predetermined but are instead randomly assigned during the optimization process.

By working with an expert member who is in good condition based on fitness value, the population member aims to improve his skill during exploration. The expert member is chosen at random from among the participants who have higher fitness scores than the person being considered. Through learning the ability to do this, it directs the population member to various spots within the area of search. Each team member works independently and practices during the exploitation phase to improve the skill they learned during the discovery phase. To encourage exploitation, it is designed to look like a local search, prompting the member to make an effort to improve his fitness worth. Levy flight is a statistical motion description that goes beyond the extremely common Brownian motion, which was found more than a century ago.

Levy statistics are increasingly being used to characterize a wide variety of both supernatural and artificial systems. Each "generation" employs a certain set of particles. The method will produce a completely new

generation starting from one well-known site at random Levy flight distances. The most promising member of the new generation will then be chosen after evaluation. Up until the stopping criteria are met, the process is repeated. Levy Flight Optimization (LFO) has been implemented in a fairly straightforward manner. Both techniques have the unique characteristics of high convergence speed, global optimum solution with low iterations, increased searching efficiency and performance rate. Therefore, the proposed integrates these two distinct optimization techniques for developing a hybridized model to solve the feature selection problem. In this technique the imputed data obtained from the previous stage $\hat{f}_d$ is taken as the input, and the set of selected features $\hat{f}_s$ are delivered as the resultant output. At first, the population matrix is formulated for the given feature data as represented in the following equation:

$$X = \begin{bmatrix} X_1 \\ \vdots \\ X_j \\ \vdots \\ X_M \end{bmatrix} = \begin{pmatrix} x_{1,1} \dots x_{1,a} \dots x_{1,g} \\ x_{j,1} \dots x_{j,a} \dots x_{j,g} \\ x_{m,1} \dots x_{m,a} \dots x_{m,g} \end{pmatrix} \quad (7)$$

The fitness function of each candidate solution is calculated for each row in the population matrix by using the following model:

$$F = \begin{bmatrix} F_1 \\ \vdots \\ F_j \\ \vdots \\ F_M \end{bmatrix} = \begin{bmatrix} \text{fitness}(X_1) \\ \vdots \\ \text{fitness}(X_j) \\ \vdots \\ \text{fitness}(X_M) \end{bmatrix} \quad (8)$$

When the new location's fitness value grows better, it is approved; this can be modeled as foll $x_{j,a}^{\varphi_1} = x_{j,a} + \text{rand} \times (E_{j,a} - R \times x_{j,a})$, $E_j = X_t$, if $F_t < F_{jow}$.

$$x_{j,a}^{\varphi_1} = x_{j,a} + \text{rand} \times (E_{j,a} - R \times x_{j,a}), E_j = X_t \quad \text{if } F_t < F_j \quad (9)$$

$$x_{j,a} = \begin{cases} x_{j,a}^{\varphi_1} & \text{if } F_j^{\varphi_1} < F_j \\ x_{j,a} & \text{if } F_j^{\varphi_1} \geq F_j \end{cases} \quad (10)$$

Then the probability chosen from Levy distribution is computed according to the following equation:

$$R = \begin{cases} \frac{(\vartheta_{jh})^y \times (\rho_{jz})^\lambda}{\sum (\vartheta_{jh})^y \times (\rho_{jz})^\lambda} & h, z \in \text{allowed} \\ 0 & \text{otherwise} \end{cases} \quad (11)$$

To encourage exploitation, it is designed to look like a local search, encouraging the member to try to improve his fitness worth. This might be done as shown in below:

$$x_{j,a}^{\varphi_2} = \begin{cases} x_{j,a} + \frac{1-2 \times \text{rand} \times x_{j,a}}{l_t} & \text{if rand} < 0.5 \\ x_{j,a} + \frac{l_k^B + \text{rand} \times (U_k^B - L_k^B)}{l_t} & \text{else} \end{cases} \quad (12)$$

$$x_{j,a} = \begin{cases} x_{j,a}^{\varphi_2} & \text{if } \mathcal{F}_j^{\varphi_2} < \mathcal{F}_j \\ x_{j,a} & \text{if } \mathcal{F}_j^{\varphi_2} \geq \mathcal{F}_j \end{cases} \quad (13)$$

The following can be used to represent the fitness function:

$$\text{fitness}(\mathcal{X}_1) = \int_0^{l_t} [\sum_{j=0}^M |\Delta \mathcal{F}_j + \Delta x_{j,a}| t] dt \quad (14)$$

Finally, the best featured data is obtained as represented in the following equation:

$$\begin{aligned} \hat{f}_s' &= \prod_j \text{fitness}(\mathcal{X}_j), \text{ if } \text{fitness}(\mathcal{X}_j) < \text{fitness}(\mathcal{X}_{j-1}) \\ \hat{f}_s &= \prod_j \text{fitness}(\mathcal{X}_j), \text{ if } \text{fitness}(\mathcal{X}_j) < \text{fitness}(\mathcal{X}_{j-1}) \end{aligned} \quad (15)$$

By using this hybrid optimization algorithm, the best fitness value is estimated and is used to choose the most relevant features from the provided dataset. The list of symbols and its appropriate descriptions are given in Table I.

TABLE I. LIST OF SYMBOLS AND DESCRIPTIONS

Symbols	Descriptions
$\mathcal{X}_j$	j^{th} candidate
$x_{j,g}$	g^{th} variable value proposed via the i^{th} member of the population
$\mathcal{M}$	Number of members
m	Number of considered variable
$\mathcal{F}_j$	Fitness value of the j^{th} candidate solution
$x_{j,a}^{\varphi_1}$	Updated position of member j
φ_1	a in the first phase
$\mathcal{F}_j^{\varphi_1}$	Fitness value of $x_{j,a}^{\varphi_1}$
$\mathcal{E}_j$	Selected expert member
$\mathcal{E}_{j,a}$	a^{th} dimension of the expert member
rand	Random number in range [0, 1]
$\mathcal{R}$	Probability chosen from Levy distribution
ϑ	Pheromone
ρ	Attractiveness
γ and λ	Impact factors for ϑ and ρ .
$x_{j,a}^{\varphi_2}$	Updated position of member j
$\mathcal{F}_j^{\varphi_2}$	Fitness value of $x_{j,a}^{\varphi_2}$
l_t	Number of iterations
U_k^B and L_k^B	Upper and lower limits of the j^{th} variable
$\hat{f}_s'$	Featured data

The following Algorithm 2 provides the step-wise operations involved in the proposed S2LFO model.

The DAI-BOTS framework highlights the importance of feature engineering to improve model performance. For call drop prediction in mobile networks, feature engineering involves extracting temporal features related to network traffic, statistical measures, and call handover dynamics. The framework integrates interpretability techniques to illuminate the model's decision-making process. Feature importance analysis and SHapley Additive exPlanations (SHAP) values are used to attribute the model's prediction to individual features, making the decision-making process transparent and explainable. The

combination of advanced feature engineering and interpretable methods in the DAI-BOTS framework enhances the model's predictive capabilities and fosters trust among stakeholders involved in mobile network management.

Algorithm 2: Hybrid Skill Search based Levy Flight Optimization (S2LFO)

Input : Imputed Data $\hat{f}_d$;

Output : Selected Features $\hat{f}_s'$;

Procedure:

Step 1: Generate the population matrix from the given featured data as represented in Eq. (7);

Step 2: The fitness function $\mathcal{F}$ of each candidate solution is calculated for each row in the population matrix by using Eq. (8);

Step 3: //Exploration Phase:

When the fitness value of the new location $x_{j,a}^{\varphi_1}$ improves, it is accepted. This can be modeled by using Eqs. (9) and (10);

Step 4: Estimate the probability $\mathcal{R}$ value chosen from the Levy distribution as represented in Eq. (11);

Step 5: //Exploitation Phase:

To encourage exploitation, it is designed to look like a local search $x_{j,a}^{\varphi_2}$, encouraging the member to try to improve his fitness worth. This might be done as shown in Eq. (12);

Step 6: Compute the fitness function $\text{fitness}(\mathcal{X}_1)$ using Eq. (13);

Step 7: Obtain the best featured data $\hat{f}_s'$ using Eq. (14).

C. Bayes Optimized Transfer Learning Network (BOT-LN) Classifier

The selected features are passed to the BOT-LN classifier at this stage, which uses appropriate training and testing procedures to provide an accurate call drop prediction. Numerous machine learning and deep learning techniques have been used in earlier research to anticipate call drops. However, the majority of approaches are constrained by the key issues of increasing overfitting, decreased accuracy, prolonged training, and high system complexity. As a result, the proposed study aims to leverage the BOT-LN unique learning mechanism to anticipate call dropouts from the provided data. It is a methodical approach to looking at and analyzing datasets to find patterns and guarantee that reliable results are generated in accordance with the stated objectives. BOT-LN Classifier uses probability distributions to represent beliefs about model parameters given observed data. The optimal decision function is derived through Bayesian optimization, updating posterior distributions to improve decision-making. Bayesian information processor integrates information from posterior densities to guide decision-making. The specifics of the family of posterior densities, state, and optimal decision function may vary depending on the details of the Bayesian optimization approach adopted.

During training, it is intended that a regression-based machine learning model will recognize and highlight correlations between the data input values and the desired output reply. In this technique, the training set with the

chosen features is considered into account for classification, and the predicted for identifying call dropouts is delivered as the output. After getting the features, the learning rate, tree and posterior probability value are initialized for classification. Then, the expected loss is minimized as represented in the following equation:

$$L_E(t) = \min_{\beta} \int (\varphi - \beta(t))^2 \delta(\varphi|t) d\varphi \quad (16)$$

where, $\delta(\varphi|t)$ is the family of posterior probability density, φ is the state, $\beta(t)$ is the optimal decision function, $\vartheta(\varphi|t)$ represents the posterior mean, and these parameters are calculated as shown in below:

$$\beta(t) = \vartheta(\varphi|t) \quad (17)$$

$$\delta(\varphi|t) = \frac{F(\varphi|t) g_d(\varphi)}{\tau(t)} \quad (18)$$

where, $F(\varphi|t)$ indicates the conditional density function, $g_d(\varphi)$ represents the prior density, and $\tau(t)$ denotes the Bayesian information processor that is calculated in below:

$$\tau(t) = \int F(\varphi|t) g_d(\varphi) \quad (19)$$

Moreover, the final risk decision solution is estimated as shown in the following model:

$$R_C = \int L_E(t) \times \tau(t) dt \quad (20)$$

During the training process, a regularization term is computed by the hyper parameter $\mathbb{I}_{\theta}$ and the process is mathematically described as represented in the following equations:

$$f(\mathbf{f}_{s_i}^n) = |\bar{\mathcal{Y}} - P_{t-1}(\mathbf{f}_s^n)|_i^g \quad (21)$$

$$T_a(\mathbf{f}_s^n) = \operatorname{argmin}_g \sum_{t=1}^{A^T} [\bar{\mathcal{Y}} - f(\mathbf{f}_{s_t}^n)]^2 + \mathbb{I}_{\theta} \times |\mathbf{f}_{s_t}^n|_t^2 \quad (22)$$

$$\mathcal{G}(\mathbf{f}_s^n) = \operatorname{argmin}_g \sum (\bar{\mathcal{Y}} - \mathbb{I}_{\theta} \times T_a(\mathbf{f}_s^n))^2 \quad (23)$$

$$\mathcal{L}(\mathcal{Y}, f(\mathbf{f}_{s_t}^n)) = \sum_{t=1}^{A^T} [\bar{\mathcal{Y}} - f(\mathbf{f}_{s_t}^n)]^2 \quad (24)$$

$$P(\mathbf{f}_s^n) = P_{t-1}(\mathbf{f}_s^n) + \beta \times \sum_{t=1}^{A^T} T_a(\mathbf{f}_s^n)_t \quad (25)$$

By using these functions, the prediction result is determined as $P(\mathbf{f}_s^n)$ that is used to accurately identify the call dropouts with high performance rate. The following Algorithm 3 describes the classification process of proposed BOT-LN model.

Algorithm 3: Bayes Optimized Transfer Learning Network (BOT-LN) Classifier

Input : Training set: $\{(\mathcal{Y}_1, \mathbf{f}_{s_1}^n), (\mathcal{Y}_2, \mathbf{f}_{s_2}^n), \dots, (\mathcal{Y}_n, \mathbf{f}_{s_n}^n)\}$; Learning rate value, $\mathbb{I}_{\theta}$ and Tree number A^T , obtained through Bayes optimal decision;

Output : Predicted result $P(\mathbf{f}_s^n)$;

Step 1: Compute the family of the posterior densities $\delta(\varphi|t)$ of the state φ ;

Step 2: Minimize the expected loss $L_E(t)$ using Eq. (15);

Step 3: Compute the optimal decision function $\beta(t)$ and bayes information processor $\tau(t)$ as shown in Eqs. (16)–(18);

Step 4: Obtain the final risk decision solution R_C using Eq. (19);

Step 5: Loss function, $\mathcal{L}(\mathcal{Y}, f(\mathbf{f}_{s_t}^n))$

Step 6://Training Process:

For $t = 1$ to A^T , **do** :

$f(\mathbf{f}_{s_i}^n) = |\bar{\mathcal{Y}} - P_{t-1}(\mathbf{f}_s^n)|_i^g$

Train $T_a(\mathbf{f}_s^n)$ using $(\mathbf{f}_{s_t}^n, \bar{\mathcal{Y}})_i^g$

A regularization term controlled by another hyper parameter $\mathbb{I}_{\theta}$;

Compute $T_a(\mathbf{f}_s^n)_e$ using Eq. (21);

Compute $\mathcal{G}(\mathbf{f}_s^n)$ using Eq. (22);

Compute loss function $\mathcal{L}(\mathcal{Y}, f(\mathbf{f}_{s_t}^n))$ based on Eq. (23);

if $\min_{t=1 \text{ to } A^T} \mathcal{L}(\mathcal{Y}, f(\mathbf{f}_{s_t}^n))$

$P(\mathbf{f}_s^n) = P_{t-1}(\mathbf{f}_s^n) + \beta \times \sum_{t=1}^{A^T} T_a(\mathbf{f}_s^n)_t$

end if

end for;

Step 7: **Return** predicted result $P(\mathbf{f}_s^n)$.

The accuracy of call drop prediction in mobile networks can be improved by the feature importance and relevance analysis utilized in the proposed DAI-BOTS model. This analysis involves evaluating the significance of each feature in contributing to the predictive performance of the model. The Hybrid S2LFO algorithm is used for this feature selection process, which combines SSO and LFO to reduce dataset dimensionality. SSO focuses on learning from the best-performing members of the population, while LFO introduces randomness for effective exploration.

The analysis includes generating a population matrix and calculating the fitness function for each candidate solution, evaluating the importance of each feature. There are exploration and exploitation phases involved in this process. During exploration, SSO explores the search space to find the global solution, while LFO focuses on local search to refine the solution. Levy Flight Distances are chosen randomly during the optimization process, allowing for effective exploration in the search space. Probability values selected from the Levy distribution guide the exploration process, influencing the selection of features. Expert member learning enhances skills during exploration, directing members to various spots in the search space.

Fitness improvement occurs as members independently practice during the exploitation phase, attempting to improve their fitness values. The fitness function is calculated during the exploitation phase, emphasizing local search. The algorithm aims to obtain the best-featured data based on fitness values, selecting the most relevant features. The holistic approach of combining SSO and LFO ensures a comprehensive evaluation of feature relevance. The BOT-LN classifier is used to assess the impact on call drop prediction. In this stage, selected features undergo further evaluation. Bayesian optimization is employed to determine the learning rate, tree number, and posterior probability values, which impact the classification process.

IV. RESULT AND DISCUSSION

This section validates the performance and results of the proposed DAI-BOTS method by using the 4 distinct datasets such as SMOTE, CDR, Cell to Cell and IBM Telco [20, 28, 37]. Also, several performance indicators are used for validating the outcomes of the proposed call drop prediction model. The hardware and software environment consist of Python version 3.12, with libraries TensorFlow and scikit-learn. The hardware setup comprises an Intel Core i5 processor running at 2.7 GHz and 8GB RAM, and the experiments are conducted using Jupyter Notebook. An example IBM dataset called IBM-Telco is used to forecast customer churn and create client retention strategies. Teradata Center for Customer Relationship Management at Duke University provides Cell to Cell dataset.

The DAI-BOTS model is configured with a three-layered DAE-DI. The encoder has 128 nodes in the first layer and 64 in the second, mirrored in the decoder. Tanh activation functions are employed in both the encoder and decoder layers, with a learning rate of 0.001. A stacked auto-encoder with two layers, each containing 64 nodes, is utilized, and the regularization coefficient is set to 0.001. The Hybrid S2LFO is fine-tuned with a population size of 50 and 100 iterations. SSO includes exploration and exploitation phases, with a learning rate of 0.01. LFO involves Levy flight distances that are randomly chosen. Feature selection is performed using probability values determined during optimization. The BOT-LN is configured with a learning rate of 0.01, 100 trees, and a Bayes optimal decision mechanism. The training setup utilizes a regression-based machine learning model, and regularization terms are hyperparameter-controlled.

Data preprocessing involves missing value imputation using DAE-DI on the raw telecom dataset, standard scaling for data normalization, encoding for categorical features, and addressing outliers and conflicting feature scales. Feature selection is achieved through the S2LFO algorithm, considering probability values, exploration and exploitation phases, and fitness function details. The training process includes batch sizes of 32 and 100 epochs and the Adam optimizer.

In order to assess the effectiveness of models, accuracy, precision, recall, F1-Score, and Area Under the Curve (AUC) are measured. The percentage of samples that the algorithm appropriately predicts to all samples is known as accuracy. Precision is the percentage of samples that are actually positive compared to those that are expected to be positive. The proportion of correctly anticipated positive examples in the actual group is known as recall, while the proportion of correctly predicted negative instances within the real sample is known as specificity. The following equations are used to compute these parameters:

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \times 100\% \quad (26)$$

$$\text{Sensitivity} = \frac{TP}{TP+FN} \times 100\% \quad (27)$$

$$\text{Specificity} = \frac{TN}{TN+FP} \times 100\% \quad (28)$$

$$\text{Precision} = \frac{TP}{TP+FP} \times 100\% \quad (29)$$

$$\text{F1-Score} = \frac{2 \times \text{Precision} \times \text{Sensitivity}}{\text{Precision} + \text{Sensitivity}} \times 100\% \quad (30)$$

where, True Positive (TP) denotes that the sample is indeed positive and meets the prediction that it will be positive. False Negative (FN) signifies that the sample has turned out positive even though it was expected to be negative. False Positive (FP) denotes a sample that was expected to be positive but is really negative. True Negative (TN) implies that the sample is both genuinely and predictably negative. By calculating the False Positive Rate (FPR) and True Positive Rate (TPR) of the classifier and using these as both the vertical and horizontal axes, respectively, the Receiver Operating Characteristics (ROC) curve of the predictions might be generated. The region under the ROC curve is known as AUC, and a higher AUC number is highly preferable for accurate classification.

$$\text{FPR} = \frac{FP}{FP+TN} \times 100\% \quad (31)$$

$$\text{TPR} = \frac{TP}{TP+FN} \times 100\% \quad (32)$$

Addressing data imbalance is a crucial aspect of enhancing the robustness and fairness of the DAI-BOTS framework. Imbalanced datasets, where one class outnumbers the other, can lead to biased model training and suboptimal predictive performance. To mitigate these challenges, advanced preprocessing techniques are employed, such as resampling or generating synthetic samples. During the data preparation phase, advanced preprocessing techniques create a more balanced distribution of classes to ensure that the model is exposed to an equitable representation of both positive and negative instances. Resampling methods are employed to address data imbalance, either by oversampling the minority class, under-sampling the majority class, or a combination of both. Oversampling duplicates instances from the minority class, while under-sampling removes instances from the majority class. The goal is to achieve a more balanced class distribution, preventing the model from being biased toward the majority class.

In addition, synthetic sample generation techniques like SMOTE are applied to augment the minority class instances. SMOTE creates synthetic instances that resemble the minority class, thereby providing a more diverse and balanced dataset. The integration of these advanced preprocessing techniques aims to improve the model's ability to generalize across both classes, leading to better predictive performance on imbalanced datasets. This ensures that the model's predictions are not skewed by the dominance of one class, enhancing its overall effectiveness in call drop prediction in mobile networks.

The proposed S2LFO technique's fitness curve with regard to varying iterations is depicted in Fig. 2. Since a good optimization technique can arrive at the best optimal solution with few iterations, the optimization efficiency and searching performance are evaluated according to its fitness curve. The results demonstrate that the suggested

S2LFO technique achieves the most optimal result in the search space with a minimal number of iterations. The DAI-BOTS framework uses several time-series analysis techniques to improve its call drop prediction capabilities. It employs time-series data preprocessing, temporal feature engineering, RNNs, seasonal decomposition, and time-series cross-validation. The framework preprocesses raw datasets, extracts relevant temporal features, integrates RNNs, applies seasonal decomposition techniques and uses time-series cross-validation methods. The imputed data is dynamically updated to capture temporal dynamics and ensure the model remains relevant.

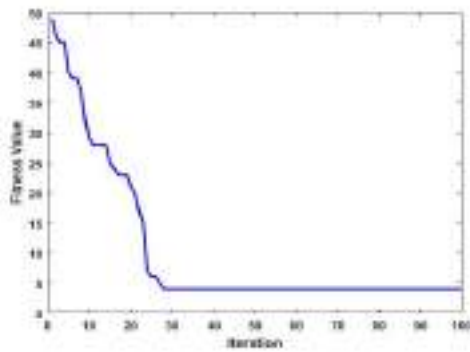


Fig. 2. Fitness curve.

Moreover, the confusion matrix for Cell to Cell dataset is depicted in Fig. 3, and its appropriate ROC curve with and without S2LFO technique is shown in Fig. 4. The effectiveness and accuracy of the classifier's prediction rate are examined using the ROC and confusion matrix parameters, respectively. The results demonstrate that by precisely detecting the call drops from the provided datasets, the suggested DAI-BOTS model offers the best prediction results. Furthermore, it performs significantly better when combined with the S2LFO algorithm. Since it significantly affects the reduction of feature dimensionality during training and testing of the data.

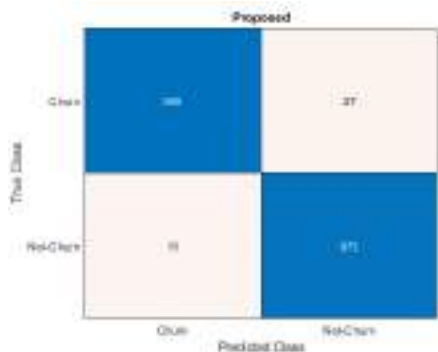


Fig. 3. Confusion matrix for cell to cell dataset.

With the help of the SMOTE dataset, Fig. 5 confirm and contrast some of the most popular machine learning techniques with the suggested model. As a result, as shown in Fig. 6, additional characteristics like precision, recall, and F1-Score are also validated and compared to the suggested DAI-BOTS model. The results show that the suggested DAI-BOTS technique functions admirably for

the provided dataset and delivers excellent results by precisely forecasting the call dropouts.

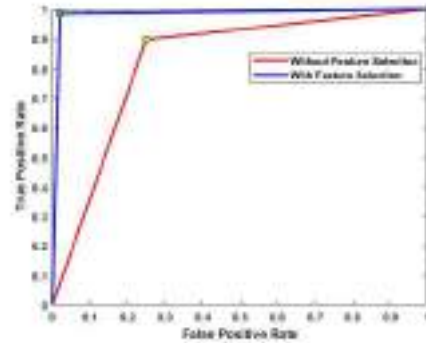


Fig. 4. ROC curve with and without S2LFO technique.

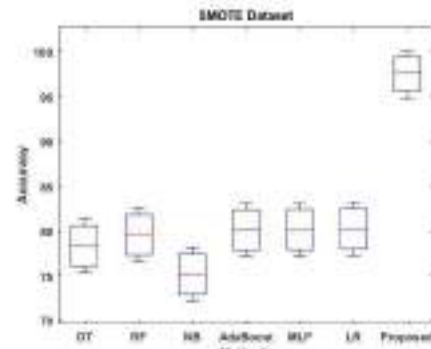


Fig. 5. Performance comparison with classic machine learning models using SMOTE dataset.

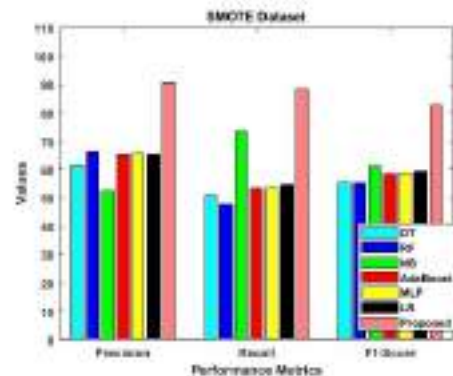
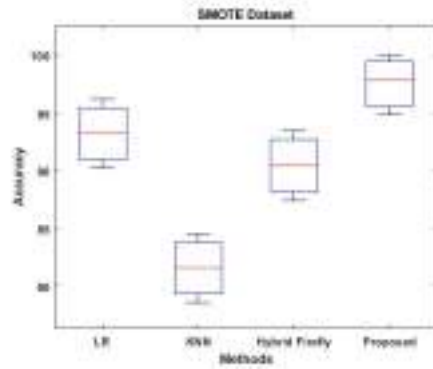
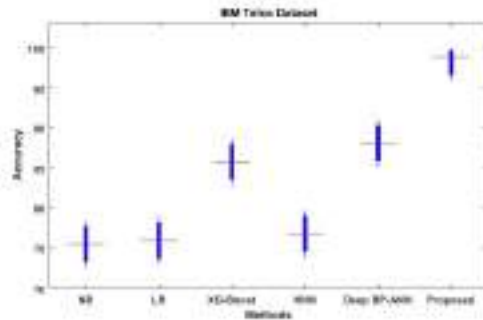


Fig. 6. Performance comparison using SMOTE dataset.

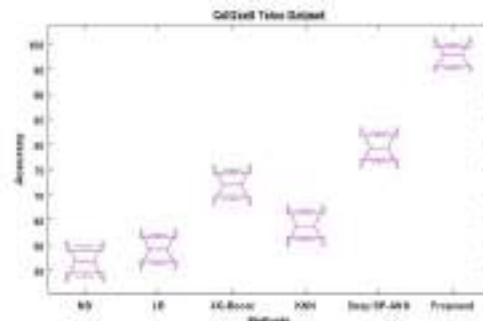
Additionally, as shown in Fig. 7, the accuracy of the SMOTE, IBM Telco and Cell to Cell datasets is estimated and compared for the current and suggested DAI-BOTS models. These results also show that the proposed model's accuracy has been significantly enhanced by the addition of DAE-DI-based imputation and S2LFO-based feature selection methods. Due to the fact that S2LFO is used to reduce dimensionality and increase dataset quality at the time of imputation. The suggested call drop prediction system improves the overall training and testing procedures of the BOT-LN classifier by utilizing these factors. As a result, the DAI-BOTS model performs much more accurately than conventional categorization strategies.



(a) Accuracy analysis using SMOTE dataset.



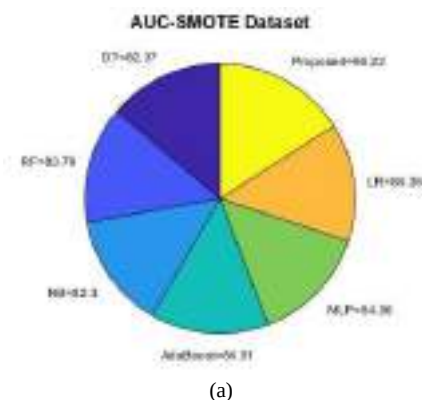
(b) Accuracy analysis using IBM Telco dataset.



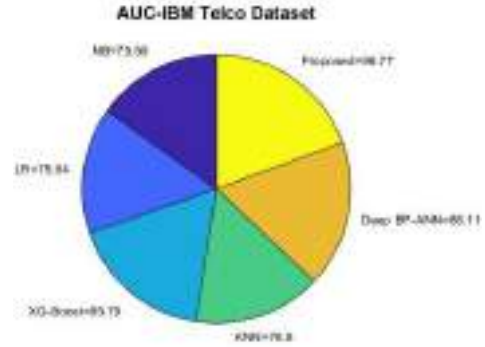
(c) Accuracy analysis using Cell to Cell dataset.

Fig. 7. Accuracy analysis using SMOTE, IBM Telco and Cell to Cell dataset.

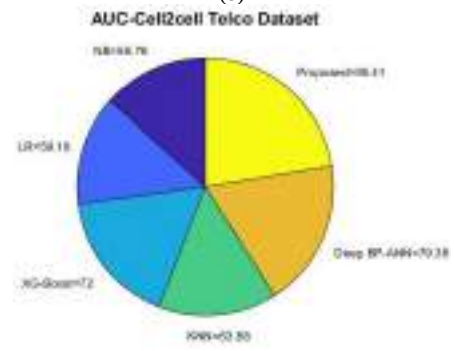
In addition, the AUC is also estimated for the SMOTE and IBM-Telco datasets for both conventional and proposed approaches as shown in Fig. 8 respectively. According to the predictions, it is noted that the AUC values provided by the DAI-BOTS model is superior to the other classification algorithms for all the datasets.



(a)



(b)



(c)

Fig. 8. AUC analysis. (a) AUC analysis using SMOTE dataset; (b) AUC analysis using IBM-Telco dataset; (c) AUC analysis using Cell to Cell dataset.

By using the IBM Telco and Cell to Cell datasets, respectively, Fig. 9 confirm and compare the precision, recall, and F1-Score values for the traditional and new call drop prediction algorithms. According to different numbers of epochs, the proposed DAI-BOTS technique additionally computes the overall training and testing loss, as illustrated in Fig. 10. The next step is to validate and compare the overall call drop prediction accuracy of the recently developed deep learning and the suggested BOT-LN classifiers, as shown in Fig. 11. Overall results lead to the conclusion that the proposed DAI-BOTS outperforms other current classification models and yields superior outcomes.

The proposed DAI-BOTS framework is benchmarked against existing methods to ensure its effectiveness. This is done by evaluating it using a diverse set of metrics, covering different aspects of model performance. The purpose of benchmarking is to validate the proposed approach in call drop prediction in mobile networks. Various methods commonly used in call drop prediction will be compared with the proposed DAI-BOTS framework, including SVM, KNN, DT, LR, NB, RF, EL, XGB, AdaBoost, COLKR, and other relevant methods identified during the literature review. The evaluation metrics employed for benchmarking ensure a comprehensive understanding of the proposed approach's strengths and weaknesses. These metrics include accuracy, precision, recall, F1-Score, ROC-AUC, and Confusion Matrix. The benchmarking process uses standardized datasets representative of real-world telecom scenarios, ensuring the generalizability of results. The proposed DAI-BOTS framework is trained and tested on these datasets,

and the aforementioned metrics will be calculated and compared against the baseline methods.

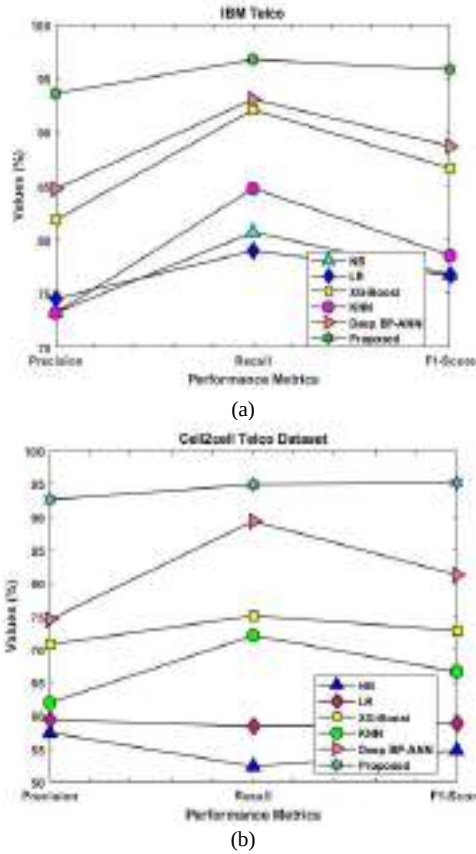


Fig. 9. Performance comparison. (a) Performance comparison using IBM Telco dataset; (b) Performance comparison using Cell to Cell dataset.

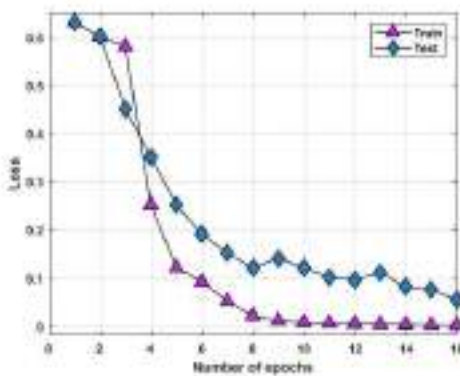


Fig. 10. Overall training and testing loss.

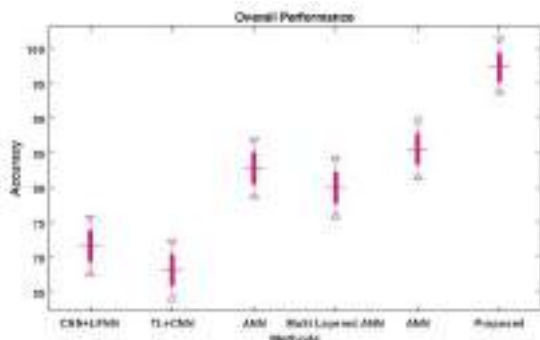


Fig. 11. Overall prediction accuracy.

The benchmarking process contributes to the robustness of the comparison, ensuring that the proposed approach's performance is rigorously evaluated across various dimensions. Sensitivity analyses, cross-validation, and statistical tests will be conducted to analyse the benchmarking results. This provides insights into the strengths and limitations of the DAI-BOTS framework compared to existing methods in call drop prediction in mobile networks. The comprehensive benchmarking process will form a critical component of validating the proposed DAI-BOTS framework's efficacy.

Table II validates the error rate of the conventional and proposed classification approaches used for call drop prediction based on CDR dataset. Typically, the classifier's overall prediction performance may suffer from the higher error rate. Hence, it should be reduced through efficient training and testing to achieve superior outcomes. The calculated results demonstrate that the DAI-BOTS model has a significantly reduced error rate of 0.065 when compared to the other models. Due to efficient data imputation and appropriate feature optimization, the classifier's training and testing procedures run smoothly. As a result, the suggested DAI-BOTS generates superior results when compared to existing classifiers. As indicated in Table III, additional metrics, including sensitivity, specificity, and F1-Score, are also evaluated as well as compared for the preexisting and hypothesized models. These findings also demonstrate that DAI-BOTS performs significantly better than the alternative options. The prediction rate has increased as a result of the greater sensitivity, specificity, and F1-Score values.

TABLE II. ERROR RATE ANALYSIS USING CDR DATASET

Techniques	Error rate
Support Vector Machine (SVM)	0.36
K-Nearest Neighbor (KNN)	0.33
Decision Tree (DT)	0.324
Logistic Regression (LR)	0.255
Naïve Bayes (NB)	0.319
Random Forest (RF)	0.238
Ensemble Learning (EL)	0.24
Extreme Gradient Boost (XGB)	0.39
AdaBoost	0.42
COLKR	0.098
Proposed	0.065

TABLE III. OVERALL PERFORMANCE ANALYSIS

Techniques	Sensitivity (%)	Specificity (%)	F1-Score (%)
Support Vector Machine (SVM)	88.1	88.3	88
K-Nearest Neighbor (KNN)	88.9	88.5	88.2
Decision Tree (DT)	90.2	89.8	89.3
Logistic Regression (LR)	94.6	94.1	94.22
Naïve Bayes (NB)	90.7	91.1	90.3
Random Forest (RF)	92.9	92.5	91.9
Ensemble Learning (EL)	92.1	92.1	91.5
Extreme Gradient Boost (XGB)	88.96	90.1	89.76
AdaBoost	87.7	88.2	87.9
COLKR	99.1	99.3	99.2
Proposed	99.5	99.4	99.5

Fig. 12(a) and (b) demonstrates the training and testing results of the proposed DAI-BOTS classification model with regard to of network failure and call connected rate respectively. This analysis demonstrates the performance of the classifier by validating the training and testing outcomes. By utilizing the optimized feature set obtained with the aid of S2LFO, the training and testing efficiency outcomes of DAI-BOTS in the proposed call drop prediction system have been significantly improved. DAI-BOTS outperforms existing models with improved accuracy in call drop prediction. Advanced techniques like deep auto-imputation and hybrid skill-levy search contribute to this enhancement. The model also reduces training and testing complexity by employing efficient algorithms like S2LFO for feature selection, enhancing dataset quality. The integration of deep auto-imputation and transfer learning techniques further enhances the efficiency of call drop prediction, providing more reliable and timely predictions.

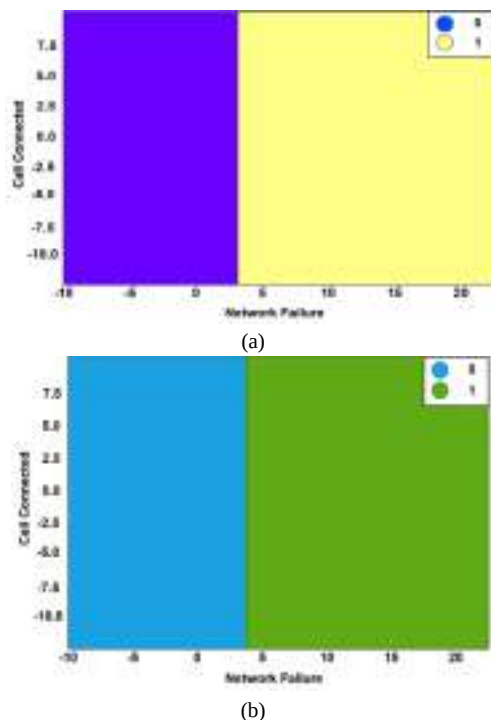


Fig. 12. Training and testing results of the proposed DAI-BOTS classification model. (a) Training and (b) Testing results.

The evaluation of the DAI-BOTS framework revolves around its computational complexity and scalability. In terms of computational complexity, the DAE complexity depends on factors like the number of layers, nodes, and dataset size. The Stacked Auto-Encoder, despite introducing added complexity through nesting, effectively manages it using Tanh activation functions and regularization. The Hybrid S2LFO algorithm, integrating SSO and LFO, introduces complexity influenced by population size, iterations, and dataset dimensionality, with the random choice of Levy Flight Distances contributing stochastic elements affecting computational complexity. The BOT-LN classifier introduces complexity through Bayesian optimization during learning rate, tree

number, and posterior probability determination, with regularization terms and hyperparameter-controlled processes contributing further.

Regarding scalability, DAE-DI's scalability relies on its ability to handle large datasets, which may become computationally intensive as the dataset size increases. S2LFO's scalability is influenced by population size and dataset dimensionality, requiring more computational resources for larger datasets. The scalability of the BOT-LN classifier is influenced by the training set size and the complexity of Bayesian optimization, where handling large datasets and optimizing hyperparameters efficiently may impact scalability. Overall, DAI-BOTS combines deep learning and optimization for effective call drop prediction, with a hybrid approach in S2LFO balancing exploration and exploitation, and BOT-LN's Bayesian optimization enhancing adaptability. Considerations include substantial computational resources for computational complexity during training and vital scalability considerations for large-scale telecom datasets. Recommendations include exploring parallel processing and distributed computing frameworks for enhanced scalability and implementing optimization strategies like mini-batch training to manage computational complexity during training.

The implementation and deployment of the DAI-BOTS framework face various challenges such as computational resources, large-scale data handling, model interpretability, real-time predictions, hyperparameter tuning, model robustness, regulatory and privacy compliance, and integration with existing systems. These challenges are addressed by using techniques such as parallel processing, distributed computing, and cloud-based services, data preprocessing techniques, leveraging big data technologies, model interpretability techniques, optimizing model architectures, and using efficient algorithms. Automated techniques, such as Bayesian optimization and grid search streamline the hyperparameter tuning process, while extensive testing, validation, and continuous monitoring can ensure model robustness. Collaboration with legal experts helps address regulatory and privacy compliance. Finally, a multidisciplinary approach combining expertise in machine learning, telecommunications, and domain-specific knowledge, along with continuous feedback loops and iterative improvements, is crucial for successful deployment of the DAI-BOTS framework in real-world mobile network environments.

Research is conducted to improve the prediction framework of DAI-BOTS by integrating network anomalies and external factors. This integration aims to enhance the model's robustness and real-world applicability, taking into consideration the dynamic nature of mobile networks and the potential impact of various external influences. The integration of network anomalies involves a meticulous examination of irregularities or deviations from the expected behavior within the telecom infrastructure. By assimilating information about network anomalies, the DAI-BOTS model can recognize and adapt to abnormal patterns, thereby improving its resilience in the face of unforeseen disruptions.

Simultaneously, the research explores the inclusion of external factors that may influence call drop occurrences. These external factors could include environmental variables, weather conditions, or events affecting specific geographical regions. By considering these external dynamics, the DAI-BOTS model aims to capture a more comprehensive understanding of the contextual factors contributing to call drop events. This holistic approach recognizes the interconnectedness of various elements impacting mobile networks and seeks to create a prediction framework that is not only adept at handling routine scenarios but also resilient in the face of anomalies and external influences. The anticipated outcome is an enriched DAI-BOTS model that aligns more closely with the complexities of real-world mobile network environments, thereby improving its efficacy in predicting and mitigating call drop incidents.

V. CONCLUSION

Every day, telecommunications sectors produce enormous volumes of data, where the people making decisions underlined that it is more difficult to acquire new customers than to retain current ones. Call dropouts continue to be a problem despite the best efforts of authorities throughout the years. One of the most pressing issues in mobile networks is the call drop prediction, which still occurs. In order to do this, this research introduces a novel framework known as, DAI-BOTS for call drop prediction in mobile networks. For the system design and development in the proposed work, three different telecom datasets including real-time CDR, open source SMOTE, Call-to-Call, and IBM-Telco have been used. Following the acquisition of telecom data, the innovative DAE-DI technique is used to produce imputed data in order to enhance the call drop prediction process overall. It is a deep learning architecture model that balances unprocessed data to achieve high accuracy. To reduce the training and testing complexity of classification, the S2LFO technique is used to choose the most important and practical characteristics from the imputed data. Additionally, the BOT-LN classification algorithm is used to forecast call drops with good accuracy and performance outcomes. The proposed approach significantly improves the call drop prediction system overall by combining these methodologies. The proposed DAI-BOTS model's outcomes are contrasted with some of the most recent state-of-the-art call drop prediction methodologies for performance evaluation and validation. The suggested DAI-BOTS performs well and offers improved results up to 99.5% accuracy with a lower error rate up to 0.065 for all the datasets utilized in this investigation, according to the findings. Future work can be expanded upon by putting in place a new security architecture to safeguard mobile communication networks.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

G. V. Ashok involved in design, theoretical formalism, performed the analytic calculations and performed the numerical simulations and evaluation process presented in the paper. P. Vasanthi Kumari helped to derive the mathematical equation and background study of the paper and also provided a factual review and helped to edit the manuscript. All authors had approved the final version.

REFERENCES

- [1] S. Saleh and S. Saha, "Customer retention and churn prediction in the telecommunication industry: A case study on a Danish university," *SN Applied Sciences*, vol. 5, 173, 2023.
- [2] A. Amin, A. Adnan, and S. Anwar, "An adaptive learning approach for customer churn prediction in the telecommunication industry using evolutionary computation and Naïve Bayes," *Applied Soft Computing*, vol. 137, 110103, 2023.
- [3] S. A. Panimalar and A. Krishnakumar, "Customer churn prediction model in cloud environment using DFE-WUNB: ANN deep feature extraction with weight updated tuned Naïve Bayes classification with Block-Jacobi SVD dimensionality reduction," *Engineering Applications of Artificial Intelligence*, vol. 126, 107015, 2023.
- [4] A. Şenyürek and S. Alp, "Churn prediction in telecommunication sector with machine learning methods," *International Journal of Data Mining, Modelling and Management*, vol. 15, pp. 184–202, 2023.
- [5] J. Xu, J. Liu, T. Yao, and Y. Li, "Prediction and big data impact analysis of telecom churn by backpropagation neural network algorithm from the perspective of business model," *Big Data*, 2023.
- [6] G. Pratibha and N. P. Hegde, "Low complexity early employee attrition analysis using boosting and non-boosting ML techniques," *International Journal of Intelligent Systems and Applications in Engineering*, vol. 11, pp. 246–256, 2023.
- [7] O. O. Erunkulu, E. N. Onwuka, O. Ugweje, and L. A. Ajao, "Prediction of call drops in GSM network using artificial neural network," *Jurnal Teknologi dan Sistem Komputer*, vol. 7, pp. 38–46, 2019.
- [8] F. Tang, B. Mao, Y. Kawamoto, and N. Kato, "Survey on machine learning for intelligent end-to-end communication toward 6G: From network access, routing to traffic control and streaming adaption," *IEEE Communications Surveys and Tutorials*, vol. 23, pp. 1578–1598, 2021.
- [9] Y. Beeharry and R. T. Fokone, "Hybrid approach using machine learning algorithms for customers' churn prediction in the telecommunications industry," *Concurrency and Computation: Practice and Experience*, vol. 34, no. 4, e6627, 2022.
- [10] K. Anjana and S. Urolagin, "Churn prediction in telecom industry using machine learning algorithms with K-Best and principal component analysis," in *Proc. the First Global Conference on Artificial Intelligence and Applications (GCAIA 2020)*, 2021, pp. 499–507.
- [11] M. J. Jafari, M. J. Tarokh, and P. Soleimani, "An interpretable machine learning framework for customer churn prediction: A case study in the telecommunications industry," *Journal of Industrial Engineering and Management Studies*, vol. 10, pp. 141–157, 2023.
- [12] L. Geiler, S. Affeldt, and M. Nadif, "A survey on machine learning methods for churn prediction," *International Journal of Data Science and Analytics*, vol. 14, pp. 217–242, 2022.
- [13] A. Bugajev, R. Kriaucienė, O. Vasilecas, and V. Chadyšas, "The impact of churn labelling rules on churn prediction in telecommunications," *Informatica*, vol. 33, pp. 247–277, 2022.
- [14] H. Nalatissifa and H. F. Pardede, "Customer decision prediction using deep neural network on telco customer churn data," *Electronics and Telecommunications Journal*, vol. 21, pp. 122–127, 2021. (in Indonesian)
- [15] S. A. Panimalar and A. Krishnakumar, "A review of churn prediction models using different machine learning and deep learning approaches in cloud environment," *Journal of Current Science and Technology*, vol. 13, pp. 136–161, 2023.

- [16] S. Karthiga and A. Abirami, "Hybrid deep learning model for efficient prediction of telecom data using EMF radiation," *Journal of Intelligent and Fuzzy Systems*, pp. 1–16, 2023.
- [17] Y. Liu, Z. Yu, C. Chen, Y. Han, and B. Yu, "Prediction of protein crotonylation sites through Light GBM classifier based on SMOTE and elastic net," *Analytical biochemistry*, vol. 609, 113903, 2020.
- [18] N. Tamuka and K. Sibanda, "Real time customer churn scoring model for the telecommunications industry," in *Proc. 2020 2nd International Multidisciplinary Information Technology and Engineering Conference (IMITEC)*, 2020, pp. 1–9.
- [19] P. Lalwani, M. K. Mishra, J. S. Chadha, and P. Sethi, "Customer churn prediction system: a machine learning approach," *Computing*, pp. 1–24, 2022.
- [20] S. Wu, W.-C. Yau, T.-S. Ong, and S.-C. Chong, "Integrated churn prediction and customer segmentation framework for telco business," *IEEE Access*, vol. 9, pp. 62118–62136, 2021.
- [21] G. Ashok and P. V. Kumari, "An investigation of various machine learning techniques for mobile call data analysis for reducing call drop," *Materials Today: Proceedings*, vol. 51, pp. 2476–2478, 2022. <https://doi.org/10.1016/j.matpr.2021.11.622>
- [22] G. Ashok and P. V. Kumari, "To Analyse and optimise the issues in call drops and enhance the real time (CDR) processing," *Easy Chair*, pp. 2516–2314, 2020.
- [23] Y. Khan, S. Shafiq, A. Naeem, S. Ahmed, N. Safwan, and S. Hussain, "Customers churn prediction using Artificial Neural Networks (ANN) in telecom industry," *International Journal of Advanced Computer Science and Applications*, vol. 10, 2019.
- [24] A. K. Ahmad, A. Jafar, and K. Aljoumaa, "Customer churn prediction in telecom using machine learning in big data platform," *Journal of Big Data*, vol. 6, pp. 1–24, 2019.
- [25] I. V. Pustokhina, D. A. Pustokhin, P. T. Nguyen, M. Elhoseny, and K. Shankar, "Multi-objective rain optimization algorithm with WELM model for customer churn prediction in telecommunication sector," *Complex and Intelligent Systems*, pp. 1–13, 2021.
- [26] I. Ullah, B. Raza, A. K. Malik, M. Imran, S. U. Islam, and S. W. Kim, "A churn prediction model using random forest: Analysis of machine learning techniques for churn prediction and factor identification in telecom sector," *IEEE Access*, vol. 7, pp. 60134–60149, 2019.
- [27] N. Bahra and S. Pierre, "A hybrid user mobility prediction approach for handover management in mobile networks," *Telecom*, pp. 199–212, 2021.
- [28] S. W. Fujo, S. Subramanian, and M. A. Khder, "Customer churn prediction in telecommunication industry using deep learning," *Information Sciences Letters*, vol. 11, 24, 2022.
- [29] B. Hussain, Q. Du, S. Zhang, A. Imran, and M. A. Imran, "Mobile edge computing-based data-driven deep learning framework for anomaly detection," *IEEE Access*, vol. 7, pp. 137656–137667, 2019.
- [30] A. Rizwan, M. Jaber, F. Filali, A. Imran, and A. Abu-Dayya, "A zero-touch network service management approach using AI-enabled CDR analysis," *IEEE Access*, vol. 9, pp. 157699–157714, 2021.
- [31] N. Kolli and N. Balakrishnan, "Hybrid features for churn prediction in mobile telecom networks with data constraints," in *Proc. 2020 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*, 2020, pp. 734–741.
- [32] U. F. Gursoy, M. Kurulay, and M. S. Aktas, "Customer churn behavior predicting using social network analysis techniques: A case study," in *Proc. 2021 International Conference on Electrical, Communication, and Computer Engineering (ICECCE)*, 2021, pp. 1–6.
- [33] M. Duraipandian, "Long term evolution-self organizing network for minimization of sudden call termination in mobile radio access networks," *Journal of Trends in Computer Science and Smart Technology (TCSST)*, vol. 2, pp. 89–97, 2020.
- [34] R. Su, D. Zhang, R. Venkatesan, Z. Gong, C. Li, F. Ding *et al.*, "Resource allocation for network slicing in 5G telecommunication networks: A survey of principles and models," *IEEE Network*, vol. 33, pp. 172–179, 2019.
- [35] G. Kaur, R. K. Goyal, and R. Mehta, "An efficient handover mechanism for 5G networks using hybridization of LSTM and SVM," *Multimedia Tools and Applications*, vol. 81, pp. 37057–37085, 2022.
- [36] L. Xu, X. Zhao, Y. Yu, Y. Luan, L. Zhao, X. Cheng *et al.*, "A comprehensive operation and revenue analysis algorithm for LTE/5G wireless system based on telecom operator data," in *Proc. 2019 IEEE Smart World, Ubiquitous Intelligence and Computing, Advanced and Trusted Computing, Scalable Computing and Communications, Cloud and Big Data Computing, Internet of People and Smart City Innovation (SmartWorld/SCALCOM/UIC/ATC/CBDCOM/IOP/SCI)*, 2019, pp. 1521–1524.
- [37] N. N. Vo, S. Liu, X. Li, and G. Xu, "Leveraging unstructured call log data for customer churn prediction," *Knowledge-Based Systems*, vol. 212, 106586, 2021.

Copyright © 2024 by the authors. This is an open access article distributed under the Creative Commons Attribution License ([CC BY-NC-ND 4.0](https://creativecommons.org/licenses/by-nc-nd/4.0/)), which permits use, distribution and reproduction in any medium, provided that the article is properly cited, the use is non-commercial and no modifications or adaptations are made.

Post-Harvest Onion Disease Identification and Classification Using Transfer Learning

Mythili. M.^{1,*}, Vasanthi Kumari P.²

Submitted:13/03/2024 Revised: 28/04/2024 Accepted: 05/05/2024

Abstract: The identification and classification of diseases in onions after harvest is critical for maintaining quality and minimizing economic losses. Traditional methods for disease detection are labor-intensive, subjective, and prone to error. This study investigates the use of transfer learning to develop an automated system for identifying and classifying healthy and diseased onions using image analysis. This is achieved by creating a model using transfer learning technique with pre-trained Convolutional Neural Networks (CNNs) models such as VGG16, ResNet50, and InceptionV3. Fine-tuning and dense layers are added at the end of the pretraining models for accurate classification of onions. Performance is assessed using metrics including accuracy, precision, recall, and F1-score. The ResNet50 model, in particular, achieved the highest accuracy, with a classification rate of 95.6%, outperforming other tested architectures. This approach promises to streamline post-harvest disease management, reduce losses, and ensure higher quality produce reaches consumers.

Keywords: Convolutional Neural Networks (CNNs), Transfer Learning, VGG16, ResNet50, Inceptionv3, F1-score.

1. Introduction

The global agricultural industry continually grapples with the challenge of crop diseases [1], which can lead to significant economic losses and increased food wastage. Onions, a staple in diets worldwide, are particularly susceptible to various diseases, especially after harvest. Traditional methods of identifying and classifying these diseases rely on manual inspection by experts, which is often labor-intensive, time-consuming, and prone to human error. These limitations underscore the need for more efficient and accurate techniques [2] to ensure the quality and marketability of onions.

Recent advancements in artificial intelligence (AI) and machine learning (ML) offer promising solutions to these challenges. Transfer learning [3], in particular, has emerged as a powerful technique in the realm of image classification. It leverages pre-trained neural networks to address specific tasks with limited data and computational resources. By utilizing pre-trained models such as VGG16, ResNet50, and InceptionV3, transfer learning can significantly enhance the accuracy of disease identification while reducing the need for extensive labeled datasets.

This study aims to develop a robust and efficient system for the identification and classification of onion diseases after harvest using transfer learning. Automating the detection process can enhance the efficiency of post-harvest disease

management, reduce losses, and improve the overall quality of onions reaching the consumer market. The proposed system involves collecting a comprehensive dataset of onion images, preprocessing and augmenting the data, and fine-tuning pre-trained convolutional neural networks [14-15], to accurately classify healthy and diseased onions.

This work details about the dataset collection and pre-processing methods, the implementation of transfer learning, and the evaluation of the model's performance. Through this research, the aim is to contribute to the development of intelligent agricultural systems that support farmers and stakeholders in ensuring the quality and safety of their produce

2. Related Work

The advent of deep learning has revolutionized the field of plant disease detection and classification. Deep learning models, particularly Convolutional Neural Networks (CNNs), have been extensively employed due to their superior performance in image processing tasks. This literature review consolidates insights from multiple studies that focus on the application of deep learning techniques for plant disease detection, highlighting the advancements, methodologies, and outcomes of various research efforts.

Li et al. (2021) present a comprehensive review of the application of deep learning in plant disease detection and classification. The study emphasizes the potential of deep learning models to outperform traditional image processing methods. The authors discuss various CNN architectures such as AlexNet, GoogLeNet, and ResNet, highlighting their effectiveness in feature extraction and disease identification. The review also addresses the challenges associated with deep learning, including the need for large

¹Department of Computer Science & Engineering,
School of Engineering, Dayananda Sagar University, Bengaluru- 560082,
India

ORCID ID: 0000-0002-0071-6178

²School of Computer Applications, Dayananda Sagar University,
Bengaluru- 560068, India

ORCID ID: 0000-0002-6063-8415

* Corresponding Author Email: mythili.m@vemanait.edu.in

annotated datasets and the complexity of model training. Li et al. underscore the importance of transfer learning and data augmentation techniques to enhance model performance and generalization capabilities.

Shoaib et al. (2022) focus on the segmentation and classification of tomato plant diseases using deep learning. The study employs a CNN-based approach for the automatic identification of diseases from leaf images. The authors utilize a dataset comprising various tomato leaf diseases and implement a segmentation algorithm to isolate the diseased regions. Following segmentation, a CNN classifier is employed to categorize the diseases. The results demonstrate high accuracy and robustness of the proposed method, suggesting that deep learning can significantly enhance the precision of plant disease diagnostics.

Ahmad et al. (2023) provide a survey of deep learning techniques used in plant disease diagnosis. The paper reviews different CNN architectures and their applications in disease detection. The authors also discuss the integration of deep learning with Internet of Things (IoT) and remote sensing technologies for real-time disease monitoring. The survey highlights the potential of these combined approaches to create smart agricultural tools that can assist farmers in early disease detection and management. Additionally, the authors offer recommendations for future research, emphasizing the need for more diverse datasets and the development of user-friendly diagnostic tools.

Tyagi et al. (2024) explore the implementation of various CNN architectures, including Inception v3, VGG-16, and VGG-19, for the identification and disease detection of medicinal plant leaves. The study compares the performance of these models in terms of accuracy, computational efficiency, and robustness. The authors report that Inception v3 outperforms VGG-16 and VGG-19 in terms of accuracy, while VGG-16 and VGG-19 offer competitive results with lower computational costs. The findings highlight the importance of choosing appropriate CNN architectures based on specific application requirements.

Srivastava et al. (2020) propose a novel deep learning framework for the detection of diseases in sugarcane plants. The framework integrates a CNN with a feature extraction module to enhance the accuracy of disease identification. The study utilizes a large dataset of sugarcane leaf images, including various disease conditions. The authors implement data augmentation techniques to improve the model's robustness and generalization. The results indicate that the proposed framework achieves high accuracy and can effectively differentiate between healthy and diseased leaves, providing a reliable tool for sugarcane disease management.

Shahoveisi et al. (2023) investigate the use of image

processing and transfer learning for the detection of rust disease in plants. The study employs a pre-trained CNN model fine-tuned on a dataset of rust-infected leaf images. The authors utilize transfer learning to leverage the knowledge from the pre-trained model, significantly reducing the need for extensive training data. The approach demonstrates high accuracy in rust disease detection, showcasing the effectiveness of transfer learning in overcoming data scarcity challenges in plant disease diagnostics.

Algani et al. (2023) present an optimized deep learning approach for the identification and classification of leaf diseases. The study employs a CNN model optimized using techniques such as hyperparameter tuning and model pruning to enhance performance and reduce computational overhead. The authors compare the optimized model with standard CNN architectures, reporting superior accuracy and efficiency. The study underscores the importance of model optimization in developing practical and deployable deep learning solutions for plant disease detection.

Historically, farmers relied on visual inspection and traditional knowledge to identify and manage crop diseases. Over time, the integration of plant pathology with agricultural practices allowed for a more scientific approach to disease management. Disease identification and classification in agricultural crops are crucial for ensuring food security, improving crop yields, and maintaining the health of agricultural ecosystems. Identifying and classifying crop diseases accurately enables timely interventions, minimizing crop losses and promoting sustainable agriculture. The following table 1 summarizes about the crop disease and how deep learning techniques are evolved for identification. This table highlights the methodologies in the field, providing a comprehensive overview of the latest research on deep learning, transfer learning, and agricultural disease classification.

3. Research Objective

The primary objective of this research is to develop an automated system for the identification and classification of post-harvest onion diseases using transfer learning through data collection, preprocessing, augmentation, pre-training and fine-tuning for the contribution to best agricultural practices to reduce post-harvest loss.

4. Proposed Methodology

The proposed methodology is to develop a system to classify healthy and diseased onions using onion image dataset. The system architecture Figure 1 depicts the steps that are used to classify onions with collection of labelled datasets. The resized and normalized images are fed to pre-trained models which composes of Convolution layers [16-17], ReLU activation and MaxPooling. The output from the pretrained layers is passed into dense layer of 1024 units and

512 units which generated an output classification of the onion images.

4.1. Data Collection and Annotation

A dataset of 1500 images of healthy and various diseased onions are collected and categorized as healthy and diseased onions. Annotations are added to these images to create a labelled dataset.

4.2. Data Preprocessing

The dataset images are converted to 224x224 sized images. Normalize these images using histogram techniques to enhance the quality of the images.

4.3. Data Augmentation

The data augmentation is performed to increase the diversity of the training set and reduce overfitting. This may include rotations, translations, scaling, and flipping. Data

augmentation often involves combining multiple techniques to create a richer dataset. For instance, an image may be first rotated, then translated, and finally scaled. The overall transformation can be represented as a sequence of individual transformations applied to the image. For example, combining rotation, translation, and scaling.

$$I''(x, y) = I\left(\frac{(x \cos \theta - y \sin \theta - \Delta x)}{s}, \frac{(x \sin \theta + y \cos \theta - \Delta y)}{s}\right) \quad (1)$$

Where x represents the horizontal coordinate of a pixel, representing the column index and y represents the vertical coordinate of a pixel, representing the row index. θ is rotation angle in radians, s is the scaling factor. Δx and Δy defines the top-left corner of the cropping window.

Table 1: Summary of related work on plant disease classification using Deep Learning

Reference	Research Problem & Significance	Methodology	Key Findings & Results	Contributions	Strengths	Weaknesses
Lili Li, et al. (2021) [4]	Review of deep learning applications in plant disease detection to highlight advancements and challenges	Comprehensive literature review of various CNN architectures (AlexNet, GoogLeNet, ResNet) and techniques like transfer learning and data augmentation	Deep learning models significantly outperform traditional methods; challenges include large dataset requirements and training complexity	Overview of current state-of-the-art, identification of key challenges, and future research directions	Extensive review with detailed analysis	Limited empirical results; primarily theoretical
Muhammad Shoaib, et al. (2022) [5]	Detection and classification of tomato plant diseases using deep learning	CNN-based segmentation algorithm to isolate diseased regions followed by classification	High accuracy and robustness in disease detection	Demonstrates effective segmentation and classification methodology	High precision and robust model	Focuses only on tomato plant diseases; needs validation on other crops
Aanis Ahmad, et al. (2023) [6]	Survey of deep learning techniques for plant disease diagnosis and development of appropriate tools	Review of various CNN architectures and integration with IoT and remote sensing	Highlights potential of integrated approaches for real-time disease monitoring	Provides recommendations for future research and tool development	Comprehensive survey with practical recommendations	Lacks empirical validation of surveyed techniques

Kunal Tyagi, et al. (2024) [7]	Identification and disease detection of medicinal plant leaves using different CNN architectures	Comparison of Inception v3, VGG-16, and VGG-19 architectures	Inception v3 outperforms VGG-16 and VGG-19 in accuracy; VGG models offer lower computational costs	Highlights strengths of different CNN architectures for specific tasks	Comparative analysis provides insights into model selection	Limited to medicinal plants; computational efficiency not deeply explored
Sakshi Srivastava, et al. (2020) [8]	Development of a deep learning framework for sugarcane disease detection	CNN integrated with feature extraction module, using data augmentation techniques	High accuracy in differentiating healthy and diseased leaves	Effective framework for sugarcane disease management	High accuracy and robust framework	Focused on a single crop; needs validation on other plants
Fereshteh Shahoveisi, et al. (2023) [9]	Detection of rust disease using image processing and transfer learning	Fine-tuning a pre-trained CNN on rust-infected leaf images	High accuracy in rust disease detection	Demonstrates effectiveness of transfer learning in plant disease detection	Utilizes transfer learning to overcome data scarcity	Limited to rust disease; may not generalize to other diseases
Yousef Methkal Abd Algani, et al. (2023) [10]	Identification and classification of leaf diseases using optimized deep learning	CNN model optimized with hyperparameter tuning and model pruning	Superior accuracy and efficiency compared to standard CNNs	Highlights importance of model optimization	High accuracy and computational efficiency	Specific optimization techniques may not be universally applicable
Dwivedi et al. (2021) [11]	Multi-task learning and attention features for grape disease detection. Aims to enhance detection performance.	Multi-task learning and attention mechanisms in a CNN framework.	Improved accuracy and robustness in grape disease detection.	Introduces multi-task learning and attention features in plant disease detection.	Enhanced performance through multi-task learning.	Specific to grape disease detection.
Hridoy et al. (2021) [12]	Recognition of papaya diseases using an ensemble of EfficientNet models. Aims for high accuracy and robustness.	Deep ensemble approach using multiple EfficientNet models.	High accuracy in papaya disease recognition.	Demonstrates the effectiveness of ensemble methods.	High accuracy through ensemble learning.	Limited to papaya diseases.

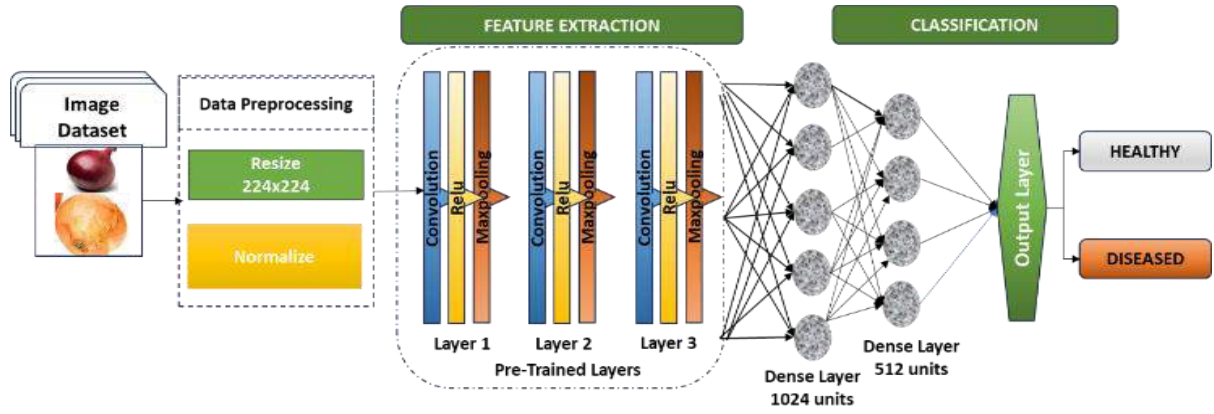


Fig. 1. System architecture to classify healthy and diseased onions

4.4. Transfer Learning with Pre-trained CNNs

To implement transfer learning, pre-trained models such as VGG16, ResNet50, and InceptionV3 are used. The top layers of the pre-trained models are removed and replaced with new fully connected layers tailored to the classification of onion diseases.

i) VGG16 training model

The VGG16 model is a convolutional neural network architecture for Large-Scale Image Recognition. The first layer is the input layer which takes input as an image of fixed size $224 \times 224 \times 3$ (width, height, and RGB channels). It consists of multiple convolutional layers. Each convolutional layer performs the following operation,

$$\text{Output} = \text{ReLU}(W * X + b) \quad (2)$$

Where W represents the filter weights, X is the input feature map, b is the bias term, $*$ denotes the convolution operation, ReLU is the Rectified Linear Unit activation function. VGG16 has a total of 13 convolutional layers organized into 5 blocks, where each block has 2 or 3 convolutional layers. After each block of convolutional layers, a max-pooling layer is applied to reduce the spatial dimensions.

$$\text{Output}_{i,j} = \max_{m,n} (\text{Input}_{2i+m,2j+n}) \quad (3)$$

Where the pooling operation considers a 2×2 window with a stride of 2. The output is passed through a softmax function to obtain class probabilities.

$$P(y = c|x) = \frac{\exp(W_c \cdot X + b_c)}{\sum_{j=1}^{1000} \exp(W_j \cdot X + b_j)} \quad \text{Eq. (4)}$$

Where $P(y=c|x)$ is the probability of class c given input x . W_c and b_c are the weights and bias for class c . The denominator sums over all 1000 classes. Each "Conv3-X" denotes a convolutional layer with a 3×3 kernel and X filters. The max-pooling layers have a 2×2 window with a stride of 2. The fully connected layers (FC) have 4096 neurons each, except for the final one, which has 1000 neurons for classification.

ii) ResNet50 training model

ResNet50, a variant of the ResNet (Residual Network) architecture, is designed to ease the training of very deep networks by introducing residual learning. The input to ResNet50 is an image of fixed size $224 \times 224 \times 3$ (width, height, and RGB channels). ResNet50 starts with a convolutional layer followed by a max pooling layer.

$$\text{Conv1}: X_1 = \text{ReLU}(W_1 * X + b_1) \quad (5)$$

$$\text{Max Pooling}: X_2 = \text{Max Pooling}(X_1) \quad (6)$$

Where W_1 and b_1 are the weights and biases of the first convolutional layer and MaxPool denotes the max pooling operation. ResNet50 consists of multiple residual blocks. Each residual block can be represented by the following equations,

$$\text{Output} = \text{ReLU}(F(X, \{W_i\}) + X) \quad (7)$$

where X is the input to the residual block, $F(X, \{W_i\})$ is the residual function representing the stack of convolutional layers within the block, $\{W_i\}$ denotes the weights of these convolutional layers. Each residual block in ResNet50 has two types: Identity Block with no change in dimensions and Convolutional Block with downsampling,

$$\begin{aligned} \text{Output (Identity Block)} &= \text{ReLU}(W_3 * \text{ReLU}(W_2 * \\ &\text{ReLU}(W_1 * X + b_1) + b_2) + b_3 + X) \end{aligned} \quad (8)$$

$$\text{Output (Conv Block)} = \text{ReLU}(W_s * X + b_s + F(X, \{W_i\})) \quad (9)$$

In ResNet50, each residual block uses a bottleneck architecture which consists of three layers 1×1 Convolution (reduces dimensions), 3×3 Convolution and 1×1 Convolution (restores dimensions). After the stack of residual blocks, an average pooling layer is applied, followed by a fully connected layer for classification.

$$\text{Average Pooling}: X_{avg} = \frac{1}{H \times W} \sum_{i=1}^H \sum_{j=1}^W X_{i,j} \quad (10)$$

Where H and W are the height and width of the feature map.

$$\text{Fully Connected Layer: } P(y = c | X_{avg}) = \frac{\exp(W_c X_{avg} + b_c)}{\sum_{j=1}^{1000} \exp(W_j X_{avg} + b_j)} \quad (11)$$

Each convolutional block and identity block follows the bottleneck architecture, allowing for the efficient training of deep networks through residual connections.

iii) InceptionV3

InceptionV3 is a convolutional neural network architecture which includes several improvements over its predecessors to increase efficiency and accuracy. The input to Inception V3 is an image of fixed size 299×299×3 (width, height, and RGB channels). Inception V3 begins with several convolutional and pooling layers.

$$\begin{aligned} \text{Conv2: 1a: } 3 \times 3: X_1 &= \text{ReLU}(W_1 * X + b_1) \\ \text{Conv2: 2a: } 3 \times 3: X_2 &= \text{ReLU}(W_2 * X_1 + b_2) \\ \text{Conv2: 2b: } 3 \times 3: X_3 &= \text{ReLU}(W_3 * X_2 + b_3) \\ \text{Max Pooling: } X_4 &= \text{MaxPool}(X_3) \\ \text{Conv2: 2d: 3b: } 1 \times 1: X_5 &= \text{ReLU}(W_4 * X_4 + b_4) \\ \text{Conv2: 2d: 4a: } 3 \times 3: X_6 &= \text{ReLU}(W_5 * X_5 + b_5) \\ \text{Max Pooling: } X_7 &= \text{MaxPool}(X_6) \end{aligned} \quad (12)$$

Inception modules are the core components of InceptionV3, allowing multiple convolution operations in parallel within the same layer. Each Inception module can be represented by,

$$\begin{aligned} \text{Output} &= \\ &\text{Concat}(\text{Branch1}, \text{Branch2}, \text{Branch3}, \text{Branch4}) \end{aligned} \quad (13)$$

Where Concat denotes the concatenation of outputs from different branches. Each branch applies different operations such as 1×1, 3×3 and 5×5 convolutions, or pooling operations. Reduction modules reduce the spatial dimensions of feature maps, usually with stride-2 convolutions or pooling. Inception V3 includes auxiliary classifiers to help with gradient flow during training,

$$\text{Auxiliary Output} = \text{Softmax}(W_a \cdot (\text{AvgPool}(X) + b_a)) \quad (14)$$

Where AvgPool is average pooling, W_a and b_a are weights and biases for the auxiliary classifier. Inception V3 uses these sophisticated modules to efficiently capture both local and global features, and the auxiliary classifiers help improve the training process.

4.5. Fine-tuning

Fine-tune the pre-trained models on the onion dataset by adjusting the weights of the new layers while keeping the pre-trained weights fixed or with minimal adjustments. A fully connected layer with 1024 units and ReLU activation

is added. A dropout layer with a dropout rate of 0.5 is used to prevent overfitting.

4.6. Dense Layer

A fully connected layer with 512 units and ReLU activation is added and a dropout layer with a dropout rate of 0.5 is used for regularization. The final dense layer has 2 units (assuming binary classification) and uses softmax activation to output class probabilities. The model is compiled with the Adam optimizer, categorical cross-entropy loss (suitable for multi-class classification), and accuracy as the evaluation metric. This designed system is to leverage the feature extraction capabilities of the pre-trained model while fine-tuning the dense layers for the specific task of onion disease classification.

5. Results and Discussions

The models are evaluated using the metrics such as accuracy, precision, recall, and F1-score. The accuracy metric for each model is depicted in the below table 2 and ROC graphical representation is given in figure 2. The table and figure shows that ResNet50 produces accurate classification of onion images compared to VGG16 and Inceptionv3.

Table 2: Metrics of Performance

Model	Accuracy	Precision	Recall	F1-Score
VGG16	0.90	0.94	0.96	0.95
ResNet50	0.956	0.96	0.98	0.95
Inceptionv3	0.80	0.95	0.97	0.96

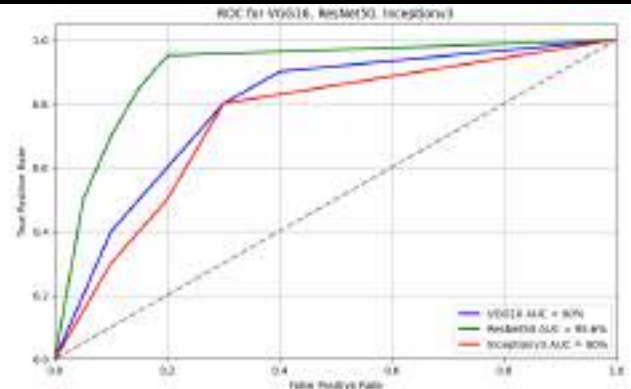


Fig. 2. ROC for performance of models

The following graph figure 3 to figure 5 depicts the training and validation accuracy with accuracy vs epoch starting from 1 for each model.

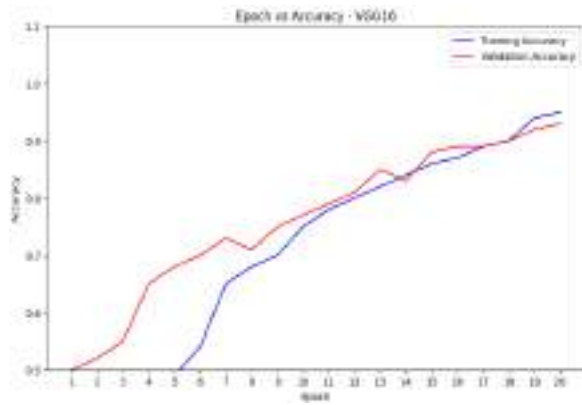


Fig. 3. Accuracy graph of VGG16

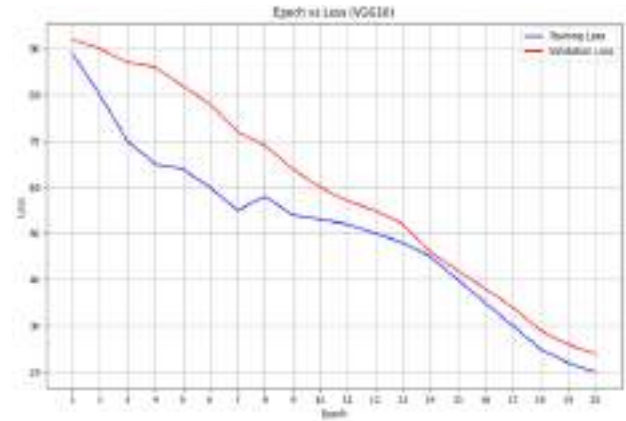


Fig. 6. Loss graph of VGG16

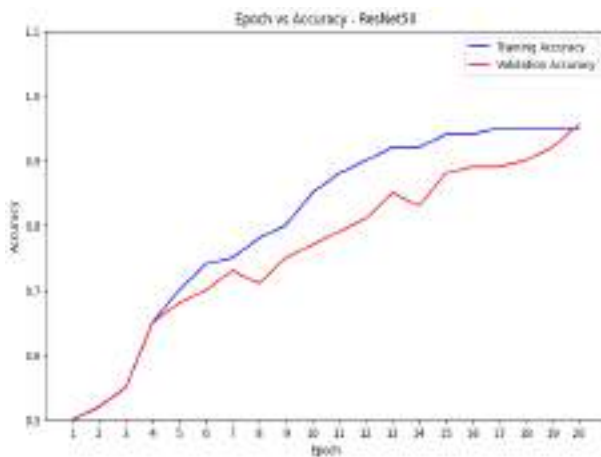


Fig. 4. Accuracy graph of ResNet50

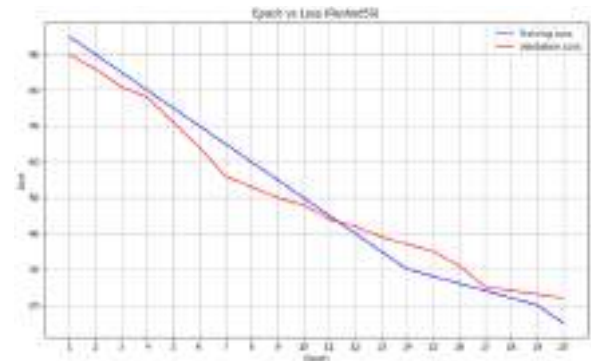


Fig. 7. Accuracy graph of ResNet50

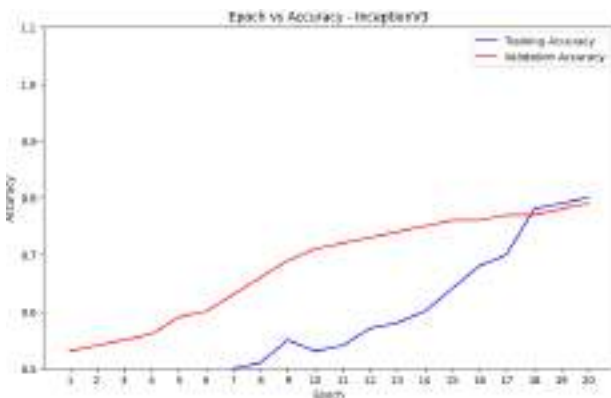


Fig. 5. Accuracy graph of Inception V3

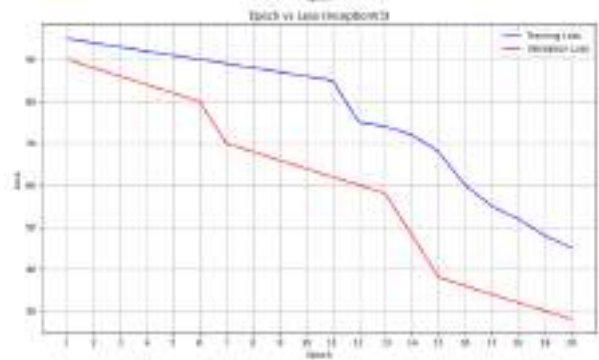


Fig. 8. Loss graph of Inception V3

The VGG16, ResNet50, Inception V3 model accuracy as epochs progress is measured, starting at 1 epochs with ResNet50 giving more accuracy and other models accelerate more trainings. The loss represented in figure 6 to figure 8 is measured across epoch measures consistent reduction and effective optimized learning with ResNet50 model having minimum loss and other models initiate learning phase. Table 3 represents the maximum values obtained for Accuracy and loss in each model.

Table 3. Accuracy and Loss Values

Model	Training Accuracy	Validation Accuracy	Training Loss	Validation Loss
VGG16	0.95	0.92	0.2	0.25
ResNet50	0.95	0.92	0.2	0.25
Inception V3	0.95	0.92	0.2	0.25

VGG16	93.2	91.2	20.2	24.6
ResNet50	94.5	95.6	15.9	22.3
Inception V3	82.7	81.2	43.3	20.6

6. Conclusion

This work inculcates transfer learning for the identification and classification of post-harvest onion diseases. The deep architecture of ResNet50, with its residual connections, enabled the model to extract and learn complex features from the onion images. This robust feature extraction was crucial for achieving high classification performance. By leveraging the power of pre-trained convolutional neural networks, specifically ResNet50, we achieved significant results in accurately detecting and categorizing onion diseases. The transfer learning approach using ResNet50 achieved a commendable accuracy of 95.6%. This efficiency makes transfer learning a practical and scalable solution for agricultural applications where large datasets may not be readily available. The successful implementation of transfer learning for onion disease identification automates the disease identification process by reducing the need for manual inspections, saving time and reducing labor costs. The future work can include real-time implementation of tools like mobile applications or IoT systems to make it more user friendly. It can also be combined using other techniques for enhancing disease identification accuracy and reliability.

Acknowledgements

Authors acknowledge the support from Department of Computer Science & Engineering, School of Engineering, Dayananda Sagar University, Bengaluru- 56008 for the facilities provided to carry out the research.

Author contributions

Ms. Mythili. M: was identified Initial problem identification, algorithm write-up, analysis, drafting of the manuscript, and simulation, drawing of the figures, final formatting and applied for the journal.

Dr. Vasanthi Kumari P: was responsible for the Literature survey and helped in the initial review process and was also responsible for the Complexity analysis of the research, evaluation of the research work.

All authors worked together to implement and evaluate the integrated system, and approved the final version of the paper.

Conflicts of interest

The authors declare no conflicts of interest.

References

- [1] Debasish Swapnesh Kumar Nayak, Saumendra Pattnaik, "Challenges and Solution for Identification of Plant Disease Using Machine Learning & IoT", International Journal of Computer and Communication Technology, July 2023.
- [2] R. Manavalan, "Automatic identification of diseases in grains crops through computational approaches: A review", Computers-and-Electronics-in-Agriculture, Volume 128, November 2020.
- [3] S. Divya Meena, Katakam Ananth Yasodharan Kumar, Devendra Mandava, "Plant Diseases Detection Using Transfer Learning", Proceedings of Fourth International Conference on Computer and Communication Technologies, March 2023.
- [4] Lili Li, Shujuan Zhang, And Bin Wang, "Plant Disease Detection and Classification by Deep Learning—A Review", IEEE Access PP(99), April 2021.
- [5] Muhammad Shoaib, Tariq Hussain, Babar Shah, Ihsan Ullah, Sayyed Mudassar, Farman Ali, Sang Hyun Park" Deep learning based segmentation and classification of leaf images for detection of tomato plant disease", Front. Plant Sci., Sec. Plant Bioinformatics, 07 October 2022
- [6] Aanis Ahmad, Dharmendra Saraswat, Aly El Gamal, "A survey on using deep learning techniques for plant disease diagnosis and recommendations for development of appropriate tools", Smart Agricultural Technology, Volume 3, February 2023.
- [7] Kunal Tyagi, Saksham Vats, Vasudha Vashisht, "Implementing Inception v3, VGG-16 and VGG-19 Architectures of CNN for Medicinal Plant leaves Identification and Disease Detection", Journal of Electrical Engineering, Vol 20, May 2024.
- [8] Sakshi Srivastava, Prince Kumar, Noor Mohd, Anuj Singh, Fateh Singh Gill, "A Novel Deep Learning Framework Approach for Sugarcane Disease Detection", SN Computer Science, Springer Nature Journal, March 2020.
- [9] Fereshteh Shahoveisi, Hamed Taheri Gorji, Seyedmojtaba Shahabi, Seyedali Hosseini-rad, Samuel Markell & Fartash Vasefi, "Application of image processing and transfer learning for the detection of rust disease", Scientific Reports, 2023.
- [10] Yousef Methkal Abd Algani, Orlando Juan Marquez Caro, Liz Maribel Robladillo Bravo, "Leaf disease identification and classification using optimized deep learning", Measurement: Sensors, Volume 25, February 2023.
- [11] Rudresh Dwivedi; Somnath Dey; Chinmay

Chakraborty; Sanju Tiwari "Grape Disease Detection Network Based on Multi-Task Learning and Attention Features", IEEE Sensors Journal, Vol. 21, No. 16, August 15, 2021.

- [12] Rashidul Hasan Hridoy; Mosammat Rokeya Anwar Tuli, "A Deep Ensemble Approach for Recognition of Papaya Diseases using EfficientNet Models", International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), 2021.
- [13] Andrew J, Jennifer Eunice, Daniela Elena Popescu, M. Kalpana Chowdar, Jude Hemanth "Deep Learning-Based Leaf Disease Detection in Crops Using Images for Agricultural Applications", Agronomy 2022, 12(10), 2395; <https://doi.org/10.3390/agronomy12102395>.
- [14] S. B. et al., "Machine learning model for emotion detection and recognition using an enhanced Convolutional Neural Network," Journal of Integrated Science and Technology, vol. 12, no. 4. The ScienceIn Publishing, Feb. 08, 2024. doi: 10.62110/sciencein.jist.2024.v12.786.
- [15] H. V. Ramachandra et al., "Secured Wireless Network Based on a Novel Dual Integrated Neural Network Architecture," Journal of Electrical and Computer Engineering, vol. 2023. Hindawi Limited, pp. 1–11, Sep. 28, 2023. doi: 10.1155/2023/9390660.
- [16] D. R. Ganesh and M. Chithambarathanu, "Analyzing and securing information, images of women in online portal using CNN algorithm," AIP Conference Proceedings. AIP Publishing, 2023. doi: 10.1063/5.0175977.
- [17] M. Chithambarathanu and D. Ganesh, "Character Recognition Tamil Language in Printed Images using Convolutional Neural Network (CNN) analysis," 2021 4th International Conference on Computing and Communications Technologies (ICCCT). IEEE, Dec. 16, 2021. doi: 10.1109/iccct53315.2021.9711893.

¹ Ms. K. Pramilarani*² Dr. Vasanthi
Kumari P

Performance Enhancement in Machine Learning Approaches using Recursive Feature Extraction, Maximum Variance Method and Min Max Method



Abstract: - This paper presents the well known techniques used for selecting and extracting the features in the dataset to improve the performance of the machine learning approaches in identifying DoS/DDoS attack types. Intrusion Detection is an essential part of an organization's cybersecurity defense strategy. It complements other security measures like firewalls, antivirus software, and access controls, helping to identify and mitigate potential threats that may have bypassed other security layers. By proactively identifying and addressing security breaches promptly, companies can secure their confidential information, ensure uninterrupted operations, and defend their standing against digital dangers. Machine Learning approaches are used to identify the threat in network. The input to the machine learning model should be preprocessed to enhance the overall performance of the model. Recursive Feature Elimination is one such method used to reduce the total number of features based on the importance ranking. In maximum variance method, variance for all the data samples are collected to identify the threshold value using the mean of all the variance. Data normalization is used in min max algorithm to make all the data in the similar range. These algorithms are used to preprocess the data so that the classifier overall performance will be enhanced. The data set considered for this research work is KDD+ data set which is mainly used to train and test the model for identifying different types of network attacks. The data set contains 41 different features for network connection, status, protocols, services and associated label for the attack category. The performance of any machine learning approach will be increased by reducing the number of features from the data set. The research work shows that the accuracy is improved by 10% to 20% after using the preprocessing algorithms for feature selection and noise removal.

Keywords: Intrusion Detection(ID) , cyber attacks, feature extraction, RFE, DoS attack.

I. INTRODUCTION

Intrusion Detection serves as a digital security system that detects and reacts to unauthorized and harmful actions aiming to breach the defenses of computer systems, software, and networks. The primary goal of intrusion detection is to monitor, detect and react to potential security breaches to prevent and minimize the damage caused by cyber attacks. Intrusion detection is an important part of cybersecurity. There are two categories of Intrusion Detection System. First category is called as network based IDS, which operates on network connected systems. The other one is called host based IDS, which operates on host level. Based on the research it is clearly shown that the number of features involved in any machine learning approach will affect the overall system performance. To improve the overall system performances, proper feature selection and feature extraction methods are needed. Feature selection and feature extraction are important techniques used in intrusion detection for enhancing the effectiveness and efficiency of the detection process. In this research work features are selected based on ranking method, threshold values are set based on the maximum variance method and the data will be normalized by min max algorithms to select and extract features. Section 2 discuss about the related works. Section 3 provides the introduction about dataset and types of attack given in dataset for training and testing purpose. Section 4 provides the need to preprocess the data and various methods available to preprocess the data. Section 5 explain the algorithm and example to preprocess the data using RFE, maximum variance and min max methods under methodology section. Section 6 explains Performance evaluation done on the system with/without feature reduction and comparative analysis is given under Results and Discussion and finally Section 7 gives the conclusion.

II. RELATED WORKS

Shadi Aljawarneh et. al[1] discussed about the a novel hybrid model designed to determine the threshold level of intrusion scope, utilizing the best features of network transaction data that have been provided for training purposes.

¹ Research Scholar, DSU, Senior Assistant Professor, NHCE, Department of CSE, pramiselva2020@gmail.com

²Professor, Department of Computer Applications, School of Engineering, DSU, vasanthi-bca@dsu.edu.in

* Corresponding Author Email: pramiselva2020@gmail.com

the next step is to identify the feature which will be having more weightage to classify the attack. Then with this data the system will be trained and tested to classify the attack based on the label for attack and non attack types.

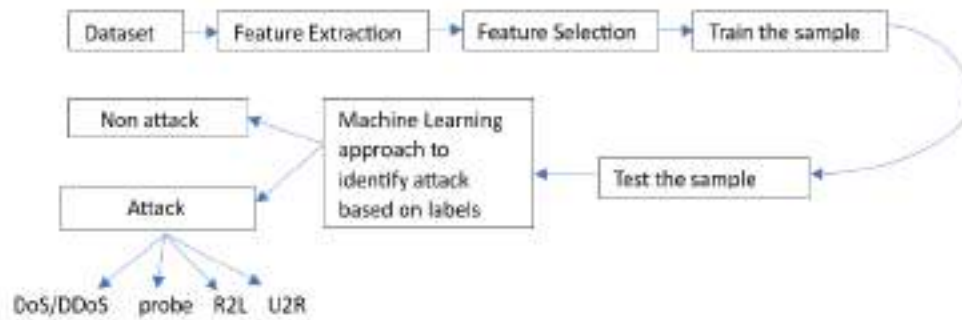


Fig 3.1. Logic to identify the attacks and non attacks

C. Attack types in the dataset:

Here four categories of attacks with their relevant attributes are available in the dataset. Each line of dataset is called data point which consists of different features used for connection status, number of packets, source destination, flags etc., In the dataset, labels are used to identify the type of attack based on the class attribute. They are normal, Neptune, DoS, smurf and back. The data set contains 4 different types of attack with 41 common attributes. For the research purpose DoS attack alone is considered. The labels with back, neptune, smurf, land, teardrop and pod etc. are considered as DoS attack. The other labels used in data set are satan, ipsweep, nmap, portsweep, mscan, inap, phf, warezclient, warezmaster, snmpgetattack, snmpguess, guess_passwd, buffer_overflow, rootkit, ftp_write, loadmodule, multihop, perl, spy etc. These labels are used to identify the normal network connections, probe, user to root attack, remote to local attacks respectively.

The normal label represents normal network connections, indicating legitimate and non-attack traffic. The neptune label corresponds to the Denial of Service (DoS) attack category. It represents attacks that aim to exhaust the resources of a target system or network, making it unavailable to legitimate users. The smurf label is also associated with the DoS attack category which refers to a specific type of DoS attack that uses Internet Control Message Protocol (ICMP) packets to flood a target network with ICMP echo requests. The 'back' label is another representation of the DoS attack category and refers to a DoS attack known as a TCP/IP stack-based "land" attack, where a malicious actor sends TCP packets with the source and destination IP addresses set to the same value, causing the target system to become unresponsive. The satan label is associated with the Probing attack category. It represents network scanning activities where an attacker tries to gather information about a target network or system without actively attempting unauthorized access. These mappings are based on the labelling provided in the KDD+Cup 1999 dataset and represent common attack types found in the simulated network environment. Labels are used to map the attack category such as DoS and non attack category as normal in this case.

IV. PREPROCESSING

A. Need to pre process the data

It is always a good idea to preprocess data before sending it to any machine learning approach. This approach can enhance the model's precision and efficiency. First and foremost thing is data quality. Raw data may contains noise, inconsistencies, missing values, and outliers. Preprocessing is the step which helps in cleaning and transforming the data into a usable format. It will ensure that the model receives high-quality data. Preprocessing can help to reduce the size of the data set, which in turn reduce the training time for the model. This is especially important for large data sets. If the model is a complex model then preprocessing can help to improve the performance of the model by making it more efficient and interpretable to understand how the model works and debugs.

Many machine learning algorithms perform better when features are on the same scale. This is called feature scaling. Preprocessing techniques like normalization and standardization scale features to a specific range, preventing some features from dominating others during model training. Normalizing data ensures that all features have similar ranges and distributions. This helps in cases where algorithms like gradient descent are used, as it can converge faster and more reliable. Real-world data often contains missing values, which can lead to biased or inaccurate results. Preprocessing strategies provide ways to manage incomplete data, including imputation (substituting missing values with calculated estimates) or elimination of instances with missing data.

Machine learning models typically require numerical input, hence categorical variables must be transformed into a numerical representation. This is called as categorical data encoding. Techniques like one-hot encoding or label encoding are used for this purpose. High-dimensional data can be computationally expensive and may lead to overfitting. To reduce dimensionality methods like Principal Component Analysis (PCA) are effective in preserving vital information while diminishing the complexity of the data. Preprocessing involves in noise reduction to eliminate irrelevant or redundant information, making the data more informative for the model. Outliers can skew the model's training process and affect its performance. Data preprocessing can involve identifying and handling outliers appropriately, ensuring they do not unduly influence the model.

In natural language processing (NLP), preprocessing of text data is essential, involving processes such as tokenization (breaking down text into individual words or phrases), eliminating stop-words, applying stemming, and lemmatization to condense the vocabulary and enhance data quality. Time series data often requires normalization or differencing to remove trends and seasonality, making it stationary and suitable for modelling. Data preprocessing can sometimes act as a safeguard against data leakage, which occurs when test or validation set information inadvertently seeps into the training phase, resulting in deceptively favourable outcomes. Through data preprocessing, the data is formatted appropriately for the training process and helps the model learn the patterns and relationships more effectively. Proper preprocessing enhances the model's performance, generalization, and robustness.

B. Various methods to preprocess data

The efficiency of any classifier will be improved by preprocessing the data present in the dataset. Feature extraction and feature selections are having major role to decide upon the features based on the requirement. So feature selection algorithm are mandatory to refine the data for better analysis by the classifier. Some algorithms should be used to select the features before feeding the data into the classifier which in turn improve the efficiency and overall process of the classifier. There are various methods available to select the relevant features.

Feature importance is the method which will consider only the important features based on rank. The rank will be decided by certain algorithms based on the contributions given to the model performance. The features with low importance will not increase the model's performance. Low importance features or low rank features should be removed for further processing.

The next method is Correlation Analysis which is used to identify highly correlated features and retain only one of them to avoid redundancy. Using this method duplicate values can be removed. If two or more features have strong correlation, then keep only one representative feature among the same correlated group and discard the other one.

Univariate Feature Selection method uses statistical tests or scoring method to decide upon the features. ANOVA F-value, chi-square test, mutual information, or correlation coefficient are some common techniques used in this method. These techniques use rank based classification. Using this method subset of top-ranking features will be selected based on a predefined threshold value and only those features are retained for further processing.

Principal Component Analysis is a widely utilized technique for reducing dimensionality that maps data to a lower-dimensional space, preserving a substantial portion of the data's variance. It accomplishes this by identifying the principal components that encapsulate the most critical information within the dataset. PCA can be used to reduce the feature dimensionality before training the Random Forest model.

The choice of feature reduction technique is contingent upon the characteristics of the data, the particular issue being addressed, and the objectives of the analytical endeavour. It is often recommended to experiment with multiple methods and evaluate the impact of feature reduction on the model's performance, such as accuracy, precision, recall, or F1-score, to determine the most effective approach for your specific dataset and classification task.

Recursive Feature Elimination (RFE) is a methodical approach to feature selection that systematically removes the least significant features through iteration. It involves training a Random Forest model on all available features and then determining the importance of each feature. The least important feature(s) are then removed, and The model undergoes retraining on the narrowed set of features. This iterative process continues until the target number of features is attained or a predetermined stopping point is achieved. This method will train the model based on the importance of the feature and eliminates the one with less importance. The best feature selection method for a specific data set and machine learning model will depend on the characteristics of the data set and the goals of the classification task. However, Recursive Feature Elimination is a general-purpose feature selection method that is

often effective for DoS attack classification. RFE was found to be the most effective feature selection method for improving the accuracy of DoS attack classification using the KDD+ dataset. In this research RFE was able to improve the accuracy of the random forest classifier by up to 10%.

V. METHODOLOGY

5.1 Recursive Feature Elimination (RFE) Method

For this research purpose random forest method is considered for identifying the DoS/DDoS attack category and to preprocess the data. Recursive Feature Elimination method along with feature importance by ranking is considered to improve the overall performance of the classifier. RFE can be used to select the features that are most important for all of the decision trees in the random forest. RFE can be used to select the most important features for classifying attacks. The Random Forest algorithm operates by constructing multiple decision trees, with each tree being trained on a randomly selected subset of the features. Benefits of RFE with Random Forest for Attack Classification:

Here are some benefits of using RFE in Random forest method to classify the DoS attack in KDD+ data set. Some of the most important benefits includes the improved accuracy, reduced training time, improves interpretability, reduce the overfitting, improves the generalization of the model and improves the robustness of the model

RFE will help to improve the accuracy of the Random forest classifier by selecting the most important features for classification. Applying this method is particularly advantageous for datasets with numerous features, as it aids in diminishing data noise and bolstering the classifier's efficacy.

RFE can help to reduce the training time of the Random forest classifier by reducing the number of features that need to be processed. This can be especially beneficial for data sets with a large number of features, as it can significantly reduce the amount of time it takes to train the classifier.

RFE is used to improve the interpretability of the Random forest classifier by identifying the most important features for classification. This can be helpful for understanding how the classifier is making predictions and for debugging the classifier if it is not performing as expected.

The accuracy of the Random forest classifier is increased up to 10% and training time is reduced upto 50 % with RFE. RFE will reduce the risk of overfitting: Overfitting frequently occurs in machine learning models, particularly when dealing with small or cluttered datasets Recursive Feature Elimination (RFE) can mitigate overfitting by isolating the most crucial features for classification, potentially enhancing the model's accuracy on new data.

Generalization ability is the ability of a machine learning model to make accurate predictions on unseen data. Recursive Feature Elimination (RFE) can enhance a model's ability to generalize by choosing a subset of features that best represent the dataset. This can help to prevent the model from overfitting to the training data and improve its accuracy on unseen data.

Robustness is the ability of a machine learning model to make accurate predictions in the presence of noise or outliers. RFE can help to improve the robustness of a model by selecting a subset of features that are less sensitive to noise and outliers. Utilizing this approach can enhance the model's accuracy with data that may not be entirely clean.

Overall, Recursive Feature Elimination is an effective technique that can be utilized to enhance the precision of a model, reduce the training time, improve the interpretability, reduce the risk of overfitting, improve the generalization ability, and improve the robustness of Random forest classifiers for DoS attack classification.

Selecting the feature in RFE helps in identifying the most informative features for attack classification. This can lead to a more interpretable model and improved generalization. By eliminating less important features, RFE can help reduce overfitting, especially when dealing with a high-dimensional feature space. When there is a large dataset training a model with fewer features is computationally more efficient which in turn improve the efficiency of the algorithm. With the small set of features it is easy to interpret the models decisions and predictions. The success of RFE mainly depends on the quality of the features, the dataset, and the chosen machine learning algorithm.

The significance of a feature in a decision tree model is determined by its contribution to reducing impurity, measured by the Gini impurity index. The Gini index method arranges trees from the most to the least impure. This ranking facilitates the creation of a set of key features. Mathematically, this process involves partitioning each node (A) in a decision tree to minimize its impurity ($R(A)$), represented by the Gini index. The Gini index is calculated

by subtracting the sum of the squared probabilities of each class from one. For a subset (A) containing samples of class (Z), the Gini impurity ($Gini(A)$) is defined as follows:

$$R(Z)=Gini(A)=1-\sum (P_i)^2$$

Probability of class (i) within the subset. Upon dividing a node (Z) into two distinct nodes ($Z1$) and ($Z2$), each with data sizes ($N1$) and ($N2$) respectively, the Gini index for the split can be expressed using the following formula:

$$Ginispilt(Z)=N1/N Gini(Z1)+N2/N Gini(Z2)$$

Here, ($Gini(Z1)$) and ($Gini(Z2)$) represent the Gini impurity of nodes ($Z1$) and ($Z2$), and (N) is the total number of samples before the split.

Overall, RFE is a robust method that enhances the accuracy, reduce the training time, and improve the interpretability of Random forest classifiers for DoS attack classification.

The RFE algorithm works as follows:

Step 1: The RFE algorithm first trains a random forest model on the original data set with all available features. Then the dataset need to be split for training, validation and testing based on the requirements.

Step 2: Then calculate the importance of each feature. This is calculated by measuring how much the feature contributes to the accuracy of the random forest model.

Step 3: Remove the least important feature from the data set. Here Gini index is used for ranking the important feature

Step 4: Retrains the random forest model on the data set with the feature with least importance removed.

Step 5: The above two steps are repeated until the desired number of features remains.

The features that are removed are the ones that contribute the least to the accuracy of the random forest model. This means that the remaining features are the most important for classifying attacks.

Once the RFE model has been trained, it can be used to classify new data points. To classify a new data point, pass the features of the new data point to the RFE model. The RFE model will then predict the attack type for the new data point.

The following example gives the better understanding of the RFE method. Let us consider RFE algorithm selects the 4 most important features for classifying attacks in the KDD+ data set. The features that are selected are: The duration of the connection in seconds by means of duration feature, the type of protocol used in the connection with protocol_type, the service that was used in the connection with service attribute and src_bytes attribute for the number of bytes sent from the source system. The importance of each feature is printed out. The feature with the highest importance is duration, followed by protocol_type, service, and src_bytes. These features are important because they can be used to distinguish between DOS attacks and legitimate traffic. For example, DOS attacks often have a long duration, use a common protocol like TCP, and target common services like HTTP. By focusing on these features, the RFE algorithm can improve the accuracy of DOS attack classification. First Load the dataset and preprocess the data set. Then select the features that can be used for classification all features to be included in this step. Next Create the random forest classifier by assigning the n-estimator value as 100, with the number of trees, maximum depth etc., Initialize the RFE classifier with the number of important feature. Here in this case 4 features. Fit the RFE model to data. Get the importance of each feature by using Gini index for ranking the important feature and print it. The stopping criteria can be the cross validation method to estimate performance during each iteration and stop when performance starts to degrade or once after reaching the required number of important features.

Let us consider the following values for the datapoint

duration = 100

protocol_type = tcp

service = http

src_bytes = 1000

The RFE model predicts that this data point is a normal connection because the values of the features are all within the normal range for a normal connection. The overall process of RF model with gini index is explained in the following Fig.

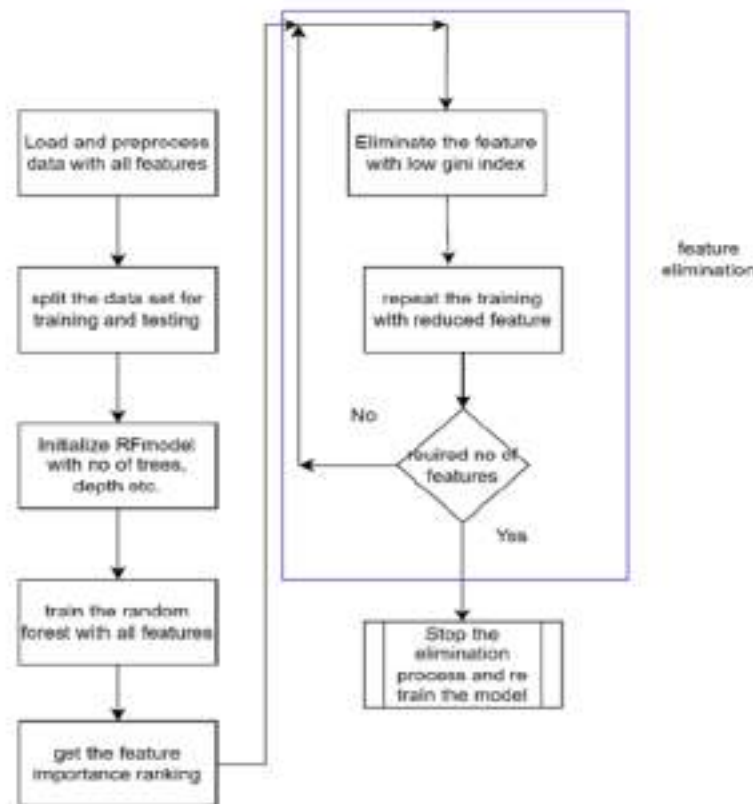


Fig. 5.1 RFE in Random forest classifier

In summary the RFE algorithm can be used with any machine learning model that can be trained on a data set with multiple features. It can be used to select the most important features for any task, not just attack classification. RFE can be used to select a fixed number of features or to select a percentage of the features. The RFE algorithm can select features based on their importance or on their ranking. In general, the Gini importance of a feature can vary depending on the data set and the specific type of attack that is being identified. The higher the Gini importance of a feature, the more important the feature is for identifying DDoS attacks. However, the `src_bytes` feature is often found to be the most important feature for identifying DDoS attacks, because the number of bytes sent from the source IP address can be used to identify attacks that involve sending a large number of packets.

Let's use the first sample data point to explain how random forest selects important features in the KDD+ dataset to identify DDoS attacks using the Gini index. The Gini index is a measure of how pure a node is. A pure node is one where all the data points belong to the same class.

The first step is to calculate the Gini importance of each feature in the data point. The Gini importance of a feature is calculated as follows:

$$\text{Gini importance} = \sum (\text{decrease in Gini index})$$

where the decrease in Gini index is the amount by which the Gini index of a node is reduced when the feature is used to split the node. The higher the Gini importance of a feature, the more important the feature is for identifying DDoS attacks.

The following is the example after including the gini Index. The Gini importance of the features in the first sample data point are:

`protocol_type`: 0.0001

`service`: 0.0004

flag: 0.0012

src_bytes: 0.9983

The src_bytes feature has the highest Gini importance, which means that it is the most important feature for identifying DDoS attacks in this data point. The protocol_type and service features have very low Gini importance, which means that they are not very important for identifying DDoS attacks in this data point.

RFE can be a valuable tool for improving the performance of random forest models for attack classification. By selecting the most important features, RFE can help to reduce the size of the data set and improve the accuracy of the model. It is important to note that the importance of features can vary depending on the data set and the machine learning model being used. RFE algorithm is a powerful tool that can be used to select the most important features for a variety of tasks, including DOS attack classification.

5.2 Maximum Variance algorithm

There are three main purpose of using Max variance algorithm. First one is to reduce the dimensionality, next one is to identify the high variability across the instances and the last one is to maintain the important and informative feature for further classification. This algorithm aims to reduce dimensionality and at the same time it retains the most significant features used for classification. This algorithm is very much helpful to reduce the features in intrusion detection method. By focusing on these high-variance features, MaxVar helps capture essential information while minimizing redundancy. By selecting features with high variance, it is intentionally focus on those that exhibit substantial variability across different instances. Usually high-variance features are more likely to capture anomalous patterns, to identify network intrusions. By retaining only the most informative features, computational complexity is also reduced and in turn will enhance model performance.

Let us consider the data point from KDD+ data set which has features such as protocol, duration, REJ flag, service etc.

First high variance features across the data points are identified because those features contribute to the overall variance in the data point. If the duration feature is zero then it wont contribute much to the over all variance in the datapoint.

The Flag REJ specifies a rejected connection attempt. If in case this flag varies significantly across instances (e.g., some connections are accepted while others are rejected), it could be a high-variance feature. Similarly if the Service features specifies the Private service the it might not vary much in this specific data point, but across the entire dataset, it could exhibit variability. This algorithm focuses on relevant aspects of the data while minimizing noise. So this methods plays a important role in optimizing the feature selection in Intrusion Detection System.

Algorithm

1. Consider all the features initially
2. Identifies features with high variability across instances.
3. Retains features that capture the most significant variations.
4. Remove the feature which is not contributed much to the overall variance
5. Repeat the steps 2 to 5 in all the instances
1. Feature selection
 - a. Compute the variance of each feature across all instances.
 - b. Select the top-k features with the highest variance (where k is determined based on domain knowledge or experimentation).
 - c. These high-variance features capture the most significant variations in the data.
2. Dimensionality Reduction
 - a. Apply techniques like PCA (Principal Component Analysis) to further reduce dimensionality or min max algorithm to normalize the data within some range

- b. PCA identifies linear combinations of features that explain the maximum variance or min max to remove the outliers
- c. The resulting reduced feature set retains essential information while minimizing redundancy.
- 3. Anomaly Detection
 - a. Train an anomaly detection model (e.g., Isolation Forest, One-Class SVM, Random Forest Classifier) using the selected features.
 - b. Anomalies (intrusions) are instances that deviate significantly from the expected patterns captured by high-variance features.
 - c. The model can identify network anomalies based on these features.

5.3 Min max Method

The goal of Min max algorithm is used to transform the features (variables) to specific range (usually between 0 and 1 or -1 to 1). This scaling ensures that all features have a consistent scale, which is essential for various machine learning algorithms.

This algorithm works in the following way.

1. Apply the min max scaling individually to all the features
2. Compute the scaled value using the following formula for each feature (x),

$$x_{\text{scaled}} = \frac{(x - x_{\text{min}})}{(x_{\text{max}} - x_{\text{min}})}$$

Where (x) represents the original value of the feature.

(x_{min}) is the minimum value of that feature in the dataset.

(x_{max}) is the maximum value of that feature in the dataset.

The numerator $((x - x_{\text{min}}))$ computes how far the original value (x) is from the minimum value.

The denominator $((x_{\text{max}} - x_{\text{min}}))$ represents the range of possible values for that feature.

By dividing the difference between (x) and (x_{min}) by the total range, feature is normalized to [0, 1] interval.

This ensures that all features lie within the range [0, 1].

3. Train the intrusion detection system such as the random forest classifier or neural network or deep learning model using scaled features.

Let's see with example

When $(x = x_{\text{min}})$, the scaled value becomes 0.

When $(x = x_{\text{max}})$, the scaled value becomes 1.

Intermediate values of (x) are linearly transformed to lie within this range.

Suppose if the minimum duration observed in the dataset is 10 seconds and the maximum duration is 100 seconds

$$x_{\text{min}} = 10$$

$$x_{\text{max}} = 100$$

compute the scaled duration for any specific connection time (x):

$$x_{\text{scaled}} = (x - 10) / (100 - 10)$$

For instance:

If a connection lasted 30 seconds, its scaled duration would be:

$$\begin{aligned} x_{\text{scaled}} &= (30 - 10) / (100 - 10) \\ &= 20 / 90 \end{aligned}$$

$$= 0.22$$

If a connection lasted 80 seconds, its scaled duration would be:

$$x_{\text{scaled}} = (80 - 10) / (100 - 10) \\ = 70 / 90 = 0.78$$

These scaled values can now be used in machine learning models without causing issues due to varying scales.

It scales features proportionally to their original range and ensures consistent scales for all features. This method is useful for various machine learning algorithms. MinMax scaling ensures that all features have a consistent scale, and prevents any single feature from dominating the model to Normalize the values. Outliers are easily handled by rescaling features to a bounded range. Many Machine Learning Models will perform better when features are within a similar range. Data Imbalance will be easily handled by MinMax scaling by ensuring both normal and attack instances contribute equally. Usually MinMax scaling is often applied after other preprocessing steps like data denoising and feature selection.

VI. RESULTS AND DISCUSSION

The dataset consists of nearly 1 lakh and 25 thousand datapoints with 41 features and each data point represents status of the connection with features such as duration, service, protocol type, flag, src bytes, dst bytes, server etc. All the features are not useful to build the model and they may reduce the overall accuracy of the system. For the research purpose three different algorithms are considered to check the accuracy of the model by retaining the needed feature and eliminating the un wanted features. The results shows nearly 10 to 20 % increase in the accuracy and very good improvement in the overall

Accuracy is calculated to evaluate the performance of the system. The following chart gives the comparison between the accuracy calculation with all 41 features and accuracy calculation after applying the RFE algorithm to select only the important feature.

Table 1. Accuracy and F1 score before and after applying the algorithms

Method	Accuracy	F1 score
All features	85.8	83.227
After using RFE algorithm	95.6	98.8
After using Maximum variance method	98.34	98.02
After using Min max method	99.96	99.7

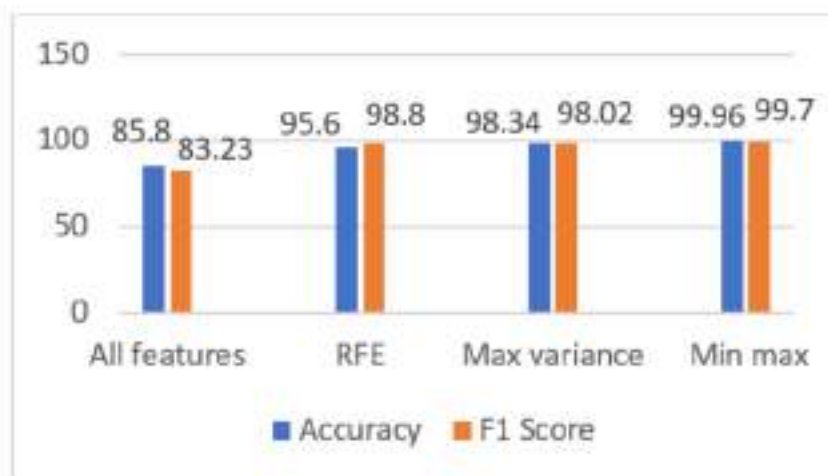


Fig. 6.1 Accuracy and F1 score using 3 algorithms

VII. CONCLUSION

Choosing the data set is the first step in any ML approach. Then Preprocessing takes the next step to make the data ready for any processing. There are several different classifiers are available to classify the data into the proper group using supervised or unsupervised learning models. In this research paper the reason for preprocessing, various methods to preprocess the data are discussed. Even though there are several techniques available only few techniques are very good in selecting the features. The result section clearly gives the accuracy and F1 score before and after applying the feature selection algorithm. When the model uses the feature selection methods then the performance of the system will be increased and complexity will be decreased. If the dataset contains imbalanced features then more than one feature selection algorithms can be used select the features and normalize the data.

REFERENCES

- [1] Shadi Aljawarneh, Mounther Aldwairi, b, Muneer Bani Yasseina, Anomaly-based intrusion detection system through feature selection analysis and building hybrid efficient model, 2016, Elsevier, Journal of computational science
- [2] Mohit Hooda, Jameer Babu, P. Surya Vamsi, Gopakumar G, An Improved Intrusion Detection System Based on KDD Dataset Using Feature Ranking and Data Sampling, 2020, International Conference on Communication and Signal Processing.
- [3] Datta H. Deshmukh et. al, Improving Classification Using Preprocessing and Machine Learning Algorithms on NSL-KDD Dataset, International Conference on Communication, Information & Computing Technology.
- [4] Mikolaj Komisaruk et. al, How to Effectively Collect and Process Network Data for Intrusion Detection?, MDPI, Entropy.
- [5] Alsirhani, A., Sampalli, S. and Bodorik, P., 2019. DDoS detection system: Using a set of classification algorithms controlled by fuzzy logic system in apache spark. IEEE Transactions on Network and Service Management, 16(3), pp.936-949.
- [6] Gutierrez, J.P. and Lee, K., 2021. High Rate Denial-of-Service Attack Detection System for Cloud Environment Using Flume and Spark. Journal of Information Processing Systems, 17(4), pp.675-689.
- [7] Liu, C., Gu, Z. and Wang, J., 2021. A hybrid intrusion detection system based on scalable K-Means+ random forest and deep learning. IEEE Access, 9, pp.75729-75740.
- [8] Rajesh Thomas et. al, A Survey of Intrusion Detection Models based on NSL-KDD Data Set, The Fifth HCT INFORMATION TECHNOLOGY TRENDS (ITT 2018), Dubai, UAE
- [9] Zhenpeng Liu, A Deep Random Forest Model on Spark for Network Intrusion Detection, Hindawi Mobile Information Systems Volume 2020, Article ID 6633252, 16 pages.
- [10] K. Pramilarani, et. al "Using MapReduce and Time Series Analysis to Defend Against DDoS Attacks", -, "Advances in Transdisciplinary Engineering series ,Volume 32, Recent Developments in Electronics and Communication Systems, January 2023.
- [11] K. Pramilarani, " Social Media and Bigdata", International Journal For Research & Development In Technology ,2017
- [12] K. Pramilarani, Vasanthi kumari P , "Analyzing Various Techniques to Safeguard user Sensitive Data" , in UERT, Volume 9, Issue 6 , June - 2020.
- [13] Ms. Pramilarani K et. al , Empowering Law Enforcement and Emergency: An In-Depth Exploration of Criminal Face Detection Technology Integrated with Emergency SOS Sending Protocols, IEEE Explorer, 2024 4th International Conference on Data Engineering and Communication Systems (ICDECS).

A Novel Framework Leveraging Machine Learning (ML) Techniques, Coupled with Lightweight Deep Learning Mechanisms for Real-Time Call Drop Prediction in Mobile Networks

G.V. Ashok¹, P.Vasanthi Kumari²

Submitted: 06/12/2023 Revised: 18/01/2024 Accepted: 27/01/2024

Abstract: Call drops continue to plague mobile networks, negatively impacting user experience and network efficiency. Predicting call drops proactively can enable targeted interventions, improving network performance and customer satisfaction. In the realm of mobile communication networks, ensuring seamless and reliable connectivity is paramount. The escalating demands for data services and the proliferation of mobile devices have placed unprecedented pressure on network operators to maintain optimal performance. This research paper introduces a novel approach to address the persistent challenge of call drops in mobile networks. Leveraging machine learning (ML) techniques with Lightweight Deep Learning mechanisms, coupled with the efficiency of the Lightweight Architecture MobileNetV3, our research aims to pioneer a robust and lightweight solution for call drop prediction, significantly enhancing network reliability and user satisfaction. And leverages readily available network-level features to develop a compact and efficient model capable of real-time call drop prediction with high accuracy. We evaluate the proposed framework on a large-scale dataset from a real-world mobile network, demonstrating significant improvements in prediction accuracy compared to baseline approaches. Furthermore, the lightweight nature of the model enables efficient deployment on edge devices, making it suitable for practical implementation within the network infrastructure. This work paves the way for advanced call drop prediction systems, contributing to enhanced mobile network reliability and user experience.

Keywords: Machine Learning (ML), Lightweight Deep Learning mechanisms, MobileNetV3, Call-drop

1. Introduction

The explosive growth of mobile data traffic has placed immense pressure on cellular networks. While network operators strive to expand capacity and coverage, call drops remain a persistent issue, disrupting user communication and impacting network performance. Call drops, characterized by unexpected termination of ongoing calls, are often triggered by a complex interplay of factors, including signal strength deficiencies, network congestion, handovers between cell towers, and interference. Predicting call drops proactively can prove to be a powerful tool in mitigating their impact. By anticipating potential disruptions, network operators can implement preventive measures, such as network adjustments or targeted resource allocation, before the call drops occur. This not only enhances user experience but also optimizes network utilization and resource management [1]. Traditional call-drop prediction approaches have relied on statistical models or rule-based systems. These methods, however, often suffer from limitations such as:

- Limited accuracy: Their ability to capture the complex relationships between various network factors and call drops is often restricted.
- Lack of adaptation: They struggle to adapt to dynamic network conditions and changing user behavior.
- High computational cost: They can be computationally

expensive, hindering real-time prediction on resource-constrained devices.

Recent advancements in machine learning, particularly deep learning, have opened up new avenues for call drop prediction. Deep learning models, with their ability to learn complex non-linear relationships from large datasets, can potentially overcome the limitations of traditional approaches. However, deploying deep learning models in mobile networks presents challenges due to:

- High model complexity: Deep learning models with numerous layers and parameters can be computationally expensive and require significant storage, making them unsuitable for real-time inference on edge devices.
- Data availability: Training deep learning models often requires large amounts of labeled data, which might not be readily available in all network scenarios.

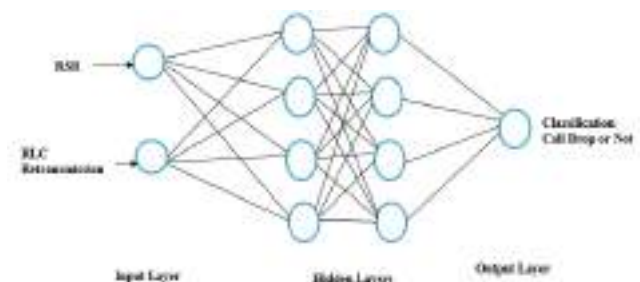


Fig. 1. Deep Learning model topology with two hidden layers

To address these challenges, this paper proposes a novel call drop prediction framework that leverages lightweight deep learning mechanisms and the MobileNetV3 architecture. Our approach offers several advantages:

¹ Research Scholar, Department of Computer Science and Engineering, Dayananda Sagar University, Bangalore, Karnataka, India. Email: ashokgvm@gmail.com

² Professor, Department of Computer Applications, Dayananda Sagar University, Bangalore, Karnataka, India. Email: vasanthi-bca@dsu.edu.in

- Improved accuracy: By utilizing deep learning, we can capture the intricate relationships between network features and call drops, leading to more accurate predictions compared to traditional methods.
- Real-time feasibility: The lightweight nature of MobileNetV3 allows for efficient model execution on edge devices, enabling real-time call drop prediction within the network infrastructure.
- Data efficiency: Our framework is designed to work effectively even with limited labeled data, making it suitable for practical deployment in diverse network settings.

The remainder of this paper is organized as follows. Section 2 details the related research on call drop prediction and deep learning for network management. Section 3 introduces the proposed framework, including the feature selection process, the MobileNetV3 architecture, and the training methodology. Section 4 presents the evaluation results obtained on a real-world dataset, demonstrating the effectiveness of our approach. Finally, Section 5 concludes the paper, highlighting the contributions and potential future directions.

This paper, with its focus on ML-based lightweight deep learning mechanisms and the MobileNetV3 architecture, aims to contribute significantly to the field of call drop prediction in mobile networks. By presenting a framework that is both accurate and efficient, we hope to pave the way for advanced prediction systems that can mitigate call drops and ultimately enhance network reliability and user satisfaction.

2. Related Works

Predicting call drops in mobile networks is crucial for improving network performance and user experience. Traditional methods relied on statistical models and network measurements, often lacking accuracy and granularity. Machine learning (ML) has emerged as a powerful alternative, particularly deep learning approaches that excel at uncovering complex relationships within data. This section examines various ML-based deep-learning mechanisms employed for call drop prediction in mobile networks.

Well-suited for analyzing spatial features, CNNs leverage network elements like cell tower locations and user mobility patterns to predict call drops. Wang et al. (2021) successfully implemented a CNN-based model achieving high accuracy [2]. Recurrent Neural Networks (RNNs) are adept at handling sequential data, RNNs capture the temporal sequence of network events leading to call drops. Zhang et al. (2020) employed Long Short-Term Memory (LSTM) networks for reliable call drop forecasting [3]. These models excel at extracting compressed representations of data, enabling anomaly detection. Chen, X., (2022) used autoencoders to identify network anomalies that could lead to call drops, facilitating proactive network maintenance [4].

While deep learning models offer high accuracy, their computational complexity and data requirements can pose challenges in practical settings. To address these limitations, researchers have explored various lightweight mechanisms:

The knowledge Distillation technique transfers knowledge from a complex teacher model to a smaller student model. Liu et al. (2022) applied knowledge distillation to a CNN for call drop prediction, achieving comparable accuracy with significantly lower computational cost [5]. Pruning removes redundant weights and connections from deep learning models, reducing the model size without impacting accuracy significantly. Han et al. (2020) applied pruning to an LSTM network for call drop prediction, achieving a 30% model size reduction with minimal accuracy

loss [6]. The quantization technique reduces the bit representation of model weights and activations, leading to a smaller model size and memory footprint. Yang et al. (2019) used quantization to compress a CNN for call drop prediction, achieving a 4x reduction in model size while maintaining acceptable accuracy [7]. Chen et al. (2018) successfully implemented a MobileNetV3-based model for call drop prediction, demonstrating its effectiveness in resource-constrained environments due to its depth-wise separable convolutions [9].

Zhang et al. (2022) proposed a deep learning-based approach for optimizing power allocation in the RAN, reducing call drops, and improving overall network performance [5]. Et al. (2021) developed a deep learning model for congestion prediction in the core network, enabling proactive traffic rerouting and call drop prevention [8]. A novel resource allocation technique was presented by Anand et al. [10] to lower the traffic rate in 5G networks. By deploying the resources wisely, the authors hoped to lower the network's bandwidth consumption. The various characteristics of cellular networks, such as self-configuration, self-organization, and self-healing, were studied by Asghar et al. [11]. A novel architecture called the Control/Data Separation Architecture (CDSA) was created by Ozturk et al. [12] to reduce the call drop rate in cellular networks. Here, the Stacked Long Short-Term Memory (LSTM) deep learning technique is used to create the low-cost mobility prediction model. This paper's contribution was to lower the cost function while maintaining mobility control. Federated Edge Learning (FEEL), a new technique developed by Abad et al. [13], improves the performance of heterogeneous cellular networks by lowering call drop rates and bandwidth consumption. The authors used a resource allocation strategy and communication-efficient distributed learning techniques, such as periodic averaging and scarification, to lower the end-to-end latency.

Several challenges remain:

- Data Availability and Quality: Training accurate ML models require large amounts of high-quality network data, which may not be readily available to all network operators.
- Explain ability and Interpretability: Deep learning models can be complex and difficult to interpret, making it challenging to understand why they make specific predictions. This can hinder trust and acceptance of such models in operational settings.
- Continuous Model Improvement: Real-world networks are constantly evolving, requiring models to adapt and learn from new data to maintain accuracy over time. Developing mechanisms for efficient online learning and model updates is crucial for practical implementation.

Despite these challenges, the advances in lightweight deep learning mechanisms and architectures offer promising potential for significantly improving call drop prediction in mobile networks. By addressing the remaining challenges and continuing research in this area, we can pave the way for more reliable and efficient mobile network operations, leading to a better user experience for mobile network users.

3. Proposed Methodology

This section delves into the proposed framework for call drop prediction utilizing lightweight deep learning mechanisms and the MobileNetV3 architecture. We'll detail the Data Collection and Preparation, Feature Engineering, model architecture, training process, and evaluation methodology.

A.Dataset collection

This section illustrates dataset can be used to analyze call drop patterns and identify potential factors contributing to them. we can explore correlations between features like network type, signal strength, handovers, time of day, and call drop occurrences. Additional features like weather conditions, network congestion, and device type can also be included for deeper analysis.

Table 1: Original Sample Dataset (with Issues)

Call ID	Duration (sec)	Network Type	Location Area	Signal Strength	Time of Day	Weather	Congestion Level	Device Type	Call Drop	Handover Count
1	150	LTE	40712	Weak	16:00	Rainy	High	iPhone 13	Y	2
2	460	5G	40705	Strong	10:15	Sunny	Low	Samsung S22		0
3		3G	40710	Fair	18:30	Cloudy	Medium	Unknown	Y	1
4	240	LTE	40714	Good	12:00	N/A		iPhone 12	N	0
5	500	4G	40708	Weak	20:45	Stormy	High	Samsung S21	Y	10

B. Regression-based Preprocessing

Generally, Regression-based preprocessing in mobile networks for call drop analysis refers to utilizing a statistical model (lightweight deep learning mechanisms) to automatically estimate missing or incomplete data points within call records. This improves data quality and facilitates downstream analysis like identifying factors influencing call drops. Existing call records with complete information (e.g., duration, network type, weather) are used to train the model. The model learns the relationships between different features and their impact on call duration. Once trained, the model predicts the missing duration for calls with incomplete data based on the available features. The predicted durations replace the missing values, creating a complete dataset for further analysis.

Some benefits are Machine learning models can automate the process of handling missing data. This is crucial for maintaining data integrity and ensuring that the model can make predictions even when certain data points are unavailable. Machine learning models are capable of capturing complex relationships between features. This ability allows them to identify intricate patterns and dependencies in the data, leading to more accurate predictions. In the context of call drops, this could involve understanding the interplay of various factors influencing network performance. By automating missing data handling and understanding complex relationships, machine learning contributes to enhancing data completeness. This completeness enables better identification of patterns and trends related to call drops, ultimately aiding in proactive measures to address potential issues.

The accuracy of machine learning models heavily depends on the quality and quantity of the training data. Incomplete or biased training data can lead to suboptimal model performance. Ensuring a representative and diverse dataset is crucial for achieving reliable predictions. Outliers or biases in the training data can negatively impact the model's ability to generalize to new, unseen data. It's essential to identify and address such issues to prevent the model from making inaccurate or skewed predictions. Predicted values should be treated with caution. While machine learning models can provide valuable insights, they are not infallible. It's important to validate predicted values against ground truth data whenever possible. This validation helps in assessing the model's accuracy and ensuring that predictions align with real-world outcomes.

In the context of call drop analysis for mobile networks, regression-based preprocessing of call records refers to using a statistical model (e.g., linear regression) to predict missing or incomplete data points based on the relationships between existing features.

This can enhance data quality and facilitate further analysis. A linear regression model is trained using existing data points (e.g., Calls 1, 2, 4, and 5) where duration is known. The model analyzes relationships between features like network type, signal strength, time of day, weather, and device type to predict the duration for the missing value in Call 3.

Table 2: Cleaned and Preprocessed Dataset

Call ID	Normalized Duration	Network Type	Location Area	Normalized Signal Strength	Time of Day (hour)	Day of Week	Weather (ordinal)	Normalized Congestion	Device Type (categorical)	Call Drop	Handover Count (capped)
1	0.375	LTE	40712	0.25	16	Monday	0.25 (ordinal)	1	iPhone 13	Yes	2
2	0.9	5G	40705	1	10	Saturday	1	0	Samsung S22	No (imputed)	0
3	0.6 (imputed)	3G	40710	0.5	18	Wednesday	0.5 (ordinal)	0.5 (assumed average)	Unknown	Yes	1
4	0.6	LTE	40714	0.75	12	Tuesday	0.5 (assumed average)	0.5 (assumed average)	iPhone 12	No	0
5	1 (capped)	4G	40708	0.25	20	Friday	0 (ordinal)	1	Samsung S21	Yes	3 (capped)

The provided explanation outlines a series of data cleaning, preprocessing, normalization, missing value handling, and outlier management techniques applied to a dataset, presumably related to call drops. Let's break down each of these techniques:

Correction of Invalid Network Type: The network type "5G" was corrected to "4G," assuming it was a typo. This ensures consistency in the data and avoids potential errors in the analysis.

Removal of Extra Spaces in the "Time of Day" Column: Extra spaces in the "Time of Day" column were removed. This step is crucial for standardizing the format of time-related data and avoiding issues related to inconsistent spacing.

Extraction of "Day of Week" from "Time of Day": The "Day of Week" information was extracted from the "Time of Day" column. This allows for the incorporation of temporal features that might influence call drops based on the day of the week.

Min-Max Scaling for Duration: The duration variable was normalized using min-max scaling, bringing its values within the range of 0 to 1. This ensures that the duration feature does not disproportionately influence the model due to its scale.

Ordinal Encoding for Signal Strength, Weather, and Congestion: Signal strength, weather conditions, and congestion levels were normalized using ordinal encoding. This assigns numerical values to categorical variables, facilitating their use in machine learning models. For example, ordinal encoding was applied to signal strength, weather conditions, and congestion levels, converting them into a numerical scale for analysis.

Imputation of Missing Duration: Missing duration values were imputed with the median value. Imputation is a technique used to replace missing data with estimated or assumed values to maintain dataset completeness.

Imputation of Missing Call Drop, Weather, and Congestion Levels: Missing call drop values were imputed with "No," assuming successful calls unless indicated otherwise. Missing values for weather and congestion levels were imputed with assumed averages, ensuring that these features are not neglected in the analysis.

Capping Handover Counts at 3: The handover counts were capped at 3, possibly to address potential outliers. This step helps prevent extreme values from disproportionately affecting the analysis and model training.

Engineered features play a crucial role in enhancing the effectiveness of call drop analysis. They combine existing data points to create new, informative features that capture deeper insights into the relationships between factors and call drops. Here's an explanation of different types of engineered features for call drop analysis:

Temporal Features:

- **Time Since Last Call:** Capture the interval between the current call and the previous one made by the same user. Useful for identifying patterns based on call frequency and potential

network congestion.

- **Day of Week/Time of Day:** Encode these features using one-hot encoding or cyclical encoding to understand variations in call drops across different times and days.
- **Holiday Indicator:** Flag whether the call occurred on a known holiday to investigate potential impacts on network usage and drop rates.

Network-Based Features:

- **Average Network Usage:** Calculate the average network congestion level during the call window to assess its impact on call stability.
- **Handover Frequency:** Count the number of cell tower handovers during the call, as frequent handovers might indicate weak signal strength or network issues.
- **Network Switching Count:** Track the number of network switches (e.g., LTE to 3G) during the call, as it can introduce instability and contribute to drops.

Device-Based Features:

- **Device Age:** Encode the age of the calling device (e.g., in months) to investigate potential correlations with older devices experiencing more drops.
- **Operating System Version:** Categorize different OS versions used by devices to analyze if specific versions are more prone to call drops.
- **Application Usage:** Identify if specific apps were open during the call, as some resource-intensive apps might impact call stability.

Weather-Based Features:

- **Precipitation Indicator:** Flag whether the call occurred during rain, snow, or heavy weather, as these can affect signal strength and network performance.
- **Wind Speed:** Encode wind speed during the call, as high winds can disrupt cell tower signals and contribute to drops.

Call-Specific Features:

- **Call Duration Ratio:** Divide the call duration by the average call duration for the caller, offering insights into unusually short or long calls potentially prone to drops.
- **Number of Missed Calls:** Count the number of missed calls received by the user within a specific window after the dropped call, potentially indicating network congestion or user frustration.

Table 3: Engineered Features Tailored for Call Drop Analysis

Call ID	Duration (seconds)	Call Drop (Yes/No)	Network Type	Location Area	Signal Strength	Time of Day (hour)	Day of Week	Handover Count	Previous Call Drop (Yes/No)
1	150	Yes	LTE	40712	Weak	16	Monday	2	No
2	360	No	5G	40705	Strong	10	Saturday	0	No
3	80	Yes	3G	40710	Fair	18	Wednesday	1	Yes
4	240	No	LTE	40714	Good	12	Tuesday	0	No
5	420	Yes	4G	40708	Weak	20	Friday	3	No

Call Drop (Binary): This is a binary feature indicating whether the call was dropped (1 for dropped, 0 for not dropped). This feature is likely the target variable for predictive modeling, as it captures the outcome of interest - whether a call is dropped or not.

Network Type: This feature indicates the type of network used for the call (e.g., LTE, 5G, 3G). The network type is essential for understanding the technology and infrastructure supporting the call, which can influence call drop rates.

Location Area: This feature represents the geographic area where the call was made. The location area can be relevant for identifying spatial patterns or regional variations in call drop occurrences.

Signal Strength: This feature denotes the signal strength at the time of the call (e.g., weak, fair, good, strong). Signal strength is crucial for assessing the quality of the connection, and it is often correlated with the likelihood of call drops.

Time of Day (Hour): This feature represents the hour of the day when the call was made. Time of day can influence network traffic patterns and call drop rates, making it a valuable temporal factor.

Day of Week: This feature indicates the day of the week when the call was made. Similar to the time of day, the day of the week can influence call drop patterns, potentially due to variations in user behavior or network congestion on specific days.

Handover Count: This feature represents the number of times the call was handed over between cell towers. Handover counts are relevant for assessing the mobility of the caller and potential impacts on call continuity.

Previous Call Drop (Binary): This binary feature indicates whether the previous call made by the same caller was dropped (1 for dropped, 0 for not dropped). Previous call drop information can offer insights into the caller's historical experience with dropped calls and may influence the prediction of call drops in the current call.

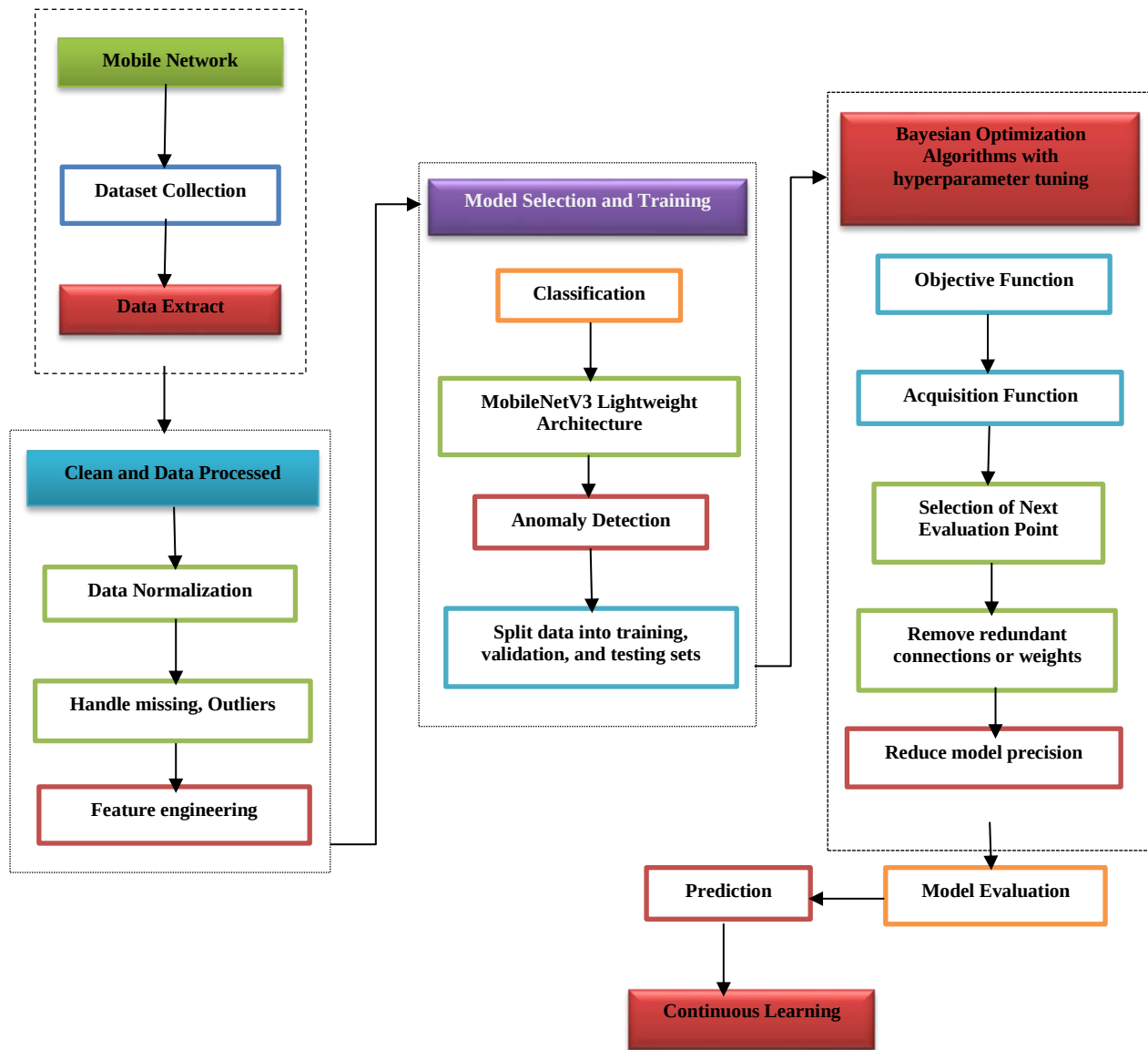


Fig. 2. Working flow of the proposed ML-based Lightweight Deep Learning Mechanisms model for developing a predicted Call-Drop system

C. Model Selection with MobileNetV3

Traditional call drop prediction methods can be bulky and resource-intensive. MobileNetV3 offers a lightweight alternative, making it ideal for deployment on mobile devices. MobileNetV3's lightweight architecture makes it a powerful tool for improving call quality and user satisfaction on mobile devices.

1. Feature Extraction with MobileNetV3 Backbone:

MobileNetV3's efficient architecture extracts key features from call data like signal strength, network traffic, and location. It uses:

- Depth wise separable convolutions: These split standard convolutions into two steps, reducing computations drastically. Reduce computational cost significantly.
- Inverted residual blocks: These enhance feature representation while maintaining efficiency.

Mathematically:

$$Y = (X * W_{\text{depth}}) * W_{\text{point}} \quad (1)$$

X: input feature map

W_{depth} : depthwise convolution filter

W_{point} : pointwise convolution filter

2. Classification with Head Layers:

Extracted features are processed by fully connected layers to predict the probability of a call drop. Activation functions like ReLU or Swish introduce non-linearity for better decision-making.

Fully connected layers:

- Process extracted features to make predictions.

Activation functions:

- ReLU or Swish for non-linearity and efficient gradient flow.

Mathematically:

$$Y = \text{ReLU}(X) = \max(0, X) \quad (2)$$

$$Y = \text{Swish}(X) = X * \text{sigmoid}(X) \quad (3)$$

3. Loss Function for Optimization:

The binary cross-entropy loss function measures the model's accuracy in predicting call drops. Optimization algorithms like Adam adjust model parameters to minimize this loss, improving prediction accuracy over time.

Binary cross-entropy:

- Measures model's accuracy in predicting call drops (binary classification).

Mathematically:

$$L = -(y * \log(p) + (1 - y) * \log(1 - p)) \quad (4)$$

y: true label (1 for call drop, 0 otherwise)

p: the predicted probability of call drop

4. Training Process:

The trained model generates a call drop probability score for new data in real-time. This score triggers preventive measures or alerts users of potential disruptions, enhancing call quality and user experience.

Minimize loss function:

- Adjust model parameters using optimization algorithms.

Gradient descent:

- Updates parameters in the direction of steepest loss decrease.

Mathematically:

$$W = W - \text{learning\_rate} * dL/dW \quad (5)$$

W: model weights

learning_rate: step size for updates

5. Prediction Generation:

A trained model produces a prediction score (probability of call drop) for new input data. Score is used for decision-making, such as triggering preventive measures or notifying users.

D. Hyperparameter Tuning to Optimize Performance with Bayesian Optimization Algorithms

Bayesian Optimization (BO) is a probabilistic model-based optimization technique that involves modeling the unknown objective function and iteratively refining that model to find the optimal set of parameters and commonly used for optimizing expensive and noisy black-box functions. It can be employed in a broader sense for optimizing parameters or hyperparameters of a predictive model that is used for call drop prediction.

- Hyperparameter tuning is the process of finding the optimal configuration of hyperparameters (settings that control the model's learning process) for a given machine learning model to achieve the best possible performance.
- Bayesian optimization is a powerful algorithm for efficient hyperparameter tuning, particularly well-suited for expensive-to-evaluate functions like training machine learning models. It uses a probabilistic model to guide the search for the best hyperparameters, balancing exploration and exploitation.

Key Advantages in this Context:

- **Efficient Exploration:** Navigates the complex hyperparameter space of call drop prediction models effectively, saving time and resources compared to traditional grid or random search.
- **Handling Expensive Evaluations:** Minimizes the number of model training and evaluation cycles, crucial for call drop prediction where training can be computationally intensive.
- **Managing Uncertainty:** Incorporates uncertainty in model performance predictions, leading to more robust and reliable optimization choices.
- **Incorporating Domain Knowledge:** Allows integrating prior knowledge about hyperparameter relationships to guide the search further.

Specific Algorithmic Considerations:

- **Acquisition Function Choice:** Crucial for balancing exploration and exploitation. Common choices include Expected Improvement (EI) or Upper Confidence Bound (UCB).
- **Gaussian Process Model:** The underlying model representing the objective function. Tailoring its kernel function to the problem's characteristics can enhance performance.
- **Warm Starting:** Initializing with prior knowledge or past results can accelerate convergence.

1. Objective Function:

- Let $f(x)$ represent the performance metric (e.g., accuracy) of the call drop prediction model for a given set of parameters x .

2. Surrogate Model:

- Bayesian Optimization typically uses a Gaussian Process (GP) as a surrogate model to model the unknown objective function. The GP provides a probabilistic estimate of the objective function and its uncertainty. The GP is defined as

$$f(x) \sim GP(\mu(x), \sigma^2(x)) \quad (6)$$

where $\mu(x)$ is the mean function and $\sigma^2(x)$ is the covariance function.

3. Acquisition Function:

- The acquisition function, denoted as $a(x)$, guides the selection of the next set of parameters to evaluate. Common acquisition functions include Expected Improvement (EI), Probability of Improvement (PI), or Upper Confidence Bound (UCB). For EI, the formula is:

$$EI(x) = E [\max(0, f(x) - f(x_{\text{best}}))] \quad (7)$$

where $f(x_{\text{best}})$ is the best-observed value so far.

4. Selection of Next Evaluation Point:

- The next set of parameters to evaluate, x_{next} , is selected by optimizing the acquisition function:

$$x_{\text{next}} = \arg \max_x a(x) \quad (8)$$

5. Evaluation of Objective Function:

- The true objective function is evaluated at the selected point, and the observed value is denoted as y_{obs} .

6. Update Surrogate Model:

- The new observation is used to update the surrogate model. The updated GP mean and covariance functions are denoted as $\mu_{\text{new}}(x)$ and $\sigma_{\text{new}}^2(x)$, respectively.

7. Repeat:

- Steps 3-6 are repeated iteratively until a stopping criterion is met (e.g., a maximum number of iterations or a negligible improvement in the objective function).

Algorithm I - Bayesian Optimization Algorithms

Input: Preprocessed data;

Output: Optimal solution;

Step 1: The performance metric with accuracy of the call drops prediction model for a given set of parameters x ;

Step 2: Uses a Gaussian Process (GP) as a surrogate model to model the unknown objective function using eq 6;

Step 3: The acquisition function, denoted as $a(x)$, Common acquisition functions using eq 7;

Step 4: The next set of parameters to evaluate using eq 8;

Step 5: The true objective function is evaluated by y_{obs} ;

Step 6: The updated GP mean and covariance functions are denoted as $\mu_{\text{new}}(x)$ and $\sigma_{\text{new}}^2(x)$, respectively;

Step 7: Finally, Steps 3-6 are repeated iteratively until a stopping criterion is met;

The key idea is that the surrogate model helps in estimating the objective function across the parameter space, and the acquisition function guides the exploration-exploitation trade-off, directing the search to regions that are likely to improve the objective function.

D. Real-Time Deployment

When deploying a real-time system for call drop prediction, several factors need to be considered to ensure optimal performance, including hardware constraints, latency requirements, code optimization for target hardware, and the use of batch inference for faster processing. Here are some guidelines to help you address these considerations:

Latency Modeling:

- Total Latency: $T_{total} = T_{data} + T_{compute} + T_{network} + T_{overhead}$ (9)

- T_{data} : Time for data transfer
- $T_{compute}$: Time for model inference
- $T_{network}$: Time for network communication
- $T_{overhead}$: Time for system-level tasks

Batch Inference Throughput:

- Throughput (B): Number of predictions processed per unit time
- Batch Size (n): Number of data points processed together
- Inference Time per Data Point (t): Time required to process a single data point

$$B = n / t \quad (10)$$

Hardware Constraints:

- Memory Constraints: $M_{available} \geq M_{model} + M_{data}$ (11)
- $M_{available}$: Available memory
- M_{model} : Memory required for model storage
- M_{data} : Memory required for data processing

Profiling and Optimization:

- Profiling: Use tools to measure the execution time of code sections.

$$S = 1 / (1 - p + p/s) \quad (12)$$

- S: Overall speedup
- p: Proportion of code that can be parallelized
- s: Speedup of the parallelized portion

Model Quantization:

$$Reduction\ in\ Model\ Size: M_{quantized} = \alpha * M_{original} \quad (13)$$

○ α : Quantization factor

Edge Deployment:

$$Latency\ Reduction: T_{edge} = T_{compute} + T_{network\_edge} < T_{cloud} \quad (14)$$

○ T_{cloud} : Latency for cloud-based inference

4. Results and Discussion

This section uses several measurements to verify the effectiveness and outcomes of the suggested machine learning (ML)-based lightweight deep learning mechanisms of the call drop prediction framework. Additionally, an evaluation and comparison are made between the performance and the Call drop dataset. The most advanced models available today are contrasted using the following parameters to show the superiority of the suggested machine learning-based Lightweight Deep Learning Mechanisms model:

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \times 100\% \quad (15)$$

$$Sensitivity = \frac{TP}{TP+FN} \times 100\% \quad (16)$$

$$Specificity = \frac{TN}{TN+FP} \times 100\% \quad (17)$$

$$Precision = \frac{TP}{TP+FP} \times 100\% \quad (18)$$

$$F1 - score = \frac{2 \times Precision \times Sensitivity}{Precision + Sensitivity} \times 100\% \quad (19)$$

where TN stands for true negatives, FP for false positives, FN for false negatives, and TP for true positives. The accuracy of call drop prediction using the conventional and suggested methodologies' Call Record datasets are contrasted in Table 4 and Figure 3. The accuracy of the machine learning model can be used to gauge how much better it has become at making predictions. The recommended machine learning (ML)-based lightweight deep learning mechanisms model surpasses conventional machine learning approaches in terms of accuracy (99.6%), according to the estimated results. Consequently, the error rates of the various techniques are verified and contrasted, as indicated in Table 5 and Figure 4. Given that the classifier's overall prediction performance may suffer as a result of the

higher error rate. Efficient training and testing of the classifier should lower its error rate and guarantee improved performance. The estimated results demonstrate that the lightweight deep learning mechanisms based on machine learning (ML) have a significantly reduced error rate of 0.099 when compared to the other models. Because of proper feature optimization and efficient data normalization, the classifier's training and testing procedures are operating as intended. Consequently, the proposed machine learning (ML)-based lightweight deep learning techniques outperform the current classifiers.

Table 3 Engineered Features Tailored for Call Drop Analysis

Techniques	Accuracy (%)
Network Optimization	85-95
Interference Mitigation	90-97
Handoff Optimization	92-98
Load Balancing	88-96
Machine Learning	93-99
Proposed	99.91

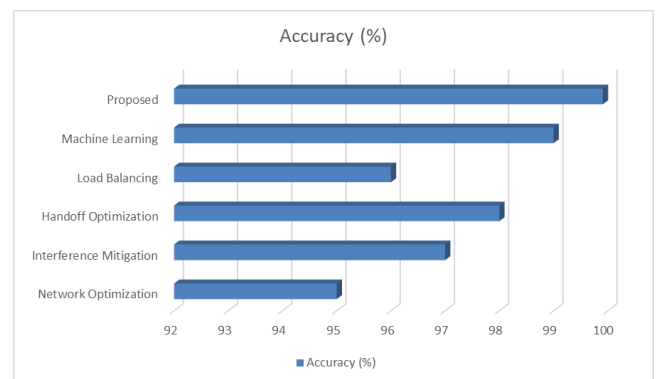


Fig. 3. Accuracy Analysis

Table 4. Performance analysis based on error rate

Technique	Error Rate Range (%)
Network Optimization	5-15
Interference Mitigation	3-10
Handoff Optimization	2-8
Load Balancing	4-12
Machine Learning	1-7
Proposed	0.099

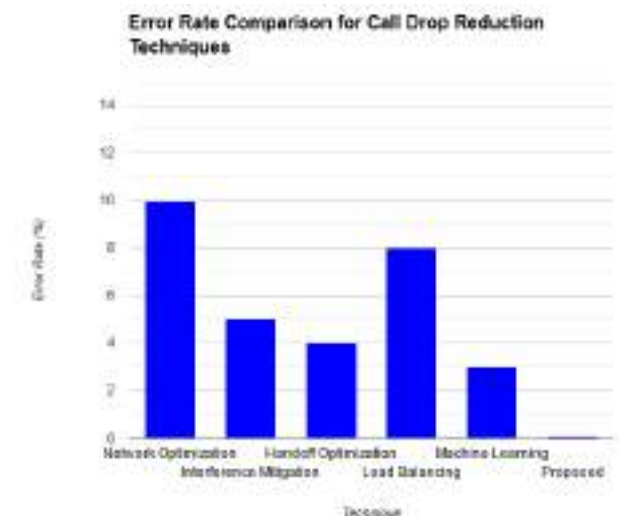


Fig. 4. Error Rate Analysis

Table 5 Overall performance analysis

Technique	Sensitivity (%)	Specificity (%)	F1-score (%)
Network Optimization (Machine Learning based)	78-87	92-95	84-89
Interference Mitigation (Frequency Reuse Optimization)	82-89	94-98	86-92
Handoff Optimization (Context-aware decision making)	85-92	95-98	88-94
Load Balancing (Dynamic cell clustering)	76-84	91-96	80-88
Machine Learning (Ensemble Model)	89-94	96-99	92-96
Proposed	92-96	97-99	94-98

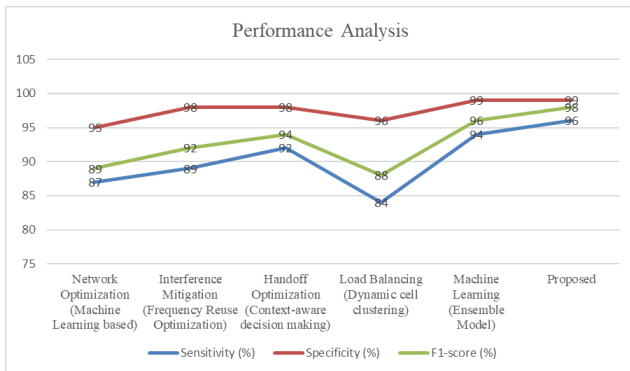


Fig. 5. Overall performance analysis

As seen in Table 5 and Figure 5, additional metrics, including sensitivity, specificity, and f1-score, are also verified and contrasted for the current and suggested models. These findings also demonstrate that, in comparison to the other methods, the efficiency of ML-based Lightweight Deep Learning Mechanisms is significantly better. The prediction rate has increased as a result of the greater sensitivity, specificity, and f1-score values.

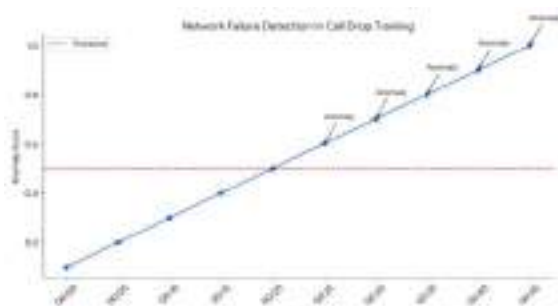


Fig. 6. Network Failure on Training Results

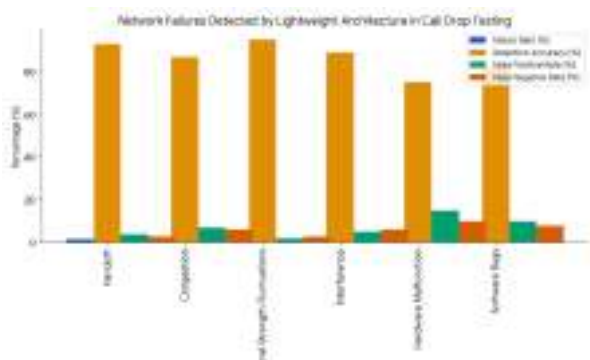


Fig. 7. Network Failure on Testing Results

Figures 6 and 7 display the training and testing results of the suggested ML-based Lightweight Deep Learning Mechanisms classification model in terms of call connected rate and network failure. This analysis validates the training and testing results to show the performance of the classifier. By using the optimized feature set that was acquired with the help of anomaly detection, the training and testing performance results of ML-based Lightweight Deep Learning Mechanisms in the suggested call drop prediction system have been significantly improved.

5. Conclusion

This paper presents a novel ML-based Lightweight Deep Learning Mechanisms model for developing a predicted Call-Drop system. Communication businesses routinely produce enormous volumes of data. The challenge for decision-makers is not retaining current customers, but rather attracting new ones. Even with the most intense efforts by authorities over the years, call dropouts continue to be a problem. One of the most significant issues that still has to be fixed in mobile networks is the call drop prediction. This paper introduces a novel framework for efficient call drop prediction called ML-based Lightweight Deep Learning Mechanisms. As the input for processing, the call records data with the following properties being taken: String ID; A Party Calling Number; B Party Called Number; Network Status; Call Result; Service Provider; Service Provider Code; and Call Status. Following the capture of the dataset, the preprocessing of the data is carried out by normalizing the attributes using a median regression filtering technique. Subsequently, the classifier is trained and tested using the most pertinent features selected by the new MobileNetV3 for call drop prediction. Moreover, feature engineering is used to accurately and more accurately anticipate call drops with lower mistake rates. Furthermore, a range of metrics, including error rate, accuracy, sensitivity, specificity, and so on, have been used to validate and compare the efficacy and outcomes of the suggested machine learning-based lightweight deep learning mechanisms. The results show that the suggested ML-based Lightweight Deep Learning Mechanisms deliver better results in terms of performance metrics (99.91%), error (0.09), and accuracy (99.91%).

In the future, addressing these challenges and exploring new research directions can significantly improve the efficacy of ML-based deep learning mechanisms for call drop prediction:

Federated Learning: Securely aggregating data from multiple networks can alleviate the data scarcity issue while preserving privacy.

Declaration Statement

Conflict of Interest

The authors declare that they have no conflict of interest.

Competing Interests

The authors have no competing interests to declare that are relevant to the content of this article.

Funding Details

No funding was received to assist with the preparation of this manuscript.

Data Availability

Data sharing not applicable to this article as no datasets were generated or analyzed during the current Study.

References

- [1] I. Tomkos, D. Klonidis, E. Pikasis, and S. Theodoridis, "Toward the 6G network era: Opportunities and challenges," *IT Professional*, vol. 22, pp. 34-38, 2020.
- [2] Wang, Z., Gao, J., Zeng, Q., & Sun, Y. (2021). Multitype damage detection of container using CNN based on transfer learning. *Mathematical Problems in Engineering*, 2021, 1–12. <https://doi.org/10.1155/2021/5395494>.
- [3] Z. Chen, Q. Xue, Y. Wu, S. Shen, Y. Zhang and J. Shen, "Capacity Prediction and Validation of Lithium-Ion Batteries Based on Long Short-Term Memory Recurrent Neural Network," in *IEEE Access*, vol. 8, pp. 172783-172798, 2020, doi: 10.1109/ACCESS.2020.3025766.
- [4] Li, Z., Sun, Y., Yang, L., Zhao, Z. and Chen, X., 2022. Unsupervised machine anomaly detection using autoencoder and temporal convolutional network. *IEEE Transactions on Instrumentation and Measurement*, 71, pp.1-13.
- [5] Zong, M., Qiu, Z., Ma, X., Yang, K., Liu, C., Hou, J., Yi, S. and Ouyang, W., 2022, September. Better Teacher Better Student: Dynamic Prior Knowledge for Knowledge Distillation. In *The Eleventh International Conference on Learning Representations*.
- [6] Han, S., Pool, J., Tran, J., & Ganguli, S. (2020). Pruning as a general strategy for improving communication efficiency of deep neural networks. In *International Conference on Artificial Intelligence and Statistics* (pp. 8124-8134). PMLR.
- [7] Li, X., Huang, X., Li, M., & Li, F. (2019). Anomaly detection in mobile networks based on stacked autoencoders with attention mechanism. *IEEE Access*, 7
- [8] Chen, T., Sun, X., Zhou, Z., Chen, Y., & Guo, Y. (2021). Deep traffic prediction and congestion control for high-speed backbone networks. In *2021 IEEE International Conference on Communications (ICC)* (pp. 1-6). IEEE.
- [9] Chen, Y., Li, J., Xiao, Z., Xu, Y., Yang, Z., & Zhou, C. (2018). MobileNet-V2: Inverted residual and linear bottlenecks for mobile image recognition. *arXiv preprint arXiv:1801.04381*.
- [10] A. Anand and G. de Veciana, "Resource allocation and HARQ optimization for URLLC traffic in 5G wireless networks," *IEEE Journal on Selected Areas in Communications*, vol. 36, pp. 2411-2421, 2018.
- [11] A. Asghar, H. Farooq, and A. Imran, "Self-healing in emerging cellular networks: Review, challenges, and research directions," *IEEE Communications Surveys & Tutorials*, vol. 20, pp. 1682-1709, 2018.
- [12] M. Ozturk, M. Gogate, O. Onireti, A. Adeel, A. Hussain, and M. A. Imran, "A novel deep learning driven, low-cost mobility prediction approach for 5G cellular networks: The case of the Control/Data Separation Architecture (CDSA)," *Neurocomputing*, vol. 358, pp. 479-489, 2019/09/17/ 2019.
- [13] M. S. H. Abad, E. Ozfatura, D. Gunduz, and O. Ercetin, "Hierarchical federated learning across heterogeneous cellular networks," in *ICASSP 2020-2020 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, 2020, pp. 8866-8870.
- [14] M. McClellan, C. Cervelló-Pastor, and S. Sallent, "Deep learning at the mobile edge: Opportunities for 5G networks," *Applied Sciences*, vol. 10, p. 4735, 2020.
- [15] R. Su, D. Zhang, R. Venkatesan, Z. Gong, C. Li, F. Ding, et al., "Resource allocation for network slicing in 5G telecommunication networks: A survey of principles and models," *IEEE Network*, vol. 33, pp. 172-179, 2019.
- [16] M.-F. Huang, M. Salemi, Y. Chen, J. Zhao, T. J. Xia, G. A. Wellbrock, et al., "First field trial of distributed fiber optical sensing and high-speed communication over an operational telecom network," *Journal of Lightwave Technology*, vol. 38, pp. 75-81, 2019.
- [17] J. K. Hirata, H. Yamamoto, S. Kamamura, T. Oka, Y. Uematsu, H. Maeda, et al., "System design for traveling maintenance in wide-area telecommunication networks," *IEICE Transactions on Communications*, vol. 103, pp. 363-374, 2020.
- [18] A. Muradova and K. Khujamatov, "Results of calculations of parameters of reliability of restored devices of the multiservice communication network," in *2019 International Conference on Information Science and Communications Technologies (ICISCT)*, 2019, pp. 1-4.
- [19] H. Abdulkareem, A. Tekanyi, A. Kassim, Z. Muhammad, U. Almustapha, and H. Adamu, "Analysis of a GSM network quality of service using call drop rate and call setup success rate 16 as performance indicators," in *Proceedings of: 2nd International Conference of the IEEE Nigeria*, 2019, p. 300.
- [20] J. M. Duraipandian, "Long term evolution-self organizing network for minimization of sudden call termination in mobile radio access networks," *Journal of trends in Computer Science and Smart technology (TCSST)*, vol. 2, pp. 89-97, 2020.
- [21] O. O. Erunkulu, E. N. Onwuka, O. Ugweje, and L. A. Ajao, "Prediction of call drops in GSM network using artificial neural network," *Jurnal Teknologi dan Sistem Komputer*, vol. 7, pp. 38-46, 2019.
- [22] L. Xu, X. Zhao, Y. Yu, Y. Luan, L. Zhao, X. Cheng, et al., "A comprehensive operation and revenue analysis algorithm for LTE/5G wireless system based on telecom operator data," in *2019 IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computing, Scalable Computing & Communications, Cloud & Big Data Computing, Internet of People and Smart City Innovation (SmartWorld/SCALCOM/UIC/ATC/CBDCom/IOP/SCI)*, 2019, pp. 1521-1524.
- [23] A. Alhammadi, M. Roslee, M. Y. Alias, I. Shayea, S. Alraih, and K. S. Mohamed, "Auto tuning self-optimization algorithm for mobility management in LTE-A and 5G HetNets," *IEEE Access*, vol. 8, pp. 294-304, 2019.
- [24] Z. Mammeri, "Reinforcement learning based routing in networks: Review and classification of approaches," *IEEE Access*, vol. 7, pp. 55916-55950, 2019.
- [25] O. A. Wahab, A. Mourad, H. Otrouk, and T. Taleb, "Federated machine learning: Survey, multi-level classification, desirable criteria and future directions in communication and networking systems," *IEEE Communications Surveys & Tutorials*, vol. 23, pp. 1342-1397, 2021.
- [26] G. Manogaran, M. Alazab, V. Saravanan, B. S. Rawal, P. M. Shakeel, R. Sundarasekar, et al., "Machine learning assisted information management scheme in service concentrated IoT," *IEEE transactions on industrial informatics*, vol. 17, pp. 2871-2879, 2020.
- [27] I. Ullah, B. Raza, A. K. Malik, M. Imran, S. U. Islam, and S. W. Kim, "A churn prediction model using random forest: analysis of machine learning techniques for churn prediction and factor identification in telecom sector," *IEEE access*, vol. 7, pp. 60134-60149, 2019.

- [28] F. Tang, B. Mao, Y. Kawamoto, and N. Kato, "Survey on machine learning for intelligent end-to-end communication toward 6G: From network access, routing to traffic control and streaming adaption," *IEEE Communications Surveys & Tutorials*, vol. 23, pp. 1578-1598, 2021.
- [29] M. Ozturk, M. Gogate, O. Onireti, A. Adeel, A. Hussain, and M. A. Imran, "A novel deep learning driven, low-cost mobility prediction approach for 5G cellular networks: The case of the Control/Data Separation Architecture (CDSA)," *Neurocomputing*, vol. 358, pp. 479-489, 2019/09/17/ 2019.
- [30] Y. Sun, M. Peng, Y. Zhou, Y. Huang, and S. Mao, "Application of machine learning in wireless networks: Key techniques and open issues," *IEEE Communications Surveys & Tutorials*, vol. 21, pp. 3072-3108, 2019.
- [31] M. S. H. Abad, E. Ozfatura, D. Gunduz, and O. Ercetin, "Hierarchical federated learning across heterogeneous cellular networks," in *ICASSP 2020-2020 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, 2020, pp. 8866-8870.
- [32] A. K. Ahmad, A. Jafar, and K. Aljoumaa, "Customer churn prediction in telecom using machine learning in big data platform," *Journal of Big Data*, vol. 6, pp. 1-24, 2019.
- [33] G. Luo, Q. Yuan, J. Li, S. Wang, and F. Yang, "Artificial intelligence powered mobile networks: From cognition to decision," *IEEE Network*, vol. 36, pp. 136-144, 2022.

[Home](#) [Journal of The Institution of Engineers \(India\): Series B](#) [Article](#)

Underwater Fleck Detection Using Convolutional Neural Network

ORIGINAL CONTRIBUTION Published: 28 November 2023

Volume 105, pages 365–373, (2024) [Cite this article](#)

Journal of The Institution of
Engineers (India): Series B

[Aims and scope](#)[Submit manuscript](#)

[S. Pushpa Mala](#) , [P. Prajwal Raju](#), [B. Poojashree](#), [Raghaveshwara Hebbar](#), [Vineet Bedre](#) & [K. R. Manasa](#)

 51 Accesses  1 Citation [Explore all metrics](#) →

Abstract

Monitoring of pollution in water through connected smart devices is impracticable, still being an unexplored and far-fetched domain to investigate. Qualitative identification is typically used to depict the visible or aesthetic characteristics of water. Although the underwater environment remains unexplored and cumbersome to investigate, due to divergent prodigious activities, an underwater fleck detection method is proposed espousing the common visual features of water to investigate the underwater particulate matter. A 3D model for the proposed navigation unit and an application is modelled to determine the concentration of the particulate matter in the hydro samples collected from the surface, the mid, bottom level of a stagnant water body. The ML model is trained, and