JOURNAL OF ACADEMIC TRENDS & INNOVATIVE RESEARCH

JATIR

VOLUME 2 ISSUE 4

April 2026

Email: editor@jatir.org
Website: jatir.org

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Volume 2, Issue 4, Apr 2026

A Study to Assess the Level of Psychological Stress Among the Patients Diagnosed with Haematologic Malignancies and Their Immediate Caretakers in A Selected Quaternary Care Centre in Delhi

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doi.org/10.64643/JATIRV2I4-140180-001

I. INTRODUCTION

"Without belief, we would be left with nothing but an overwhelming doom, every single day. And it will beat you i didn't fully see, until the cancer, how we fight everyday against the creeping negatives of the world, how we struggle daily against the slow slapping of cynicism"

– Lance Armstrong

Haematologic malignancies are common malignant disorders. Their prevalence has increased significantly in recent decades, especially in developed countries and, therefore, they are a significant health problem with marked consequences for society and the economy. In the Indian studies, a wealth of evidence demonstrates that haematologic malignancies have adverse effects in a variety of domains, including quality of life, physical and mental health, and healthcare-related costs. The diagnosis, treatment and surveillance of haematological cancers often have a profound psychological impact on patients and their families and can result in clinically significant problems and increased carer stress. These may manifest at any stage from diagnosis to death or living as a survivor.

Most measuring instruments provide a holistic, overarching approach to psychological stress, which includes assessing a number of different aspects, such as social, family and work functioning, psychological well-being as well as environmental factors that may affect, at least to some degree, an individual's quality of life, such as physical environment, financial resources, educational attainment and employment opportunities

BACKGROUND OF RESEARCH

Patients with hematologic malignancies have a high symptom burden throughout the illness journey. Stress management interventions effectively reduces the symptoms.

Therefore, the study of psychosocial factors influencing the course and the experience of the severe disease has received increased attention, which is associated with the increasing acceptance of the biopsychosocial (BPS) model of health, in the scientific and in the clinical community. Psycho-oncology, the field examining cancer through the lens of psychology, suggests that most cancer patients deal with numerous personal and interpersonal problems and fears that have been called the 6 D's. These issues include discomfort, dependency, disability, disfigurement, disruption and death. Studies examining depression in haematological cancer patients revealed that those patients experience several burdens. Specifically, a review of Allart-Vorelli et al. (2015), based on various depression assessment tools results, pointed out that haematological cancer patients appear to have lower quality of life in the physical, psychological, emotional and social domains compared with the general population. Unsurprisingly, patients with hematologic malignancies exhibit lower overall health and extremely high levels of fatigue and pain, which are common features of such medical conditions. Patients also show cognitive impairments, such as problems with memory and attention, increased levels of anxiety and depression and decreased sexual activity, which is also linked to the development of a negative body image.

Their relationships with family members, although in many cases are likely to be strengthened, are characterized by high-stress levels, uncertainty and fear, while the person's friendly relationships may also be disrupted. These individuals also face work-related and financial challenges which are associated with the suppression caused by their disease and with the fact that hematologic cancer treatment is often expensive and takes place, almost exclusively, in urban areas, forcing patients and probably family members to temporarily change their residence from one place to another place.

NEED OF STUDY

The purpose of this study is to investigate psychological stress among the patients diagnosed with haematological malignancies and quality of life among patients and immediate care takers with hematologic malignancies and the possible relationships between them.

a) Patients show cognitive impairments, such as problems with memory and attention, increased levels of anxiety and depression and decreased sexual activity, which is also linked to the development of a negative body image.

b) Their relationships with family members, although in many cases are likely to be strengthened, are characterized by high-stress levels, uncertainty and fear, while the person's friendly relationships may be disrupted.

c) The purpose of this study is to assess psychological distress of patients with haematological malignancies.

PROBLEM STATEMENT

A study to assess the level of psychological stress among the patients diagnosed with haematologic malignancies & their immediate caretakers in a selected Quaternary Care Centre in Delhi.

AIM OF THE STUDY:

- ❖ To assess the level of psychological stress among the patients diagnosed with haematologic malignancies & immediate caretakers.

OBJECTIVES OF THE STUDY:

- ❖ To assess the psychological stress among the patients diagnosed with haematological malignancy.
- ❖ To assess the psychological stress among the immediate caretakers of the patients with haematologic malignancy.
- ❖ To assess the association between factors affecting psychological stress.
- ❖ To modify the treatment strategy for the patients diagnosed with haematologic malignancy.

OPERATIONAL DEFINITION:

- Assess

The word assess means to evaluate the psychological stress of patients.

- Psychological Stress:

Psychological stress can be defined as a state of worry or mental tension caused by a difficult situation (WHO)

- Haematological malignancies:

Haematological malignancies are cancers that begin in blood-forming tissue, such as the bone marrow, or in the cells of the immune system. (National Institute of Health)

- Quaternary Care Hospital:

Quaternary care has been defined as an extension of tertiary care in reference to advanced levels of medicine which are highly specialised and not widely accessed, and usually only offered in a very limited number of national and international centres.

- Care taker:

Any person, including a family member, who provides care or
assistance to one who is ill.

RESEARCH HYPOTHESIS

H1: There is a correlation between psychological stress and diagnosis of hematological malignancies

H0: There is no association between psychological stress and diagnosis of hematological malignancies

SELECTED DEMOGRAPHIC VARIABLES ARE:

- Age
- Sex
- Education level
- Occupation
- Social status
- Residence
- Diagnosis
- Duration of disease

SCOPE OF STUDY:

- The study will give awareness to patients to cope up with the haematological malignancy among the patient and their care takers.
- This study will help to identify the gap in knowledge and compliance so that further reinforcement in health education can be done.
- This study will help to understand the importance of improving mental and physical health outcomes and of reducing psychosocial stress of patients.

INCLUSION CRITERIA:

- ❖ Patients diagnosed with haematologic malignancy in AH R&R.
- ❖ Immediate caretakers of patients with haematologic malignancy.

EXCLUSION CRITERIA:

- ❖ Patients who have non-malignant haematological disorders.
- ❖ Patients/caretakers who are below 18yrs

DELIMITATIONS:

- ❖ Study is limited to the haematological malignancy patients and care givers of Quaternary care hospital.
- ❖ Data collection period is limited to 04 weeks
- ❖ Psychological stress of other patients and care givers are not assessed.
- ❖ Small sample size
- ❖ Other medical /surgical comorbidities.
- ❖ Health status of caretaker

II. REVIEW OF LITERATURE

A Literature Review is "a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners."

- Sarah Smith

Literature review is a comprehensive summary of previous research on a topic. The literature review surveys scholarly articles, books, and other sources relevant to a particular area of research. The review should enumerate, describe, summarize, objectively evaluate and clarify this previous research. It should give a theoretical base for the research and helps to determine the nature of the research. The literature review acknowledges the work of previous researchers, and in so doing, assures the reader that the work has been well conceived. It is assumed that by mentioning a previous work in the field of study, that the author has read, evaluated, and assimiliated that work into the work at hand. Review of literature is considered as an essential step of research process. It involves a systematic identification, location, scrutiny and survey of written material that contain information as a research problem.

The overall process of review of literature is to develop a strong knowledge base to carry out research and clinical practice activities. It helps to determine gaps and consistencies in the literature about a subject under study. Review of literature guides the investigator to design the proposed study in a scientific manner to achieve the desired results. It gives an overview of what has been said, who the key writers are, what the prevailing theories are and hypothesis, what questions are being asked, and what methods and methodologies are appropriate and useful.

Review of Literature related to:

• Haematologic malignancies

• Stress among patients with haematologic malignancy

• Stress among caretakers of patients with haematologic malignancy

A) REVIEW OF LITERATURE RELATED TO HEMATOLOGICAL MALIGNANCY:

In recent years, there has been an increased recognition that the principles of palliative care should be made available earlier in the course of any chronic terminal illness, and that these principles can be delivered alongside therapies intended to prolong life. Despite this, the available evidence got from a cross-sectional study conducted by Merrole Cole- Sinclair et al among 200 patients published in Journal of pain and symptom management in the year 2011 suggests that patients with haematological cancers are less likely to access palliative care services, and those who do are more likely to do so at a later stage of illness than patients with other malignancies.

A study that was conducted in 2021 by Department of Haematology, Medline, Embase, Cochrane by Vanessa Manitta et al among 200 patients to analyse the burden of haematological malignancy & treatment patterns, published online in Clinical lymphoid & myeloid leukemia, the results from Indian studies on adult Haematologic malignancy are heterogeneous, reporting a diverse incidence and poor overall outcomes using varied non-contemporaneous treatment protocols adapted from the developed world. They suggest that a comprehensive countrywide approach to diagnosis, treatment, and follow-up and the potential incorporation of novel therapies could improve the prognosis and outcomes of adult ALL in India.

Another study conducted by Rachel Zordan which was published in American Society of Haematology in the year 2014 gave a conclusion as there are significant challenges in the management of Haematological malignancy in India. The major reason for not proceeding with treatment is the absence of financial resources. Induction deaths are related to a high incidence of multi-drug resistant organisms and fungal infections. The biggest constraint is the cost of the treatment and the absence of a health security net to treat all patients with this diagnosis.

B) REVIEW OF LITERATURE RELATED TO STRESS AMONG PATIENTS WITH HAEMATOLOGIC MALIGNANCY

A study to evaluate whether chronic stress enhances progression of acute lymphoblastic leukemia via β-adrenergic signalling published online in National library of Medicine suggest that stress-related bio behavioural factors can accelerate progression of hematopoietic cancers such as acute lymphoblastic leukemia (ALL), but it is unclear whether such effects are causal or what biological pathways mediate such effects. Given the network of sympathetic nervous system (SNS) fibres that innervates the bone marrow to regulate normal (non-leukemic) hematopoietic progenitor cells, we tested the possibility that stress-induced SNS signalling might also affect ALL progression.

According to a cross-sectional study conducted by Psychiatry department of University of "Sotiria", Athens General Hospital Athens, Greece published in the journal of MEDICINE & PHARMACY REPORTS in the year 2020 a study to assess depression, anxiety & stress among patients with haematological malignancies and the association with quality of life showed result that health-related Quality of Life in haematological patients undergoing chemotherapy is affected by psychological distress. Qol domains such as physical Health, psychological Health, social relationships and general Health are negative affected by depression, anxiety and stress in patients with hematologic malignancies.

A study conducted by Department of Psychooncology in the year 2018 in assessing traumatic stress in acute leukemia patients concluded that symptoms of Acute Stress Disorder are common and often persist or recur following diagnosis or relapse of Acute Leukemia. They recommend research urgently to determine the impact of interventions to prevent and treat psychological distress in this population.

C) REVIEW OF LITERATURE RELATED TO PSYCHOLOGICAL STRESS AMONG CARETAKERSOF PATIENTS WITH HAEMATOLOGIC MALIGNANCY:

A study conducted by Department of Nursing, University of Peloponnese, published in the international journal of Indian Psychology to assess stress and coping among primary caregivers of patients with haematological malignancies found that most of the caregivers of hematologic cancer patients experience moderate stress and had average coping skills. It is important to establish a care program, so that the caregivers can their own health and provide the best care to the patient.

A study published in Top Legal Education in India in the year 2018 to assess the stress experienced and coping strategies adopted by the mothers of children suffering from Leukemia, it is shown that majority of the mothers of children suffering from Leukemia had been experiencing moderate level of stress and Coping Strategies adopted by them in most of the samples also were moderately successful. There was negative correlation between the experienced stress and adopted coping strategies; i.e., when stress experience was increasing, coping was decreasing and also had significant correlation. There was no significant association between stress and selected variables and coping strategies also had no significant association with selected variables.

According to study conducted by Department of Psychology, Faculty of Humanities Sciences, Islamic Azad University Sari Branch, Sari, Iran published in Journal of Nursing & midwifery sciences indicated that positive thinking training has a great impact on depression, anxiety, and several areas of quality of life in this group of mothers of children with Leukemia compared to control group. Hence, using positive thinking intervention can be a helpful and supportive therapy to traditional training.

III. METHODOLOGY

INTRODUCTION

Research methodology is a systematic way to solve the research problem. In this chapter the research methodology is described in terms of design, methods, population, instruments and procedures used for data collection as well as procedures used during the data analysis. The research design enables the researcher to achieve the purpose and objectives of the study.

RESEARCH APPROACH

Research approaches are the plans and procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis and interpretation. The approach used by the researcher was descriptive study with the help of self–administered structured questionnaire and standardized tools. Descriptive research provides an accurate account of characteristics of an individual, event or group in real life situations.

RESEARCH DESIGN

The research design is a blueprint or outline for conducting the study in such a way that maximum control will be exercised over factors that could interfere with the validity of the research results. It is the researcher's overall plan for obtaining answers to the research questions guiding the study. Designing helps researchers to plan and implement the study in a way that will help them to obtain the intended results, thus increasing the chances of obtaining information that could be associated with the real situation.
The study design adopted by the investigator in the present study is non-experimental design.

The study was conducted in two phases.

❖ Phase I:

- Identifying the target population

- Administration of self-administered structured questionnaire and standardized tools

❖ Phase II:

- Tabulation
- Analysis and interpretation
- Inference of data collected.

RESEARCH SETTING

The research setting is the physical, social and cultural site in which the researcher conducts the study. The main study was conducted in the Haematology department of a quaternary care hospital. In this study the data was collected from patients who are diagnosed with hematological malignancies and their immediate care takers.

POPULATION

Population is defined as the totality of all subjects that conform to a set of specifications, comprising the entire group of persons that is of interest to the researcher and to whom the research results can be generalized. Patients diagnosed as a case haematological malignancies and their immediate care takers of haematology department were selected as our sample population.

IDENTIFICATION OF TARGET AND ACCESSIBLE POPULATION

Target population is the entire set of unit for which the research data is used to make inference whereas accessible population is subset of target population from where samples are drawn.

In this study, the target population identified was all adult patients diagnosed with haematological malignancies and their immediate care takers in the haematology ward and day care centre. The accessible population was the patients with haematological malignancies and their immediate care takers in the haematology department of a quaternary care hospital at the time of data collection period fulfilling the inclusion criteria and willing to participate in the study.

SAMPLE

A sample is a subset of population selected to participate in a study. In this study sample consisted of 50 haematology malignancy patients and their immediate care takers from the selected quaternary care hospital.

SAMPLING TECHNIQUE

Sampling is the process of selecting cases to represent an entire population so that inferences about the population can be made. A research population is generally a large collection of individuals or objects that is the focus of scientific study. Due to large size of population researchers often cannot test every individual in the population as it is too expensive and time consuming. This is the reason why researchers rely on sampling techniques.

The investigator used simple random sampling technique for the study. In this type of sampling design, every population member has a similar chance of being picked as the subject. The researcher included patients with haematological malignancies and their immediate care takers

who were available during the data collection period in both in-patient and out-patient department. Considering the limited period and availability of the sample, simple random sampling was selected as it is more appropriate and suitable for this study.

SAMPLE SIZE

Sample size refers to the number of sample elements from which the data is collected to evaluate the findings to be statistically significant. Sample size in our study is 50.

INCLUSION CRITERIA

a) Patients diagnosed with hematologic malignancy in AH R&R and their immediate care takers.

EXCLUSION CRITERIA

a) Patients who have non-malignant haematological disorders.
b) Patients who are below 18yrs

VARIABLES

Variables are qualities, properties or characteristics of persons, things or situations that change or vary. In this study the research and demographic variables are as follows:

- Research variables:
- Socio- Demographic variables:

TOOL AND TECHNIQUES

The DASS is a 21-item self-report instrument designed to measure the three related negative emotional states of depression, anxiety and tension/stress. The principal value of the DASS in a clinical setting is to clarify the locus of emotional disturbance, as part of the broader task of clinical assessment. The essential function of the DASS is to assess the severity of the core symptoms of depression, anxiety and stress. As the scales of the DASS have been shown to have high internal consistency and to yield meaningful discriminations in a variety of settings, the scales should meet the needs of both researchers and clinicians who wish to measure current state or change in state over time (e.g., in the course of treatment).

DEVELOPMENT OF BLUE PRINT

A blue print of the instruments was developed. The first part was the socio demographic questionnaire consisting of 10 items. The second part of the tool was a standardized questionnaire (DASS SCALE) to assess the psychological stress among patients who diagnosed with haematological malignancies.

VALIDITY

Validity is the degree to which inferences made in a study are accurate and well founded. Content validity refers to the degree to which an instrument measures what it is supposed to measure. Socio demographic questionnaire was submitted to experts to ensure content validity. The experts were selected based on their clinical/ teaching experience and interest in the problem studied.

The semi-structured socio demographic questionnaire was validated by the following experts:
(01) Brig Rajan Kapoor VSM, HoD, Medical & Clinical Hematology
(02) Col Rajeev Kumar, Senior Advisor, Medical & Clinical Hematology
(03) Maj Priyadarshika Pradhan, Onco Matron
As per their suggestions and guidance necessary changes were made and final tool was formed.

RELIABILITY

Reliability is the degree of consistency or dependability with which an instrument measures an attribute. The reliability of a measuring instrument is a major criterion for assessing its quality and adequacy. Dass scale standardized scale.

TRANSLATION OF TOOL

The socio demographic questionnaire was translated to Hindi versions.

DESCRIPTION OF INSTRUMENT

Data collection instruments refer to devices used to collect data such as standardized self-report questionnaire and semi-structured demographic questionnaire. The most important and crucial aspect of any investigation is the collection of appropriate information which would provide necessary data.

Questionnaire is the most efficient and objective method and it is a quick and generally inexpensive means of obtaining data from many respondents. A semi-structured questionnaire was constructed to assess the socio demographic data of the subjects. After obtaining permission from the author, investigator used DASS SCALE for assessing the stress in patients who are diagnosed with haematological malignancies. The tool was selected according to the objectives of the study.

TESTING OF THE TOOL

Testing of the structured tool was done to avoid ambiguity in the language and to establish appropriateness of the term used and to determine the clarity in direction.

Tool was found to be clear, understandable and unambiguous. The average time spent for each respondent was 20 minutes to answer the questions.

APPROVAL

The study proposal was scrutinized thoroughly by the subject experts to exclude violation of human rights and was agreed upon by the ethical committee board of the institution.

PERMISSION

The investigator had obtained formal permission to conduct the research study from the administrative authorities of the quaternary level hospital mentioned in the study.

CONSENT

The participants were given the full right of self-determination as to whether to participate in the study. Participant's right to privacy was maintained. Informed consent was taken from each

subject after explaining the purpose of the research. The principles were not violated, and emphasis was given to the sensitive aspects of human behaviour.

PRIVACY

No revelation of any information identifying the participant, or the study setting was mentioned in the tool. Their names were represented as codes in the compiled data sheet. Anonymity of all the participants and confidentiality of the information conveyed was ensured throughout the study.

PROTECTION

The respondents were not subjected to any kind of physical or psychological harm. No subjects were forced into the study. Lastly the information gathered was not misused in any form to exploit the participants.

DEBRIEFING

The purpose of the research was briefed to the participants

REWARDS/PROMISES

There were no rewards or promises offered to the participants. However, informational and technical assistance and support was extended to all the participants by the investigator during their period of association with hospital.

FINAL DATA COLLECTION

After obtaining the formal permission from the concerned hospital authorities the data collection commenced in the months of April, May and June.

The haematology department authorities were approached and explained the nature of help and cooperation required for conducting the research. Self-introduction was given and then rapport was established with the respondent. The following steps were followed:

- Informed written consent was obtained from willing and eligible participants.
- Separate code numbers were used for each respondent.
- The patient's data was collected through interviewing.
- Respondents were interviewed for collecting socio demographic data
- They were provided DASS scale for self-reporting.
- The socio demographic data and quality of life scores were entered to an Excel database and analysed.

DATA ANALYSIS PROCEDURE

After organizing data on the master sheet, tabulation and analysis was done using the following descriptive and inferential statistics:

The analysed data is presented in the form of tables, figures and graphs

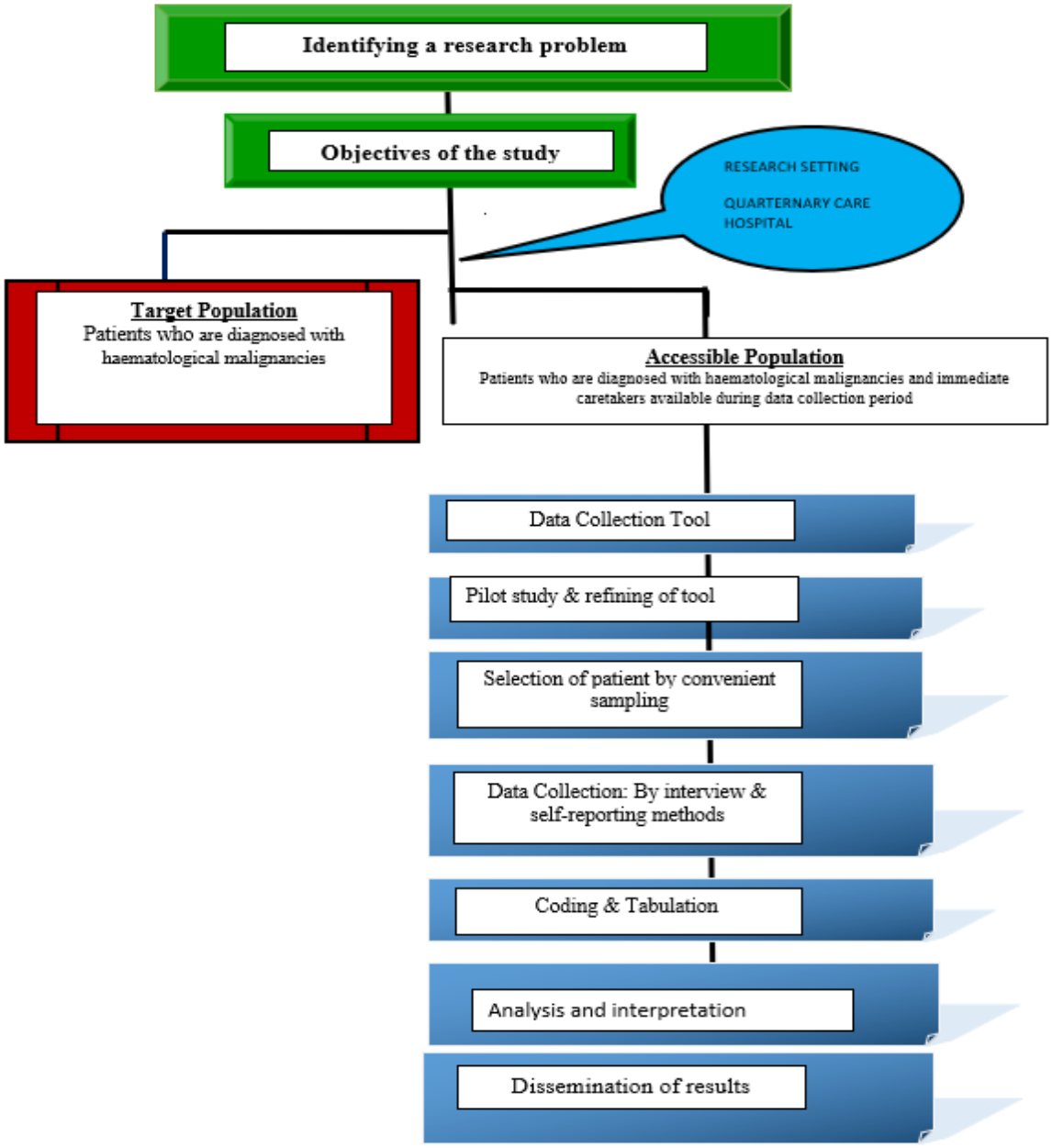


Fig1: Schematic Presentation of Research Methodology

SUMMARY

This chapter explicitly described the sequence in which the investigator had carried out the research. It described the research approach, research design, setting, sample, sampling method, research tool, validity and reliability of tool, pilot study and data collection procedure adopted for the study.

IV. DATA ANALYSIS AND INTERPRETATION

Analysis and interpretation of data is the most important phrase of research process which involves computation of certain measures along with searching of patterns of relationships that exist among data groups. Analysis is "categorizing, ordering, manipulating and summarizing the data to obtain the answer of the question."

Analysis is done to interpret and understand the data collected so that the researcher can reach the conclusion. It is performed based on objectives and hypothesis of the study. Through this the research problem can be studied and tested.
In this chapter the data collected from the samples are organized, coded, tabulated, analyzed, described and interpreted using descriptive statistics in the form of tables and graphs.
The data collected includes socio-demographic variables and structured questionnaire to assess the psychological stress among the patients diagnosed with hematological malignancies and quality of life among patients and immediate care takers with hematological malignancy patients admitted in a Quaternary care hospital, Delhi.

OBJECTIVE OF THE STUDY

i) To evaluate psychological distress of patients with hematological malignancies, as well as to identify the prognostic factors that aggravate their condition.
ii) To assess the psychological distress of their immediate care takers.
iii) To modify the treatment modality by including frequent counselling sessions for patients as well as their caretakers.

ORGANISATION OF STUDY FINDINGS

The data collected are organized, tabulated, analyzed and presented under the following headings-

- Section I: -Description of socio demographic variables. This section deals with the description of socio-demographic variables of the selected sample. The social demographic variables include
  - Gender
  - Age
  - Marital status
  - Number of children
  - Education
  - Employment
  - Residence
  - Living arrangement
  - Disease
  - Duration of disease

- Section II - Assessment of the psychological stress level by DASS scale among hematological malignancy patients and their care takers admitted in quatenary Care Hospital, Delhi. The data has been analyzed using descriptive statistics and distribution of sample in relation to the demographic variables has been explained. They have been represented with the help of tables and graphs.

Table -1: Distribution of gender in frequency and percentage:

n = 50

GENDER:

Gender	No	%
Male	17	34
Female	33	66

Table 1: depicts, males are 17 (34%) among the sample and females are 33 (66%) among the samples.

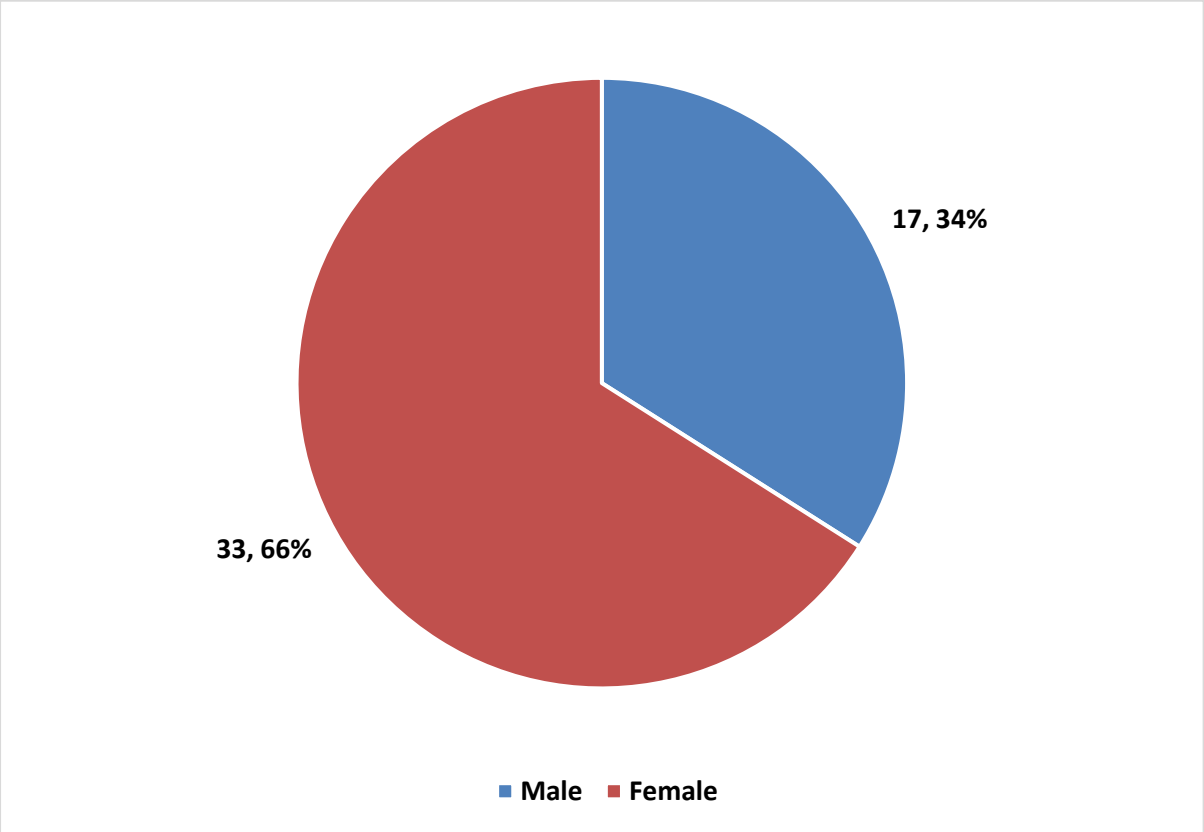


Figure 1: Simple pie graph representing distribution of gender with respect to haematological malignancy patients.

Table -2: Distribution of age in frequency and percentage

n = 50

AGE:

Age	No	%
20-34	16	32
35-49	20	40
50-64	11	22
65-80	3	6

Table 2 depicts, 16 were in the age group of 20-34(32%); 20 in the age group of 35-49 (40%); 11 in age group 50-64 (22%); 3 in age group 65-80yrs (6%).

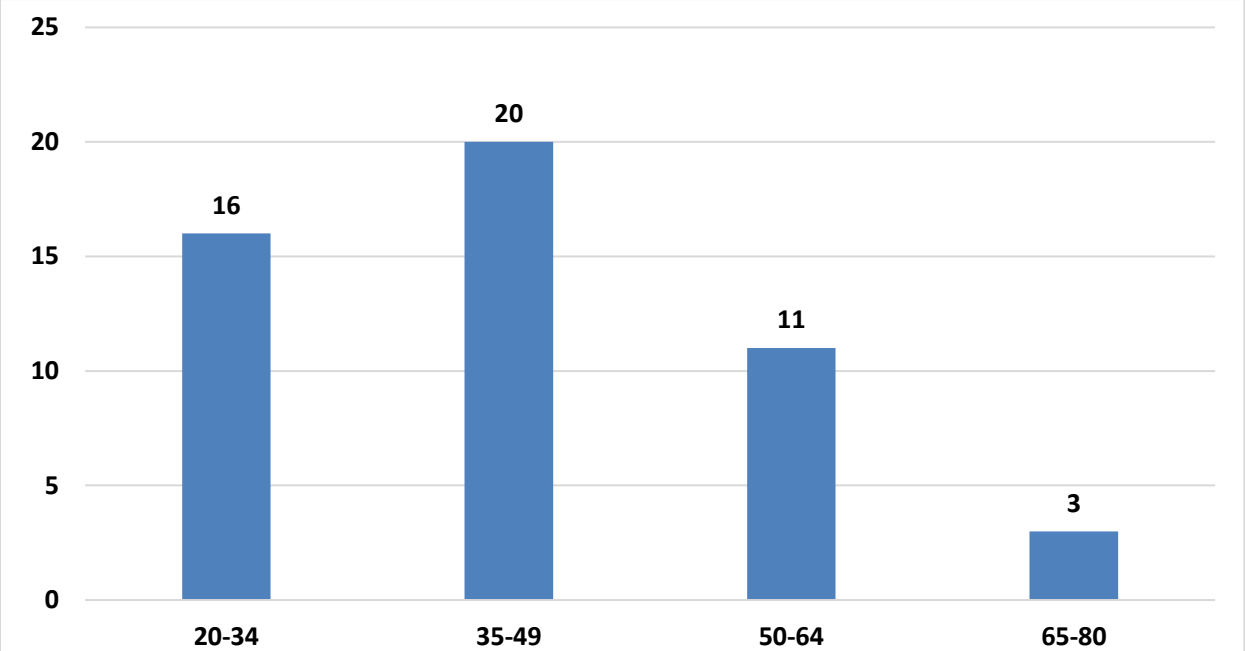


Figure 2: Simple bar diagram representing age wise distribution of samples

Table -3 : Distribution of marital status in frequency and percentage:

n = 50

MARITAL STATUS:

Marital status	No	%
Married	46	92
Unmarried	4	8

Table 3 depicts, 46 were married (92%) and 4 were unmarried (8%)

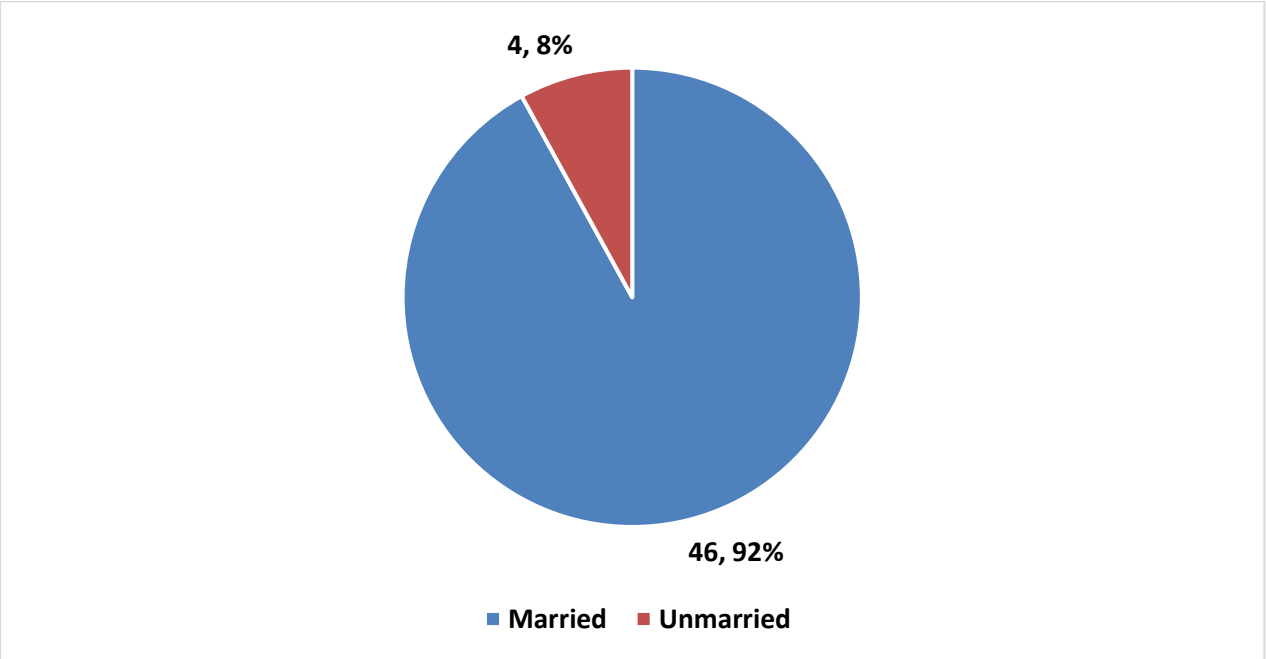


Figure 3: Simple pie graph representing distribution of samples with respect to their marital status

Table -4: Distribution of no of children in frequency and percentage

n = 50

NO. OF CHILDREN:

No. of children	No	%
0	8	16
1 to 2	39	78
>2	3	6

Table 4 depicts, 8 were not having children (16%); 39 were having 1-2 children (78%); 3 were having more than 2 children (6%).

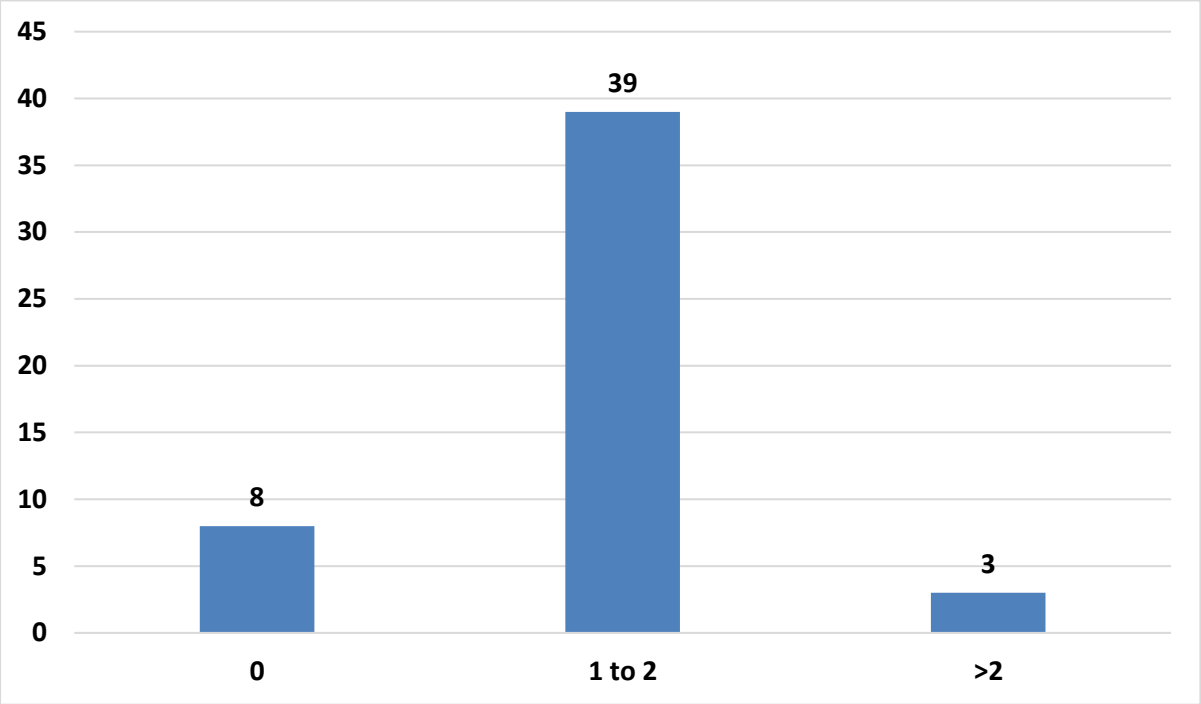


Figure 4: Simple bar diagram representing children wise distribution of samples

Table -5 : Distribution of educational qualification in frequency and percentage

n = 50

EDUCATION:

Education	No	%
Illiterate	7	14
Read & write	26	52
Diploma	8	16
Bachelor	9	18

Table 5 depicts, 7 were illiterate (14%); 26 were able to read and write (52%); 8 were completed diploma (16%);9 were bachelor (18%).

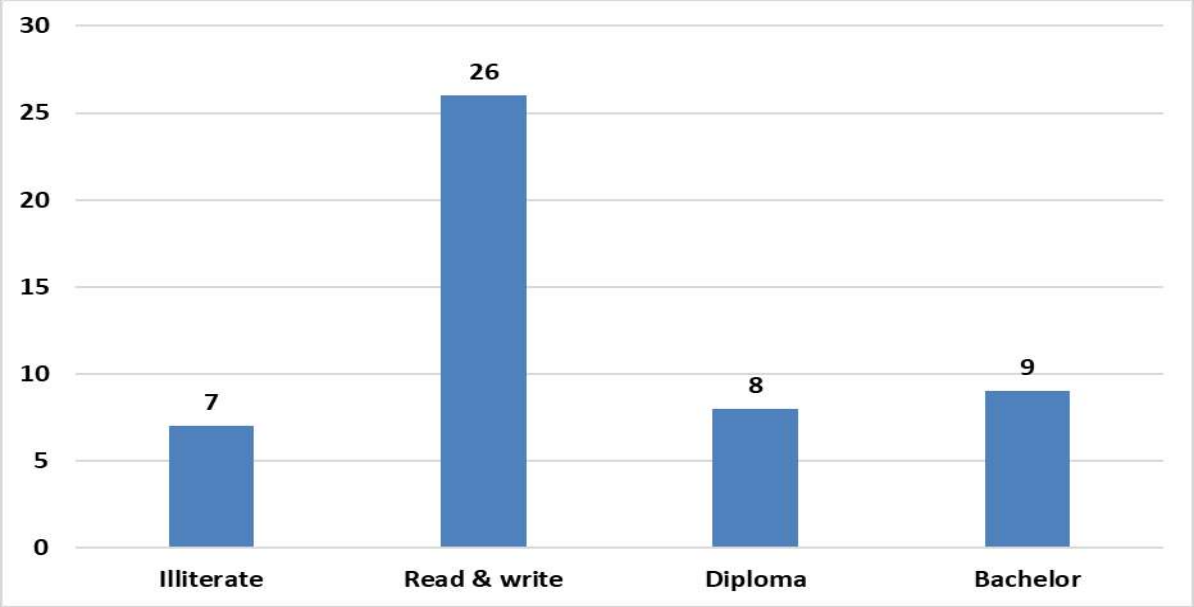


Figure 5: Simple bar diagram representing educational qualification of samples

Table -6 : Distribution of employment status in frequency and percentage

n = 50

EMPLOYMENT STATUS:

Employment	No	%
Clerical	6	12
Technical	16	32
House wife	14	28
Retired	3	6
Not working	11	22

Table 6 depicts, 6 were doing clerical job (12%); 16 were doing technical job (32%); 14 were housewife (28%); 3 were retired; 11 were not working (22%).

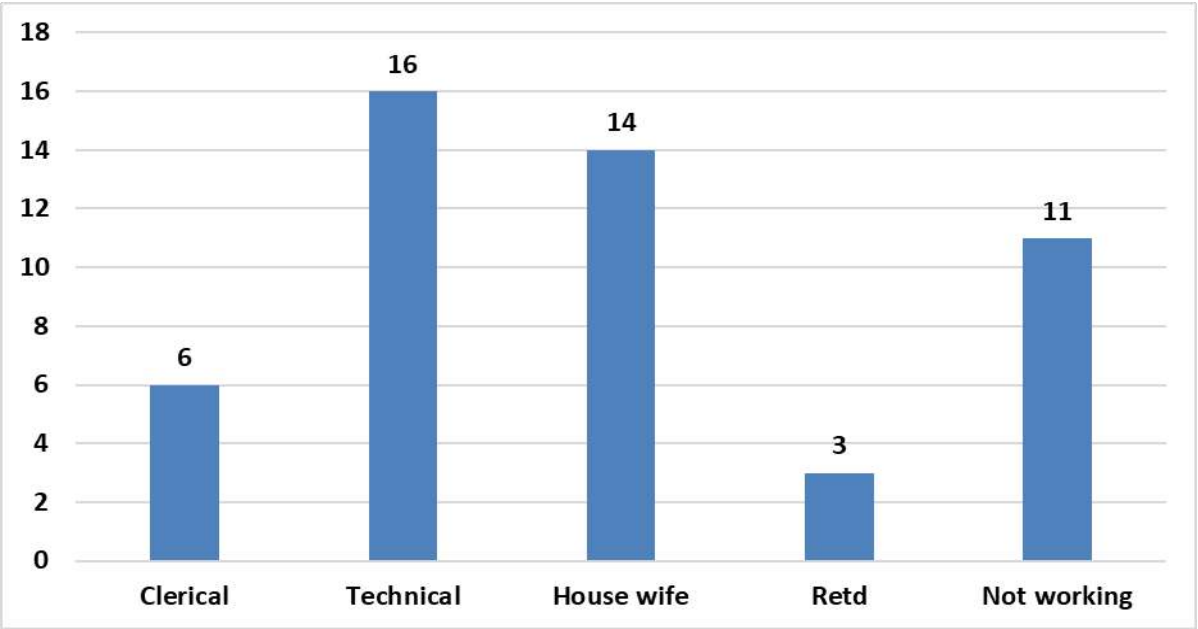


Figure 6: Simple bar diagram representing educational status of samples

Table -7 : Distribution of residential area in frequency and percentage

n = 50

RESIDENCE:

Residence	No	%
Urban	10	20
Semi urban	21	42
Rural	19	38

Table 7 depicts, 10 were from urban area (20%); 21 were from semi urban area (42%); 19 were from rural area (38%).

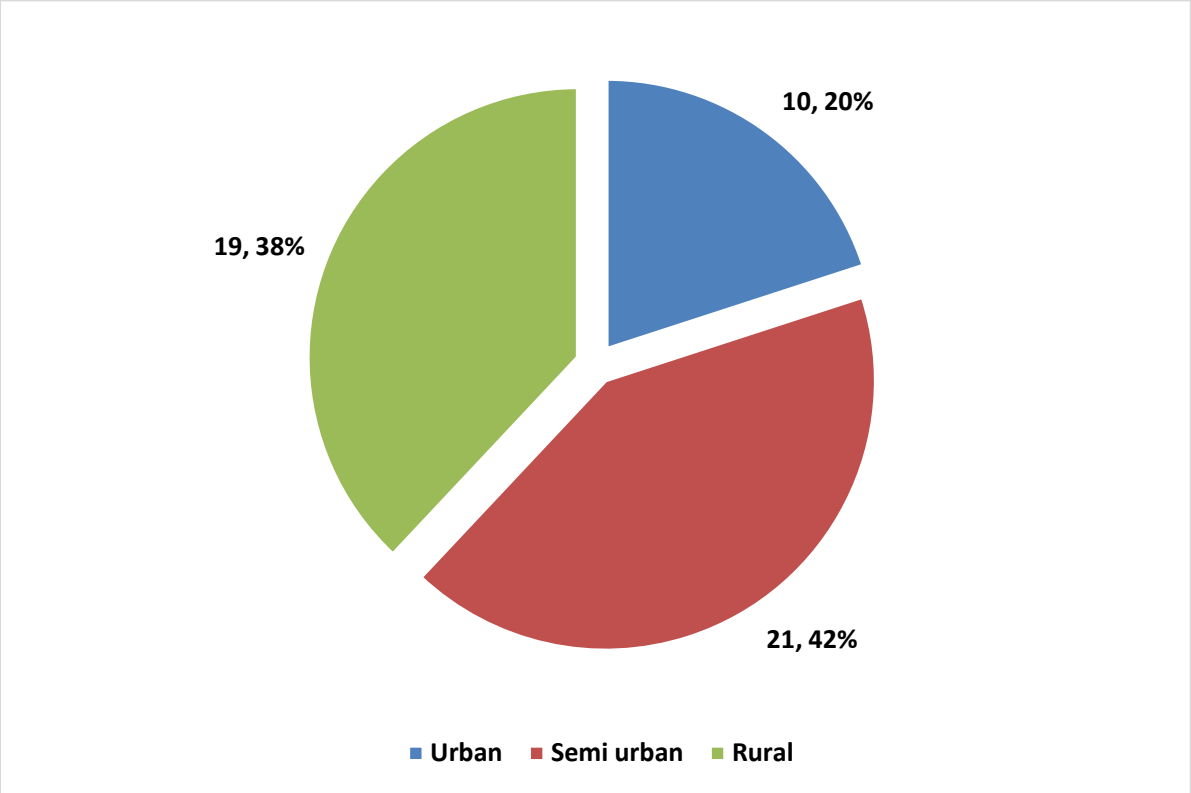


Figure 7: Simple pie graph representing distribution of samples with respect to the residential area

Table -8: Distribution of living arrangement in frequency and percentage

n = 50

LIVING ARRANGEMENT:

Living arrangement	No	%
Alone	4	8
With family	46	92

Table 8 depicts, 4 were living alone (8%); 46 were living with family (92%).

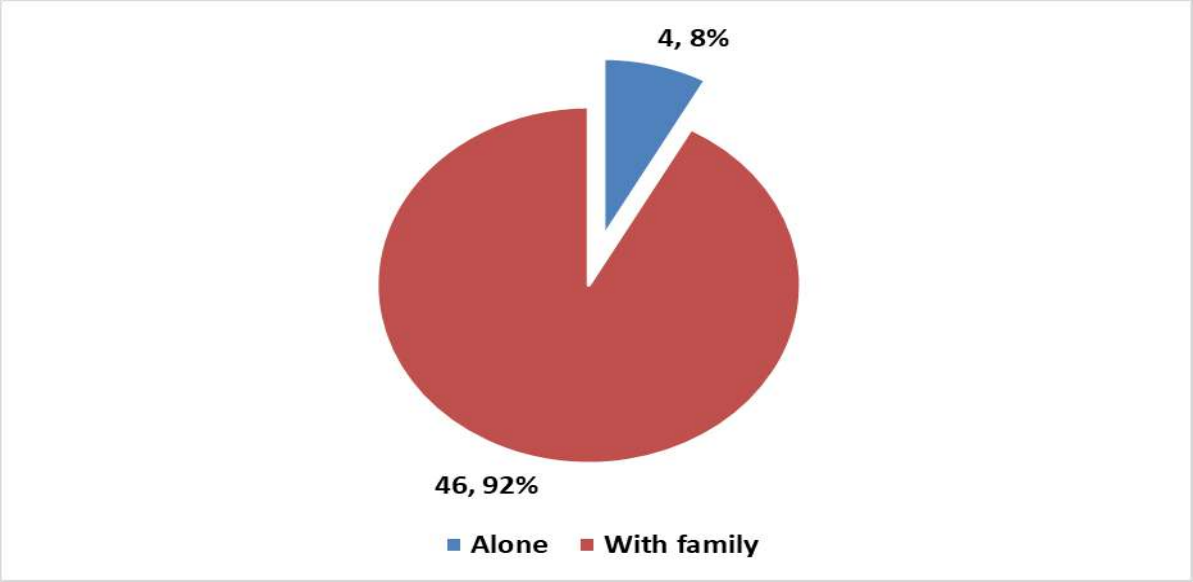


Figure 8: Simple pie graph representing distribution of samples with respect to their living status

Table -9 : Distribution of sample disease in frequency and percentage

n = 50

DISEASE:

Disease	No	%
Leukemia	25	50
Lymphoma	6	12
MM	9	18
MDS	3	6
Other	7	14

Table 9 depicts, 25 were leukemia patients (50%); 6 were lymphoma patients (12%); 9 were myeloma patients (18%);3 was MDS patients (6%); 7 were having other haematological malignancies (14%)

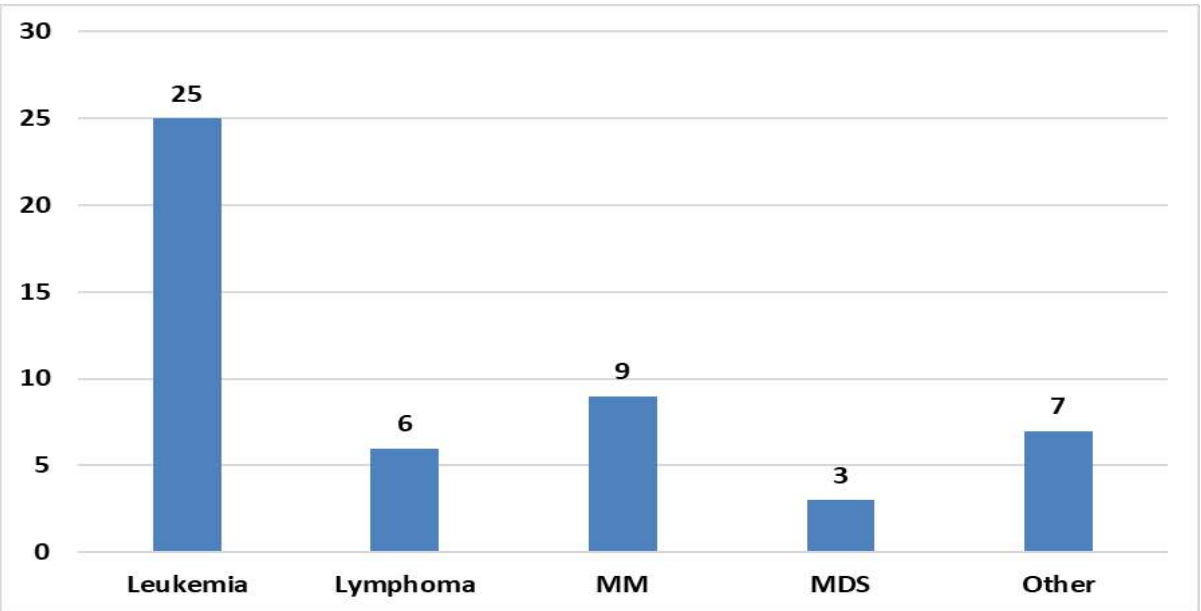


Figure 9: Simple bar diagram representing the disease of samples.

Table -10: Distribution of disease duration in frequency and percentage

n = 50

DURATION OF DISEASE:

Duration of disease	No	%
<5 yrs	34	68
>5 yrs	16	32

Table 11 depicts, 34 were having more than 5 yrs of disease (68%); 16 were having less than 5 yrs of disease (32%).

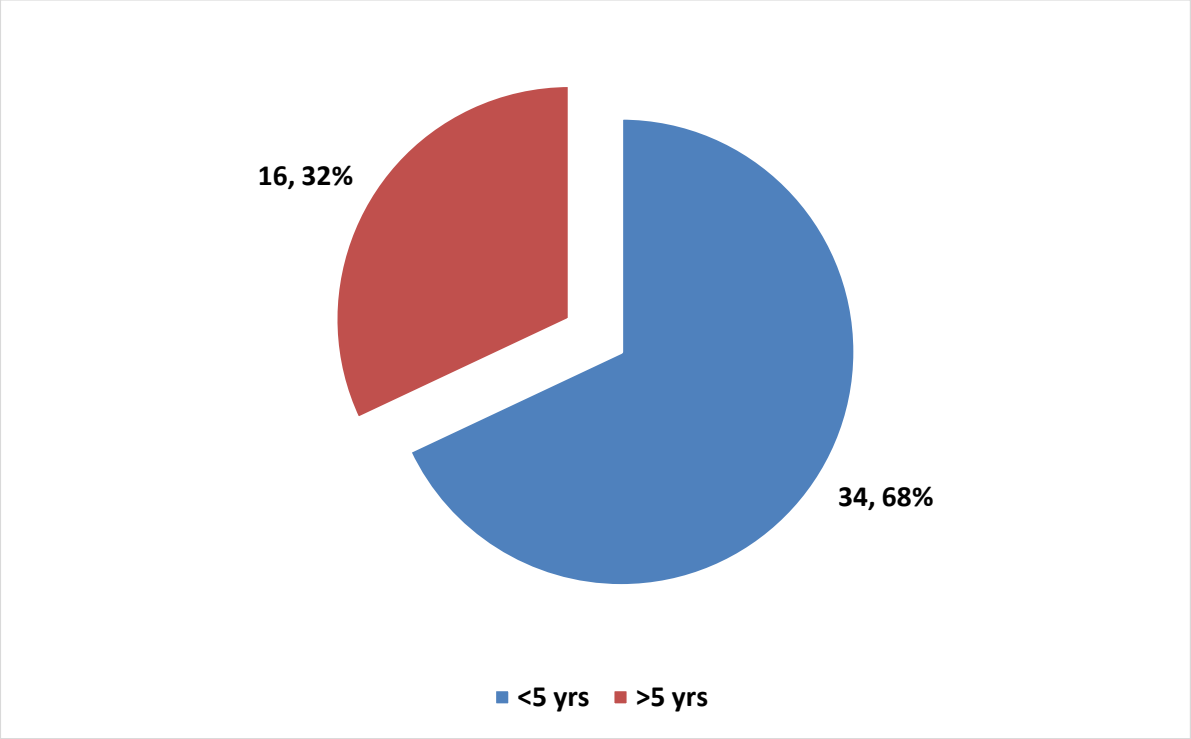


Figure 11: Simple bar diagram representing the disease duration of samples

Table -12 : Distribution of stress among samples in frequency and percentage

n = 50

STRESS

Stress	No	%
Extremely severe	23	46
Mild	3	6
Moderate	12	24
Normal	6	12
Severe	6	12

Table 14 depicts, 23 were extremely stressed (46%); 3 were mildly stressed (6%); 12 were moderately stressed (24%); 6 were normal (12%); 6 were severely stressed (12%).

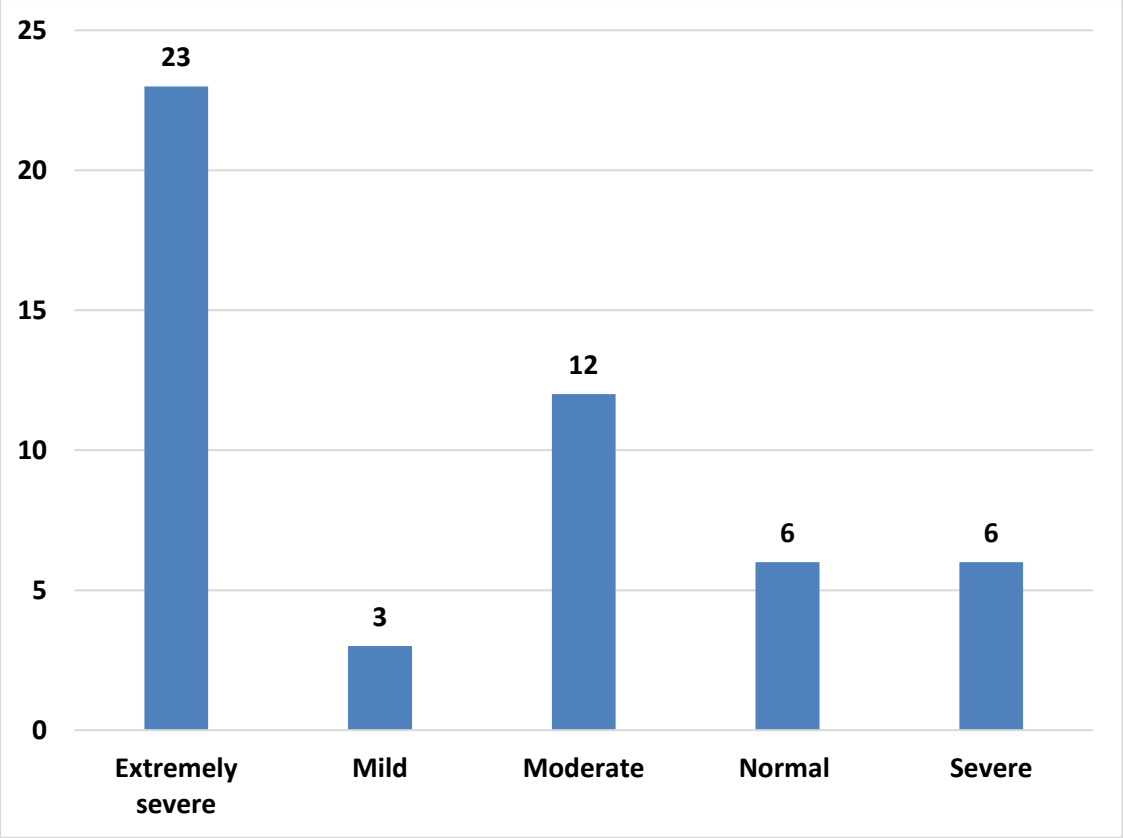


Figure 12: Simple bar diagram representing stress among distribution of samples.

Table -13 : Distribution of stress vs disease in frequency and percentage

n = 50

STRESS VS DISEASE:

Stress/Disease	Leukemia	Lymphoma	MDS	MM	OTHERS	Total
Extremely severe	10	6	2	4	1	23
Mild	2	0	0	0	1	3
Moderate	8	0	1	1	2	12
Normal	3	0	0	1	2	6
Severe	2	0	0	3	1	6
Total	25	6	3	9	7	50

Table 13 depicts, 23 were extremely stressed (66%); 3 were mildly stressed (6%); 6 were normal (12%) ; 6 were severely anxious (12%).

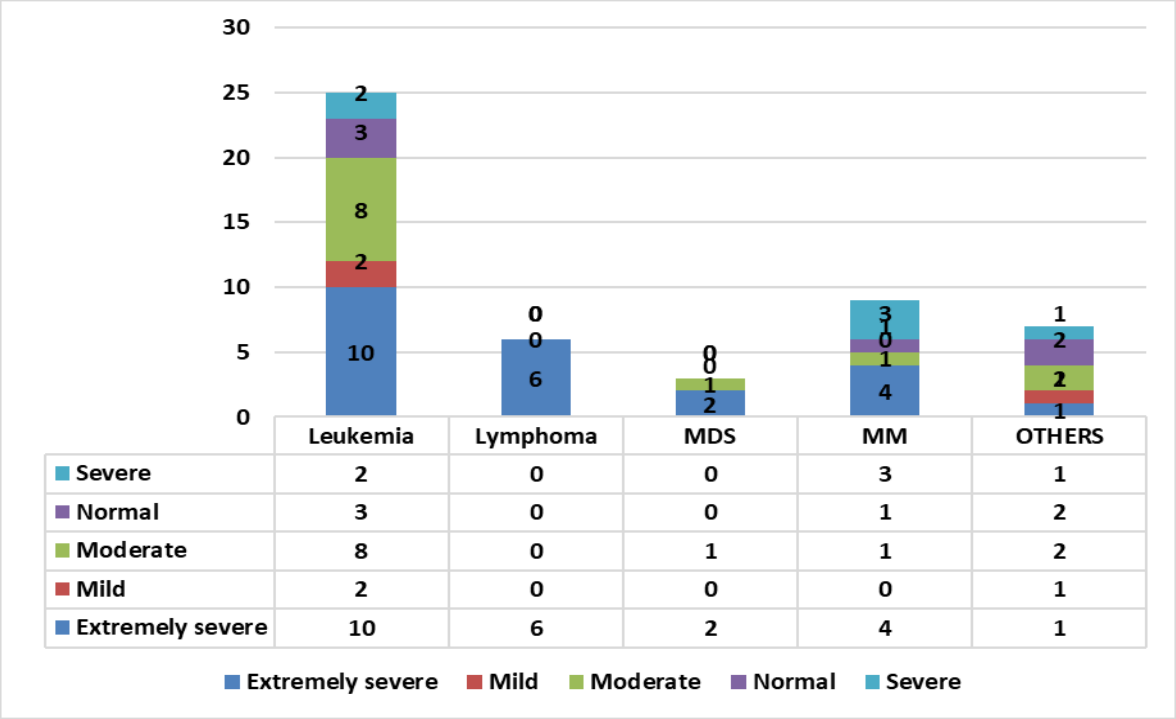


Figure 13: Simple bar diagram representing stress vs disease wise distribution of samples.

Table -14 : Distribution of gender vs disease in frequency and percentage

n = 50

GENDER VS DISEASE:

Gender/Disease	Leukemia	Lymphoma	MDS	MM	OTHERS	Total
Female	17	5	3	5	3	33
Male	8	1	0	4	4	17
Total	25	6	3	9	7	50

Table 18 depicts, 33 were female among the sample vs disease (66%): 17 were male among the sample vs disease (34%).

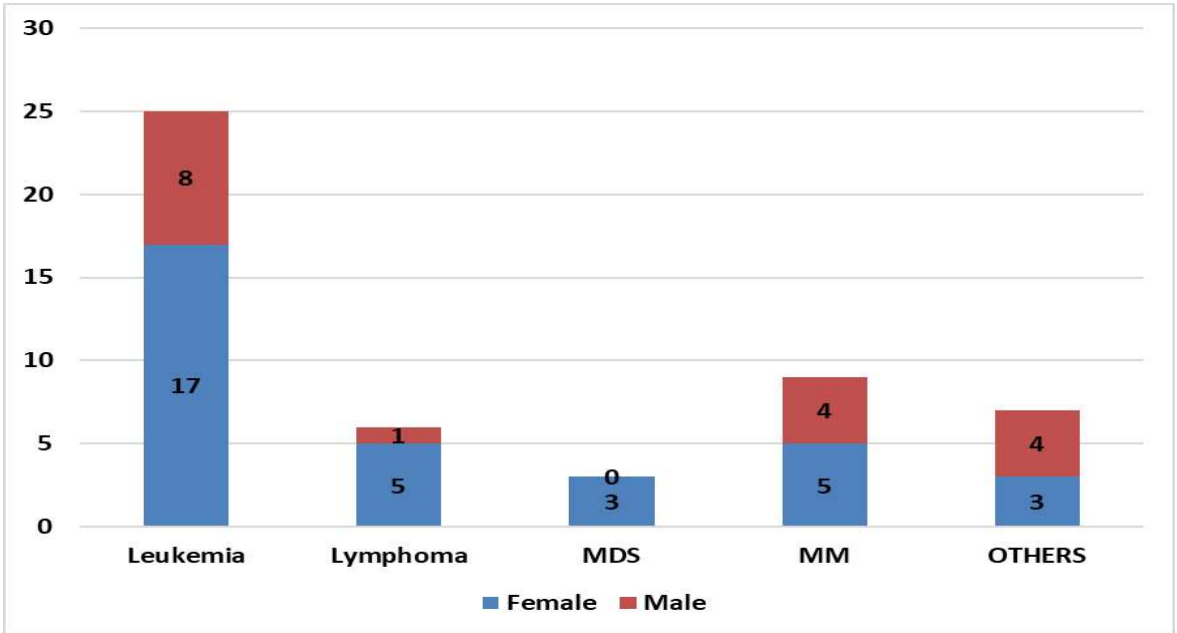


Figure 14: Simple bar diagram representing gender vs disease wise distribution of samples

Table -15 : Distribution of age vs disease in frequency and percentage

n = 50

Age/disease	Leukemia	Lymphoma	MDS	MM	Others	Total
20 - 34	12	0	2	0	2	16
35 - 49	7	3	1	4	5	20
50 - 64	4	3	0	4	0	11
65 - 80	2	0	0	1	0	3
Total	25	6	3	9	7	50

AGE VS DISEASE:

Table 15 depicts, 16 (32%) were in the age group of 20-34yrs among the disease; 20 (40%) were in the age group of 35-49yrs among the disease; 11(22%) were in the age group of 50-64yrs among the disease ;2 (4%) was in the age group 65 -80yrs among the disease

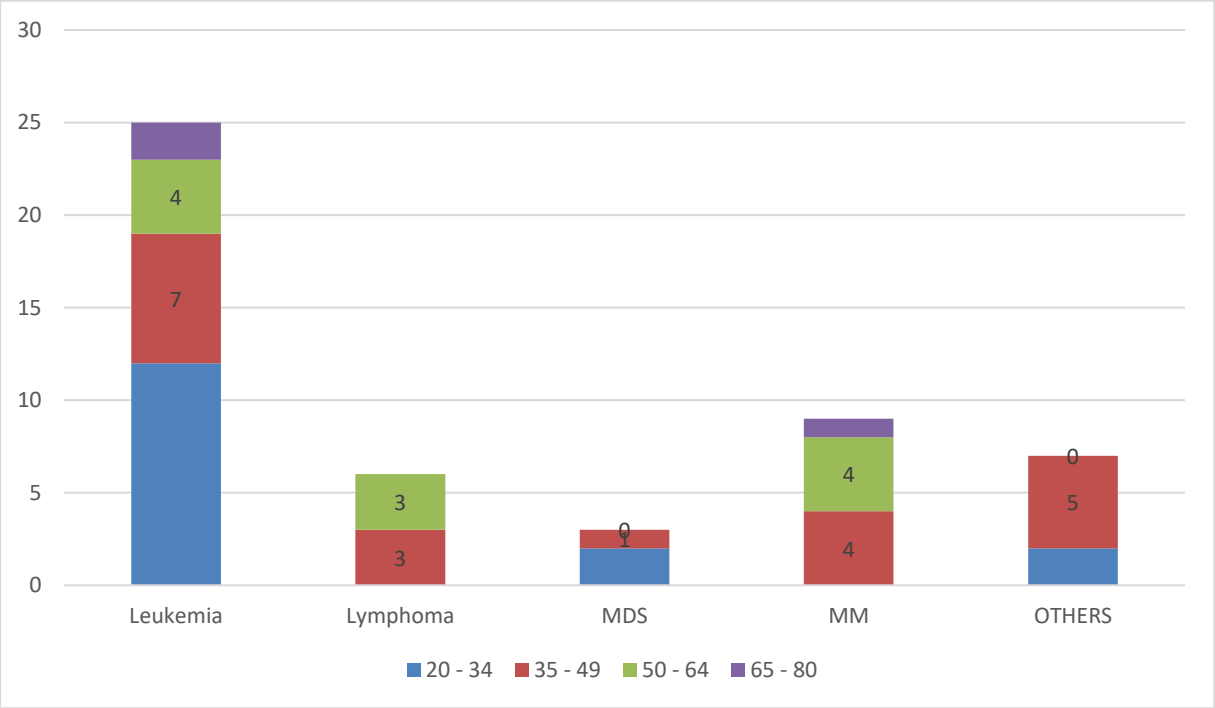


Figure 15: Simple bar diagram representing age wise distribution of samples

Table -16: Distribution of age vs stress in frequency and percentage: n = 50

AGE Vs STRESS:

Age	Stress									
	Extremely severe		Mild		Moderate		Normal		Severe	
	no	%	no	%	no	%	no	%	no	%
20 - 34	7	44	1	6	6	38	1	6	1	6
35 - 49	8	40	1	5	3	15	5	25	3	15
50 - 64	6	55	1	9	2	18	0	0	2	18
65 - 80	2	67	0	0	1	33	0	0	0	0

Table 16 depicts the severity of stess level according to the age level among the samples .

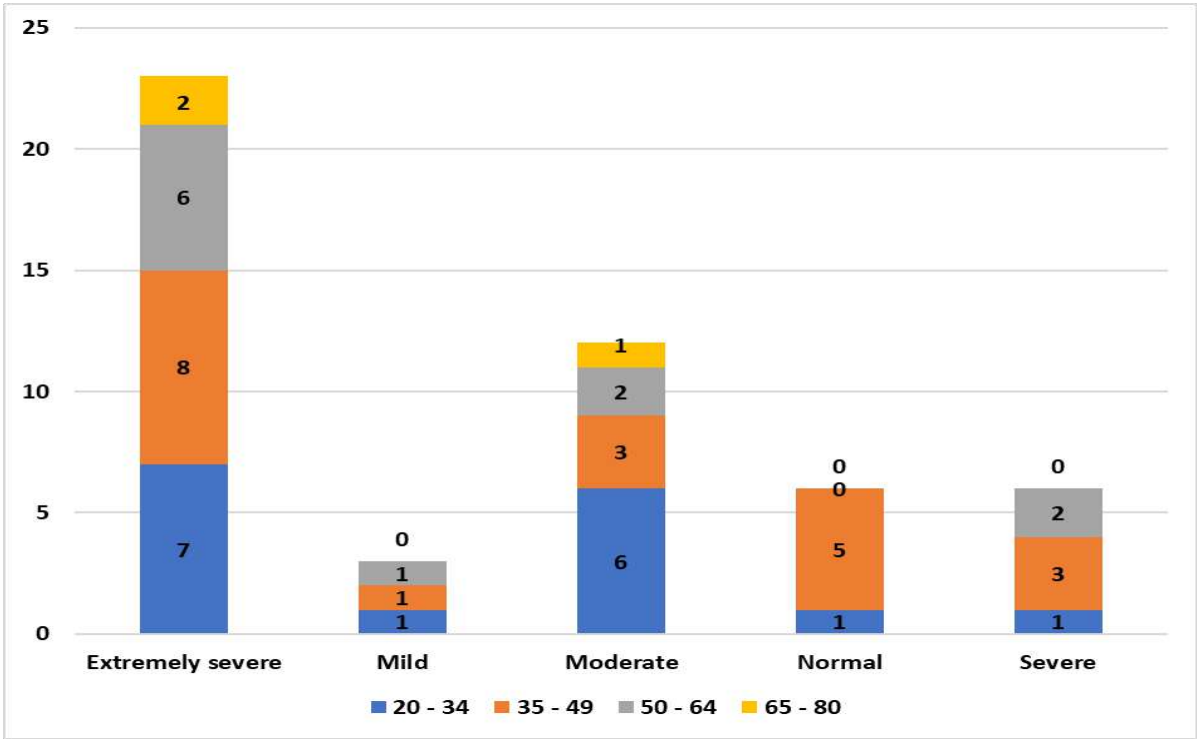


Figure 16: Simple bar diagram representing age vs stress wise distribution of samples.

Table -17 : Distribution of age vs stress in frequency and percentage

n=50

Gender	Stress									
	Extremely severe		Mild		Moderate		Normal		Severe	
	No	%	no	%	no	%	no	%	no	%
Female	15	46	2	6	5	15	6	18	5	15
Male	8	47	1	6	7	41	0	0	1	6

Gender vs stress:

Table 17 depicts severity of stress level among the gender of the samples

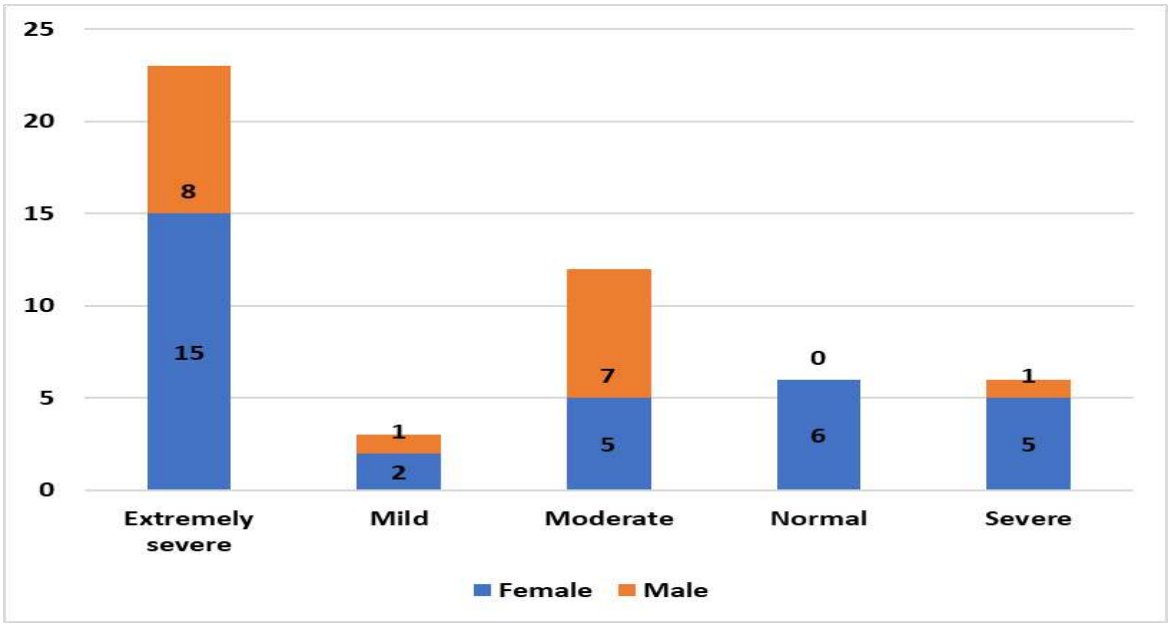


Figure 17: Simple bar diagram representing gender vs stress wise distribution of samples.

Table -18 : Distribution of education vs stress in frequency and percentage

n=50

Education	Stress									
	Extremely severe		Mild		Moderate		Normal		Severe	
	no	%	no	%	no	%	no	%	no	%
Bachelor	2	22	1	11	2	22	3	33	1	11
Diploma	5	63	0	0	2	25	0	0	1	13
Literate	3	43	0	0	1	14	1	14	2	29
Read & write	13	50	2	8	7	27	2	8	2	8

Education vs stress:

Table 18 depicts severity of stress level among the educational status of the samples

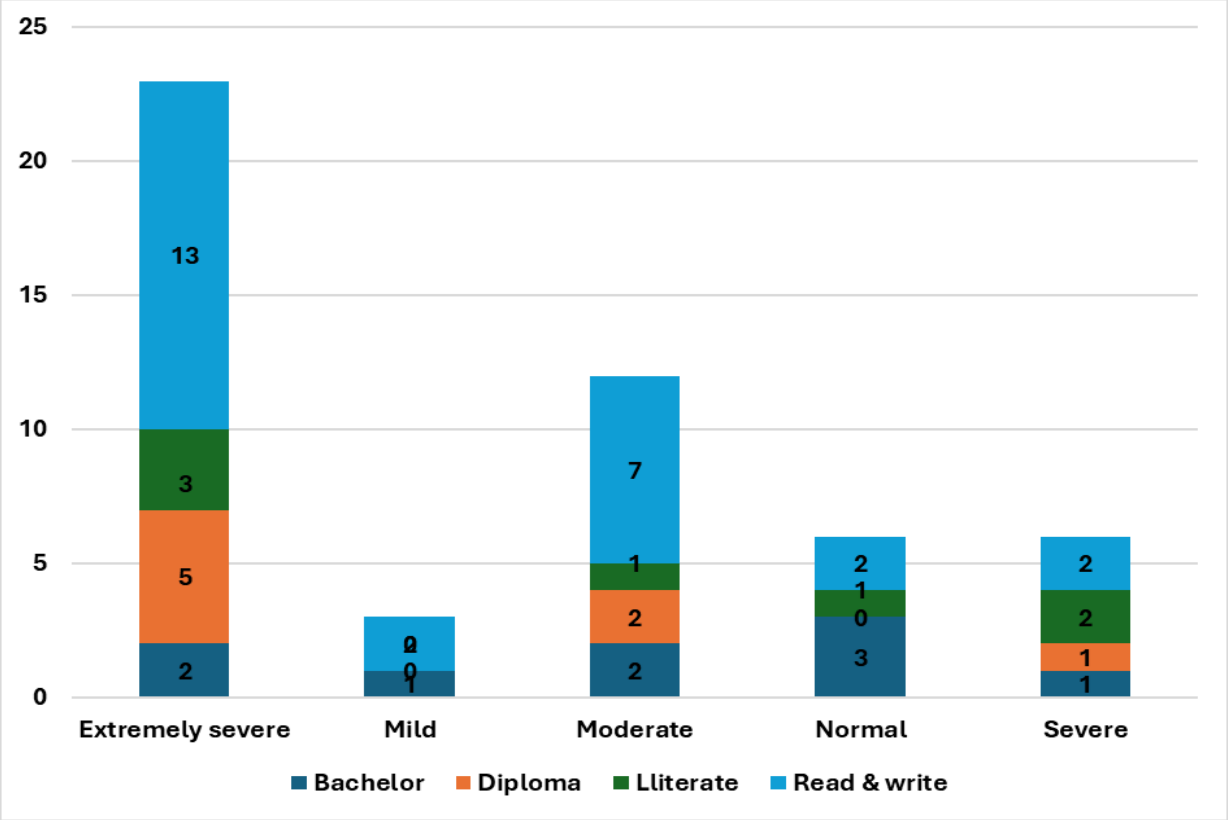


Figure 18 Simple bar diagram representing education vs stress wise distribution of samples

Table -19 : Distribution of marital status vs stress in frequency and percentage

n=50

Marital_status	Stress									
	Extremely severe		Mild		Moderate		Normal		Severe	
	no	%	no	%	no	%	no	%	no	%
Married	20	44	2	4	12	26	6	13	6	13
Unmarried	3	75	1	25	0	0	0	0	0	0

MARITAL STATUS VS STRESS

Table 19 depicts severity of stress level among marital status of the samples

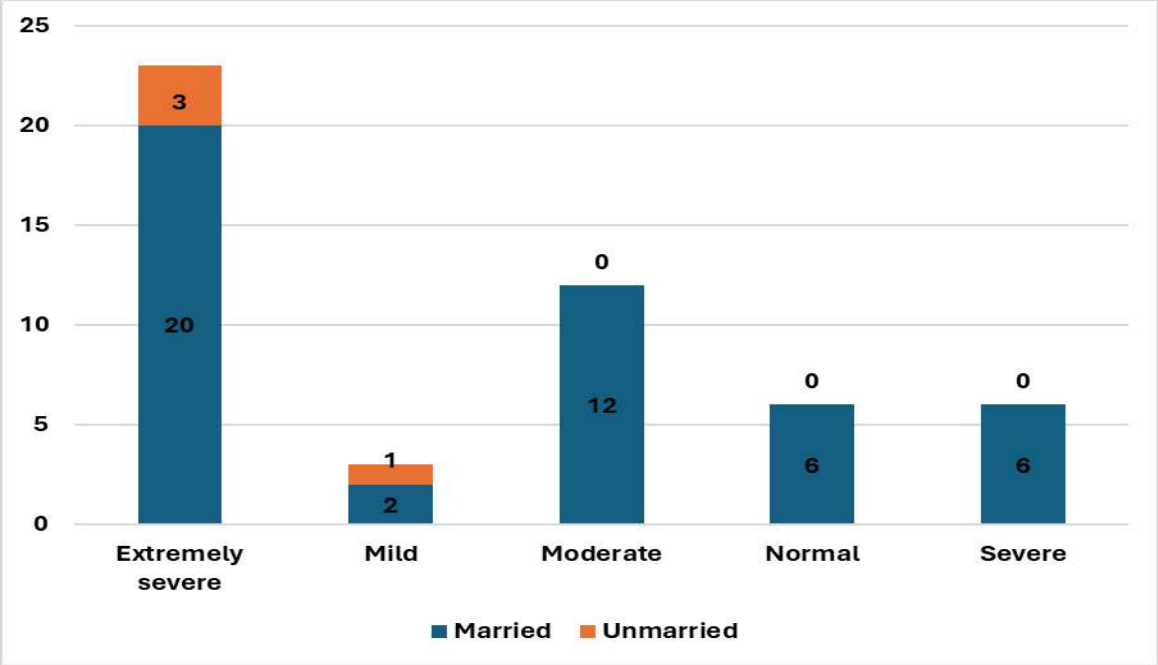


Figure 19 Simple bar diagram representing marital status vs stress wise distribution of samples

Table -20 : Distribution of residence vs stress in frequency and percentage

n=50

Residence	Stress									
	Extremely severe		Mild		Moderate		Normal		Severe	
	no	%	no	%	no	%	no	%	no	%
Rural	8	42	2	11	2	11	4	21	3	16
Semi urban	10	48	1	5	9	43	0	0	1	5
Urban	5	50	0	0	1	10	2	20	2	20

RESIDENCE VS STRESS

Table 20 depicts severity of stress level among the residential area of the samples

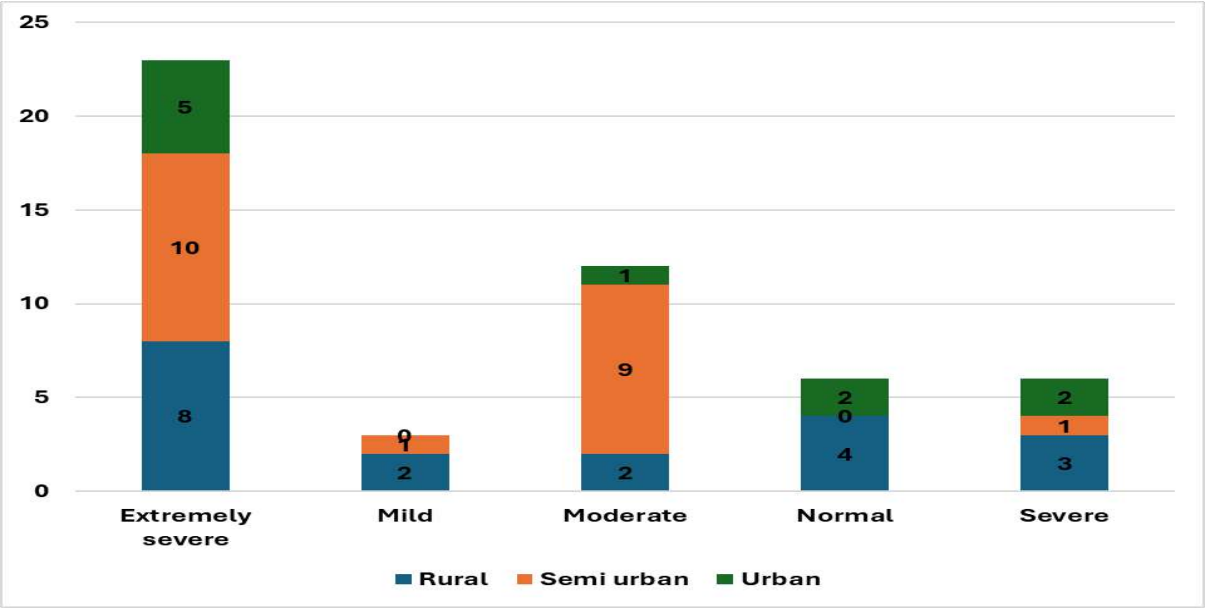


Figure 20 Simple bar diagram representing residence vs stress wise distribution of samples

Table -21 : Distribution of living condition vs stress in frequency and percentage

n=50

Living Condition	Stress									
	Extremely severe		Mild		Moderate		Normal		Severe	
	no	%	no	%	no	%	no	%	no	%
Alone	1	25	1	25	1	25	0	0	1	25
With Family	22	48	2	4	11	24	6	13	5	11

LIVING CONDITION VS STRESS:

Table 21 depicts severity of stress lvel among the living condition of the samples

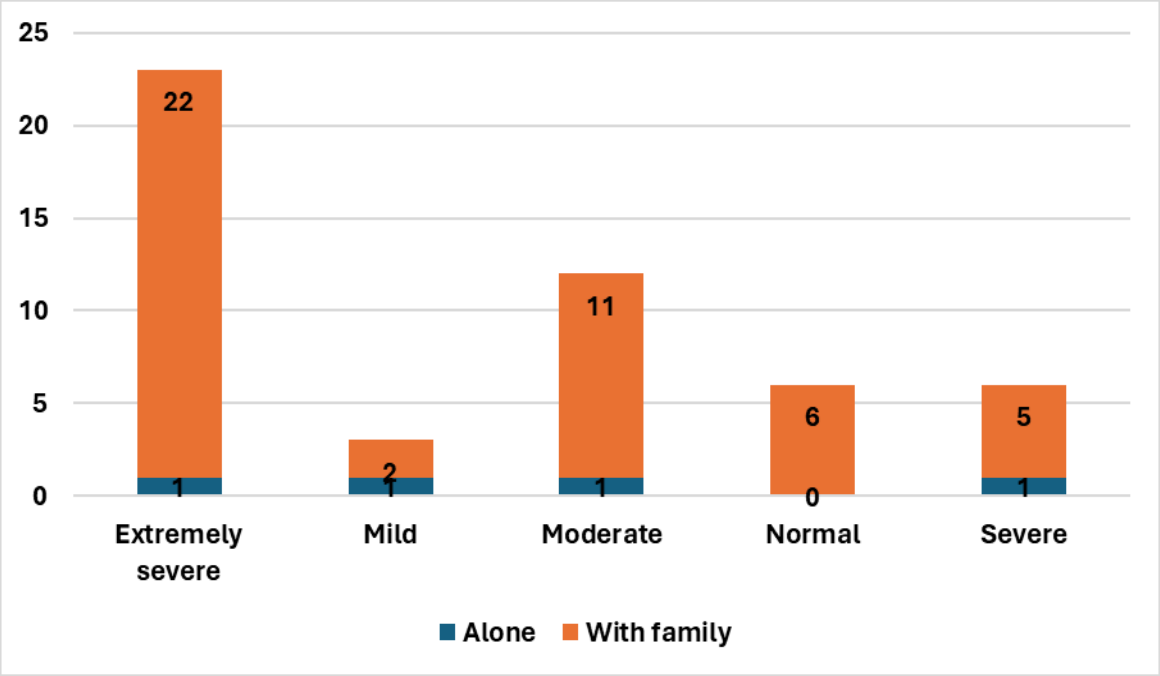


Figure 20 Simple bar diagram representing living condition vs stress wise distribution of samples

Hypothesis testing:

H1: There is a correlation between psychological stress and diagnosis of hematological malignancies.

Discussion: Out of 50 patients, 46% had extremely severe stress, 12% had severe stress, 24% had moderate level of stress, 6% had mild stress, Only 12% had no stress. These findings are consistent with the reviews of literature

CHAPTER V

The chapter presents the major findings of the study, after analyzing the data using descriptive statistics. It also presents a summary of the study and the various recommendations made by researcher based on the findings of the study.

SUMMARY

Problem statement of the study was a descriptive study to assess the level of psychological stress among the patients diagnosed with haematologic malignancies & their immediate caretakers in a selected Quaternary Care Centre in Delhi. The study was conducted in a selected institution after obtaining permission from the head of the selected institution. The validation of tool was done by experts from the field of psychiatry. Sample was chosen as per the inclusion and exclusion criteria.

The sample size was 50 and simple random sampling was done. Informed consent was taken from the sample. Data was collected from the samples using self-administered questionnaires consisting of two sections- socio demographic variables and DASS Scale under researcher's supervision. The data collected was organized, tabulated, analysed and inferences were drawn. The objectives of the study were achieved. Review of literature helped to gain a better understanding of the topic and in formulating appropriate methodology for the study.

The socio- demographic variables were selected. The psychological stress using DASS Scale was assessed under all four domains. Both were then correlated and the associations between them were found out.

SIGNIFICANT FINDING

Section I

1. The maximum samples are female which was 33 (66%) and male which was 17 (34%)
2. The maximum sample were in the age group of 35 to 39 years which was20 (40%) in the age wise distribution of samples.
3. The maximum samples 46 were married (92%) and 4 were unmarried (8%)
4. The maximum samples having 1-2 children were 39 (78%);
5. 26 (52%) of the samples were able to read and write.
6. 16 (32%) of the samples were doing technical job.
7. 21(42%) of the total samples were from semi urban area.
8. 46(92%) samples out of 50 were living along with families.
9. Maximum samples 25(50%) were diagnosed as leukemia.
10. The maximum samples 34(68%) were having the duration disease more than five years.

Section II

1. Most patients 46% found to have extremely severe stress, 12% had severe stress, 24%had moderate stress and 12% had no stress
2. In the age group 65 to >80 years, samples had extremely severe stress whereas age group most patients in age group 35 to 49 yrs had least stress.
3. Most patients who has extremely severe stress are diploma holders and those who have severe stress are illiterate and those who do not have stress are those who are bachelor degree holders.

4. Most patient who developed extremely severe stress had the diagnosis of leukemia and the pattients who had lymphoma presented with least stress.
5. Most patients who are married had extremely severe and severe stress whereas unmarried had least stress
6. The samples who are living alone had extremely severe stress than those who were living with family
7. The samples place of residence, whether urban, rural and semi urban did not contributed anything in the level of stress they experienced
8. The samples duration of disease more than five years of disease have extremely stressed.

IMPLICATION

This study has implications in all the fields of nursing as it covers the subjects with diagnosis of haematological malignancies and includes those admitted or attending OPD in haematology ward of a tertiary care hospital and is helpful for those working in the specialized field of psychiatry, general, education as well as administrative branches of nursing.

1. NURSING SERVICE

Nursing is considered as one of the most challenging profession where the nurses must deal with patients with different disease conditions. This study will help the nurse in assessment and management of patients with haematological malignancy disorder. The study will also help nurses to identify the adverse effect of disease on various domains and thus helps to provide effective care.

2. NURSING EDUCATION

Nursing education is another important area of nursing research where the nursing researcher tries to find out the knowledge regarding haematological malignancy disorder, effect of disease on patients including the physical, psychological, social and environmental domain. The nurse educator can utilize the findings of the study and proactively identify and avoid the psychological stress of haematological malignancy patients and can sensitize the students about the disease condition and its management so that they can provide effective care in their field of work.

3. NURSING ADMINISTRATION

The nurse administrator oversees the overall wellbeing and performance of the staff working under her. Our study on assessment of psychological stress level of hematolgicalpatients help the nurse administrator to identify the level of knowledge of the staff and also help them to plan and formulate appropriate teaching programs. The nurse administrator utilizes the findings of this study making policy for care of patient with haematological malignancy. Nurse administrator also encourages the staff to assess the condition of ADS patient and provide the effective care. The study will help the nurse administrator to assess the requirement of specialized staff in special units and post the staff according to the requirements, to provide quality care to the patient and thus help in smooth functioning of the organization.

4. NURSING RESEARCH

Research is an important part of any profession, which helps it to develop forward. It uplifts the profession and provides for new knowledge and research facts. This study also contributes to the field of nursing and objectively highlights the knowledge regarding effects of stress on patients who are diagnosed with hematological malignancies. The study can be a basis and encouragement of further research and studies in similar areas. It adds to the nursing literature which can be used in future by other nurses and students for reference, quoting more advance researches and bring about evidence-based practice in nursing profession.

RECOMMENDATION

Keeping in view the findings of the study the following recommendations are made:

- ❖ The study can be conducted on the large scale to generalize the findings of the study.
- ❖ Study can be conducted in Indian Army personnel who are diagnosed with haematological malignancies as the stress will adversely affect their job profile.
- ❖ The study can be used to about restructuring and amendment in the policies related to military set up.
- ❖ Therapeutic modalities can be planned and provided according to the domains most effected.
- ❖ The patients who are diagnosed with haematological malignancies get awareness about the different domains of stress which will adversely affect their wellbeing
- ❖ Interventional study can be conducted to assess the effect of intervention in different domains

LIMITATION

The limitations faced by the researcher in the present study were:

- Accuracy of participants self-report
- Unavailability of adequate number of samples.
- Inexperience of the researcher
- Slow turnover of the patient
- Reluctance of the samples to participate

ACKNOWLEDGEMENT

We would like to express our sincere gratitude to the government of India and College of Nursing, Army Hospital (R&R), for allowing us to pursue our Post Basic Diploma in Haematology Nursing (including Stem Cell Transplant) – Residency program. At the outset, we are profoundly grateful to Maj Gen Amita Rani, ADGMNS for all her support and encouragement to conduct the study. She had a pivotal role in moulding and shaping our attitude by her intelligent, firm and pleasant demeanor. We are influenced and inspired by her. Our sincere thanks and gratitude to Maj Gen I Delos Flora, Principal Matron Army Hospital (R&R) for facilitating the study. We would also like to extend our heartfelt thanks to Lt Gen Ashok Kumar Jindal, AVSM, YSM, Commandant Army Hospital (R&R) for giving us permission to conduct the study.

In the course of conducting this study, we are sincerely thankful to Brig Rajan Kapoor, VSM, Consultant & Head of Department, Medical & Clinical Haematologist, Army Hospital AH(R&R), for his technical inputs and design for conducting the study and Col Rajeev Kumar, Sr Adv, Medical & Clinical Haematologist, Army Hospital (R&R) for his support during the course and facilitating the study. We are obliged to Col Dechen Choedon, Professor and Principal, College of Nursing, Army Hospital (R&R), foe extending administrative and academic support to carry out this study. Our sincere thanks to Lt Col Bindu Sara Mathew, Vice Principal OIC Academics, for her expert lectures in research and in her personal support through the study.

We would like to acknowledge our profound obligation and appreciation to our supervision Lt Col Sunita, Tutor and Maj Anju S, Tutor College of Nursing, Army Hospital (R&R), without her care, patience, whole hearted encouragement and tremendous support, the completion of this dissertation would not have been possible. We extend our sincere gratitude for her professional and personal approaches towards the completion of the study. We cannot thank enough for your support and constant feedback that has enabled us to arrive at the shape it is today.

We are obliged to the entire teaching faculty of AH(R&R), Medical and Nursing Officers of AH (R&R) for the valuable inputs for validating our intervention and tools. We thank all the teachers of College of Nursing, Army Hospital (R&R), for shaping our academic upbringing which has influenced our persona to become a more refined professional.

Last but not the least and most importantly we are thankful to all the participants who have participated in our study, without whom this dissertation would not have seen the light of the day. We therefore, humbly dedicate our study to all haematological malignancy patients.

CONCLUSION

The findings of our study indicate that there is a correlation between psychological stress and diagnosis of haematological malignancies. Most patients (88%) were found to have psychological stress after diagnosing with haematological malignancies. Out of which 46% had extremely severe stress; which emphasizes the need for timely intervention to manage stress in patients who are diagnosed with haematological malignancies for improvement of their wellbeing.

ANNEXURE I
LETTER GRANTING PERMISSION BY ETHICAL COMMITTE

सहमति फार्म

1. मैं .....

स्वेच्छा से इस शोध अध्ययन में भाग लेने के लिए सहमत हूँ।

2. मैं समझता हूं कि चाहे मैं अभी भाग लेने के लिए सहमत हूँ, मैं किसी भी समय पीछे हट सकता हूँ या बिना किसी परिणाम के किसी भी प्रश्न का उत्तर देने से इंकार कर सकता हूँ।

3. मेरे अध्ययन का उद्देश्य और प्रकृति मुझे लिखित रूप में समझाई गई थी और मुझे अध्ययन के बारे में प्रश्न पूछने का अवसर मिला था।

4. मैं समझता हूँ कि मेरे द्वारा इस अध्ययन के लिए प्रदान की जाने वाली सारी जानकारी गोपनीय रखी जाएगी।

5. मैं समझता हूँ कि इस शोध के परिणामों पर किसी भी रिपोर्ट में, मेरी पहचान अज्ञात रहेगी।

6. मैं समझता हूँ कि मेरी निगरानी से गुप्त निष्कर्ष का हवाला प्रस्तुति और दस्तावेज में किया जाएगा।

7. मैं समझता हूँ कि यदि मैं शोधकर्ता को सूचित करता हूँ कि मुझे या किसी और को जोखिम या नुकसान है, उन्हें संबंधित प्राधिकारी को इसकी रिपोर्ट करनी पड़ सकती है- वे पहले मेरे साथ इस की चर्चा करेंगे परंतु मेरी अनुमति से या मेरी अनुमति के बिना रिपोर्ट करना आवश्यक हो सकता है।

8. मैं समझता हूँ कि अध्ययन के लिए एक विशिष्ट प्रासंगिक अवधि के लिए हस्ताक्षरित सहमति फार्म सेना अस्पताल अनुसंधान और रेफरल में रखा जाएगा।

9. मैं समझता हूँ कि सूचना की स्वतंत्रता, वैधीकरण के तहत मैं किसी भी समय उस जानकारी का मूल्यांकन करने का हकदार हूँ जो मैंने प्रदान की है, जबकि यह एक विशिष्ट समय पर भंडारण में है।

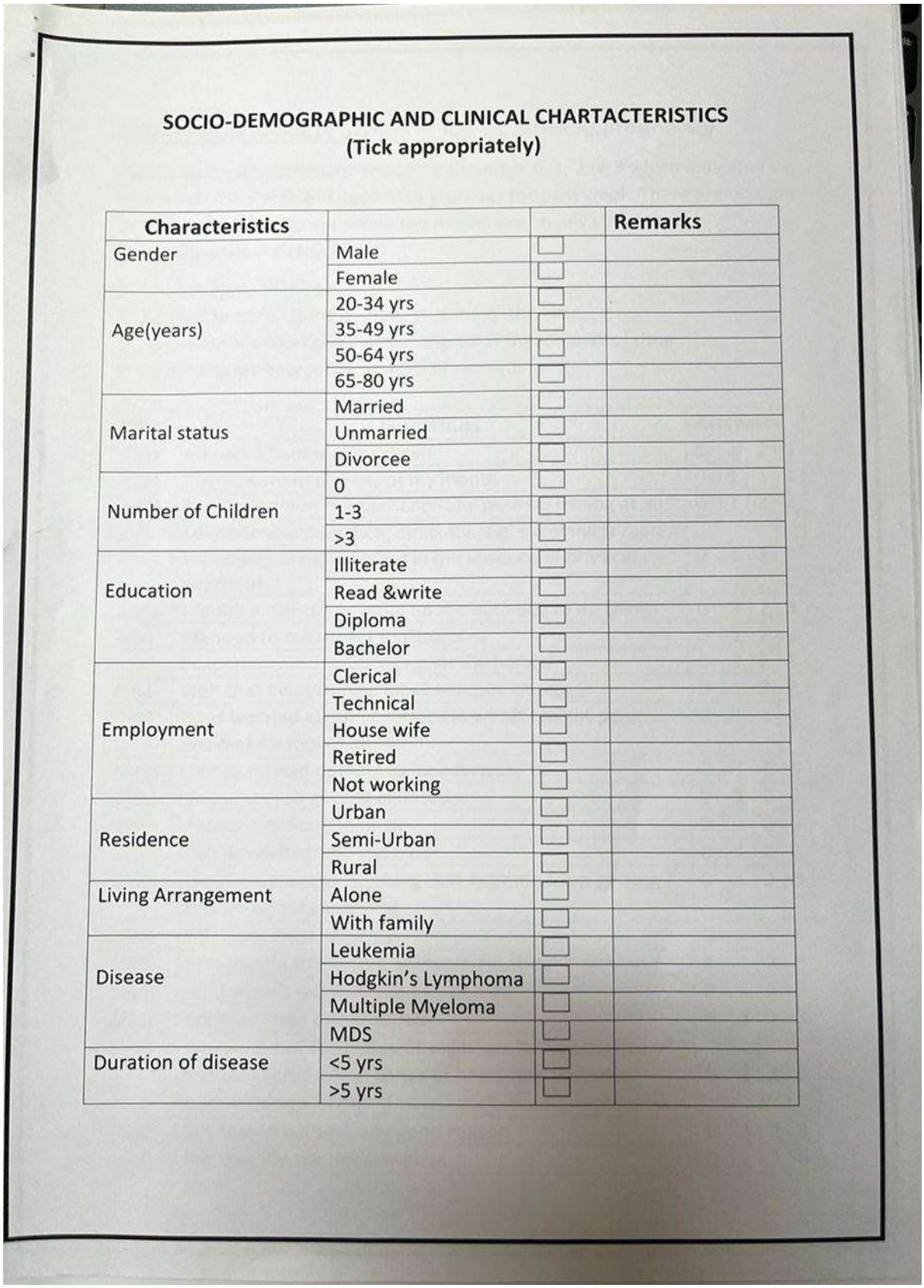
शोध प्रतिभागी के हस्ताक्षर ..... तारीख .....

मुझे विश्वास है कि प्रतिभागी इस अध्ययन में भाग लेने के लिए सूचित सहमति दे रहा है।

शोधकर्ता के हस्ताक्षर ..... तारीख .....

ANNEXURE II

CONSENT FORM FROM THE PARTICIPANT



SOCIO-DEMOGRAPHIC AND CLINICAL CHARTACTERISTICS
(Tick appropriately)

Characteristics			Remarks
Gender	Male	☐	
	Female	☐	
Age(years)	20-34 yrs	☐	
	35-49 yrs	☐	
	50-64 yrs	☐	
	65-80 yrs	☐	
Marital status	Married	☐	
	Unmarried	☐	
	Divorcee	☐	
Number of Children	0	☐	
	1-3	☐	
	>3	☐	
Education	Illiterate	☐	
	Read &write	☐	
	Diploma	☐	
	Bachelor	☐	
Employment	Clerical	☐	
	Technical	☐	
	House wife	☐	
	Retired	☐	
	Not working	☐	
Residence	Urban	☐	
	Semi-Urban	☐	
	Rural	☐	
Living Arrangement	Alone	☐	
	With family	☐	
Disease	Leukemia	☐	
	Hodgkin's Lymphoma	☐	
	Multiple Myeloma	☐	
	MDS	☐	
Duration of disease	<5 yrs	☐	
	>5 yrs	☐	

ANNEXURE III (a)

SOCIO DEMOGRAPHIC DATA

भाग I

सामाजिक-जनसांख्यिकीय और नैदानिक विशेषताएं

(उपयुक्त श्रेणी लिखें)

क्र.सं	विशेषताएँ	वर्ग	उत्तर:	टिप्पणियां
1.	लिंग	1) पुरुष		
		2) स्त्री		
2.	उम्र (साल)	1) 20-34 साल		
		2) 35-49 साल		
		3) 50-64 साल		
		4) 65-80 साल		
3.	वैवाहिक स्थिति	1) विवाहित		
		2) अविवाहित		
		3) तलाक		
4.	बच्चों की संख्या	1) 0		
		2) 1-3		
		3) >3		
5.	शिक्षा	1) निरक्षर		
		2) पढ़ें और लिखें		
		3) डिप्लोमा		
		4) स्नातक		
6.	रोज़गार	1) लिपिक		
		2) तकनीकी		
		3) गृहिणी		
		4) सेवानिवृत्त		
		5) काम नहीं कर रहा		
7.	निवास स्थान	1) शहरी		
		2) अर्ध-शहरी		
		3) ग्रामीण		
8.	रहने की व्यवस्था	1) अकेला		
		2) परिवार के साथ		
9.	बीमारी	1) ल्यूकेमिया		
		2) लिंफोमा		
		3) एकाधिक मायलोमा		
		4) एम.डी.एस		
		5) अन्य रुधिर संबंधी विकृतियां		
10.	रोग की अवधि	1) <5 साल		
		2) > 5 साल		

ANNEXURE III (b)

DASS SCALE

DASS21

Name: Date:

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you **over the past week**. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree or a good part of time
3 Applied to me very much or most of the time

1 (s)	I found it hard to wind down	0	1	2	3
2 (a)	I was aware of dryness of my mouth	0	1	2	3
3 (d)	I couldn't seem to experience any positive feeling at all	0	1	2	3
4 (a)	I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5 (d)	I found it difficult to work up the initiative to do things	0	1	2	3
6 (s)	I tended to over-react to situations	0	1	2	3
7 (a)	I experienced trembling (e.g. in the hands)	0	1	2	3
8 (s)	I felt that I was using a lot of nervous energy	0	1	2	3
9 (a)	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10 (d)	I felt that I had nothing to look forward to	0	1	2	3
11 (s)	I found myself getting agitated	0	1	2	3
12 (s)	I found it difficult to relax	0	1	2	3
13 (d)	I felt down-hearted and blue	0	1	2	3
14 (s)	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15 (a)	I felt I was close to panic	0	1	2	3
16 (d)	I was unable to become enthusiastic about anything	0	1	2	3
17 (d)	I felt I wasn't worth much as a person	0	1	2	3
18 (s)	I felt that I was rather touchy	0	1	2	3
19 (a)	I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat)	0	1	2	3
20 (a)	I felt scared without any good reason	0	1	2	3
21 (d)	I felt that life was meaningless	0	1	2	3

ANNEXURE IV

DASS 21
डिप्रेशन (अवसाद) चिंता तनाव पैमाना- २१

कृपया प्रत्येक कथन को पढ़ें और कोई एक संख्या 0, १, २ या ३ पर गोला करें .जो यह दर्शाता है कि पिछले एक सप्ताह में कथन आप पर कितना लागू हुआ। कोई भी सवाल सही या गलत नहीं है। किसी भी कथन पर ज्यादा समय न लगाएं।

रेटिंग पैमाना इस प्रकार है:

0 मुझ पर बिल्कुल भी लागू नहीं होता - कभी नहीं

१ मुझ पर कुछ हद तक, या कुछ समय के लिए लागू हुआ - कभी-कभी

२ मुझ पर काफी हद तक, या एक अच्छे खासे समय के लिए लागू हुआ - अक्सर

३ मुझ पर बहुत अधिक या अधिकतर समय लागू हुआ - लगभग हमेशा

१	मुझे आराम करने मे मुश्किल हो रही थी।	0	1	2	3
२	मेरे शुष्क मुँह की मुझे जानकारी थी।	0	1	2	3
३	मैं कोई भी सकारात्मक भावना को महसूस नहीं कर पा रहा था।	0	1	2	3
४	मुझे सांस लेने में कठिनाई का अनुभव हुआ (जैसे, अत्यधिक तेजी से सांस लेना, शारीरिक परिश्रम के अभाव में सांस का फूलना)।	0	1	2	3
५	मुझे चीजों की शुरुआत करने में कठिनाई हुई।	0	1	2	3
६	मैं परिस्थितियों पर अति प्रतिक्रिया करने के लिए प्रवृत्त हुआ।	0	1	2	3
७	मुझे कम्पन का अनुभव हुआ (जैसे, हाथों में)।	0	1	2	3
८	मुझे लगा कि मैं बहुत अधिक नर्वस एनर्जी (तंत्रिका ऊर्जा)का उपयोग कर रहा था।	0	1	2	3
९	मैं उन स्थितियों के बारे में चिंतित था जिनमें मैं घबरा सकता था और खुद को मूर्ख बना सकता था।	0	1	2	3
१०	मुझे लगा कि मेरे पास आगे देखने की कोई उम्मीद नहीं हैं।	0	1	2	3
११	मैंने अपने आप को व्यथित पाया।	0	1	2	3
१२	मुझे आराम करना मुश्किल लगा।	0	1	2	3
१३	मैं उदास और निराश महसूस कर रहा था।	0	1	2	3
१४	मैं जो कुछ कर रहा था उसमे बाध्य रूप कोई भी चीज़ के प्रति मैं असहिष्णु था।	0	1	2	3
१५	मुझे लगा कि मैं दहशत के करीब था।	0	1	2	3
१६	मैं किसी भी चीज़ को लेकर उत्साहित नहीं हो पा रहा था।	0	1	2	3
१७	मुझे लगा कि मैं एक व्यक्ति के रूप में ज्यादा लायक नहीं था।	0	1	2	3
१८	मुझे लगा कि मैं यूँ ही अतिभावुक था।	0	1	2	3
१९	मैं शारीरिक परिश्रम के अभाव में अपने हृदय की क्रिया से अवगत था (उदाहरण के लिए, हृदय गति में वृद्धि की भावना, हृदय की धड़कन का छूटना)।	0	1	2	3
२०	मुझे बिना किसी उचित कारण के डर लग रहा था।	0	1	2	3
२१	मुझे लगा कि जीवन व्यर्थ था।	0	1	2	3

Piper beetle: A Comprehensive Review of its Ethnobotanical and Pharmacological Potential

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doi.org/10.64643/JATIRV2I4-140094-001

Abstract- *Piper betle* L. (Piperaceae), commonly known as the betel vine, holds a unique position in the sociocultural fabric of South and Southeast Asia. While largely recognized for its role in the masticatory "betel quid" (Paan), the leaf itself possesses a rich history as a potent therapeutic agent in traditional medicine systems like Ayurveda, Siddha, and Unani. This review transcends the leaf's recreational identity to explore its status as a "healing master." We examine the phytochemistry of *P. betle*, highlighting bioactive compounds such as eugenol, hydroxychavicol, and chavibetol, responsible for its medicinal properties. The review comprehensively analyzes current pharmacological evidence supporting its antimicrobial, antioxidant, anti-inflammatory, gastroprotective, and potential chemopreventive activities. Furthermore, a critical distinction is drawn between the therapeutic profile of the isolated betel leaf versus the carcinogenic risks associated with the complete betel quid (containing tobacco and areca nut). The review concludes that *P. betle* represents an underutilized reservoir of bioactive molecules with significant potential for modern therapeutic applications, warranting further clinical exploration.

Index-Terms: *Piper betle*, Phytochemistry, Eugenol, Hydroxychavicol, Antimicrobial, Antioxidant, Traditional Medicine.

I. INTRODUCTION

The relationship between humanity and the plant kingdom is ancient, with plants serving as the primary source of medicine for millennia. Despite the advent of synthetic pharmaceuticals, a significant portion of the global population relies on traditional herbal remedies for primary healthcare. Among the myriad plants utilized in traditional systems of South and Southeast Asia, *Piper betle* L., belonging to the family Piperaceae, is ubiquitous.

Known variously as "Paan" in Hindi, "Tambula" in Sanskrit, and "Sirih" in Malay, the heart-shaped leaf of the betel vine is deeply embedded in cultural rituals, social gatherings, and religious ceremonies. Its most visible use is as a wrapper for the "betel quid," a masticatory mixture usually containing areca nut and slaked lime, and often tobacco. This widespread social usage has, to some extent, overshadowed the intrinsic medicinal value of the leaf itself.

Ancient texts of Ayurveda designate *P. betle* not merely as a breath freshener but as a powerful therapeutic agent. It is classified as pungent, warming, and capable of balancing Kapha and Vata doshas. Historically, it has been employed to treat conditions ranging from halitosis and digestive disorders to respiratory ailments and dermal wounds.

This review aims to reclaim the status of *Piper betle* as a "healing master" by systematically examining its phytochemical composition and evaluating contemporary scientific evidence for its pharmacological activities. It seeks to bridge the gap between traditional knowledge and modern scientific validation, emphasizing the therapeutic potential of the leaf extract distinct from the associated risks of the betel quid.

II. BOTANICAL DESCRIPTION AND PHYTOCHEMISTRY

Piper betle is a perennial, dioecious, creeping herb rooted at the nodes. It thrives in warm, humid climates and is extensively cultivated across India, Bangladesh, Sri Lanka, Malaysia, and Indonesia. The leaves are simple, alternate, heart-shaped, and bright green, possessing a characteristic aromatic odor and a pungent taste.

The healing prowess of *P. betle* is attributable to its rich and complex phytochemical profile. The leaf contains water, proteins, carbohydrates, minerals (calcium, potassium), and vitamins (A, C, and B-complex). However, its primary pharmacological activity resides in its essential oil and various extracts.

2.1. Essential Oil Components

The essential oil constitutes about 0.08% to 0.2% of the fresh leaf weight. The composition varies significantly based on the cultivar and geographical origin, but major bioactive components consistently include:

- Chavibetol (Betelphenol): An isomer of eugenol, often the dominant compound in many Indian cultivars, contributing to the characteristic aroma and antimicrobial properties.
- Eugenol: A phenylpropene notable for its anesthetic, analgesic, and anti-inflammatory effects.
- Hydroxychavicol: A major phenolic compound exhibiting potent antioxidant and anti-carcinogenic properties.
- Chavicol: A phenolic compound with strong antiseptic qualities.
- Caryophyllene and Cadinene: Sesquiterpenes contributing to anti-inflammatory activity.

2.2. Other Bioactive Constituents

Beyond the volatile oil, extracts of the leaf yield significant secondary metabolites including tannins, flavonoids (like quercetin and kaempferol), and various alkaloids. These compounds work synergistically, enhancing the overall therapeutic effect of the leaf.

III. TRADITIONAL MEDICINAL USES (ETHNOBOTANY)

Before modern pharmacological screening, indigenous communities utilized *P. betle* for a wide spectrum of ailments.

In Ayurveda, the leaf juice is used as an adjuvant to various medicines to enhance their effects. It is considered a digestive stimulant (Deepana) and carminative (Pachana). Warm leaves smeared with oil are applied to the chest to relieve coughs and respiratory congestion in children.

In traditional Chinese medicine, betel roots and leaves are used to treat coughing, edema, and rheumatic pain. In Malaysia and Indonesia, the leaves are often boiled, and the water is used as a mouthwash for oral hygiene to treat toothaches, gum swelling, and bad breath, demonstrating early knowledge of its antimicrobial properties.

Furthermore, the leaves have been traditionally employed as an antiseptic for healing wounds, boils, and cutaneous infections. The leaf paste is applied topically for its analgesic properties to relieve headaches and joint pain.

IV. PHARMACOLOGICAL ACTIVITIES: SCIENTIFIC VALIDATION

Modern research has increasingly validated many of the traditional claims surrounding *Piper betle*.

4.1. Antimicrobial and Antifungal Activity

Perhaps the most extensively documented property of *P. betle* is its broad-spectrum antimicrobial action. The essential oil and various extracts (ethanol, methanol, aqueous) have demonstrated significant inhibitory effects against a range of pathogenic bacteria, including *Staphylococcus aureus*, *Streptococcus mutans*, *Escherichia coli*, and *Pseudomonas aeruginosa*.

The mechanism of action is believed to involve the disruption of bacterial cell membranes by phenolic components like eugenol and hydroxychavicol, leading to leakage of cellular constituents and cell death.

Furthermore, *P. betle* shows potent antifungal activity against dermatophytes and yeasts, including *Candida albicans*. This validates its traditional use in treating oral thrush and skin infections. Its activity against *Streptococcus mutans* makes it a valuable candidate for preventing dental caries and maintaining oral hygiene.

4.2. Antioxidant Activity

Oxidative stress, resulting from an imbalance between free radicals and antioxidants, is implicated in numerous chronic diseases, including cardiovascular disorders and cancer. *Piper betle* extracts exhibit strong antioxidant properties.

Hydroxychavicol and eugenol are powerful scavengers of free radicals, such as superoxide anions and hydroxyl radicals. They also enhance the activity of endogenous antioxidant enzymes like superoxide dismutase (SOD) and catalase (CAT) in biological systems. The high phenolic content of the leaf directly correlates with its ability to mitigate oxidative damage to lipids and DNA.

4.3. Anti-inflammatory and Analgesic Properties

Inflammation is a root cause of many pathologies. The topical application of warm betel leaves for pain relief is a common folk remedy. Scientific studies confirm that betel leaf extracts possess significant anti-inflammatory activity.

Extracts have been shown to inhibit the production of pro-inflammatory mediators like prostaglandins and nitric oxide, and suppress the activity of enzymes like cyclooxygenase-2 (COX-2). The presence of eugenol, a known local anesthetic and anti-inflammatory agent, significantly contributes to these effects, validating its use in treating rheumatism and painful swellings.

4.4. Gastroprotective and Digestive Activity

Contrary to the irritating effects of tobacco/areca nut on the gastric lining, the pure *P. betle* leaf is gastroprotective. Aqueous extracts contain mucilages that coat the stomach lining, protecting it from acid pepsin. Studies in animal models have shown that betel leaf extract can significantly reduce the ulcer index and increase the gastric mucus content, exhibiting anti-ulcerogenic activity comparable to standard drugs like ranitidine.

Furthermore, the leaf is known to stimulate the secretion of saliva and digestive enzymes (amylase, lipase), confirming its traditional role as a digestive aid taken after meals.

4.5. Anticancer and Chemopreventive Potential

This is the most complex and crucial area of *P. betle* research. It is vital to distinguish between the *betel quid* and the *betel leaf*.

Epidemiological studies have strongly associated chronic chewing of betel quid (specifically those containing tobacco and areca nut) with a high incidence of oral submucous fibrosis and oral cancer. The International Agency for Research on Cancer (IARC) classifies betel quid with tobacco as a Group 1 carcinogen.

However, research on extracts of the *Piper betle leaf alone* tells a different story. Isolated compounds like hydroxychavicol have demonstrated chemopreventive and anti-cancer properties

in vitro and in vivo models. Hydroxychavicol has been shown to induce apoptosis (programmed cell death) in various cancer cell lines, including chronic myeloid leukemia cells and oral carcinoma cells, without significantly affecting normal cells. It appears to act by interfering with the cell cycle progression of cancer cells.

Therefore, while the "vehicle" (the quid) is toxic, the leaf itself contains compounds that may actively fight cancer.

4.6. Antidiabetic Activities

Emerging research suggests that *P. betle* leaf extracts may have hypoglycemic effects. Studies in diabetic rats have shown that administration of the leaf extract can lower blood glucose levels, potentially by inhibiting enzymes responsible for carbohydrate digestion (like alpha-amylase and alpha-glucosidase) or by improving insulin sensitivity.

V. SAFETY AND TOXICOLOGY PROFILE

The dichotomy of *Piper betle*—as a healing agent versus a component of a carcinogenic habit—requires careful delineation.

Oral toxicity studies in animal models have generally found aqueous and ethanolic extracts of *P. betle* leaves to be relatively non-toxic at typical dietary doses. The World Health Organization (WHO) has recognized the traditional use of the leaf as generally safe when not combined with known carcinogens.

The toxicity associated with "paan" is overwhelmingly linked to the additives:

1. Areca Nut (Supari): Contains arecoline, which causes fibroblast proliferation leading to oral submucous fibrosis, a precancerous condition.
2. Tobacco: Contains potent tobacco-specific nitrosamines (carcinogens).
3. Slaked Lime (Chuna): Causes chronic irritation and alkaline injury to the oral mucosa, promoting the penetration of carcinogens.

Therefore, the "healing master" title is reserved for the leaf used in isolation or with non-toxic adjuncts, not the complete, habitual betel quid.

VI. CONCLUSION AND FUTURE DIRECTIONS

Piper betle is a botanical paradox. It is globally recognized as the wrapper of a harmful, addictive quid, yet the leaf itself is a repository of potent therapeutic molecules. This review confirms that *P. betle* is indeed a "healing master" in its own right, with validated antimicrobial, antioxidant, anti-inflammatory, and gastroprotective properties.

The presence of hydroxychavicol and eugenol makes the leaf a promising source for developing novel therapeutic agents, particularly for oral health products, wound healing treatments, and potentially chemopreventive adjuncts.

Future research must focus on:

1. Standardization of extracts based on key bioactive markers to ensure consistent therapeutic effects.
2. More extensive human clinical trials to translate preclinical findings into viable medical treatments, particularly for digestive disorders and oral hygiene.
3. Public health education clarifying the distinction between the medicinal properties of the leaf and the dangers of the tobacco/areca nut quid.

In conclusion, separating *Piper betle* from its toxic associations reveals a plant of immense medicinal value, validating centuries of traditional wisdom with modern scientific rigor.

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UPI Payment: Standerdizing Its Usage in Diverse States

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doi.org/10.64643/JATIRV2I4-140178-001

Abstract: Unified Payments Interface (UPI) has become the backbone of India's digital economy, enabling seamless transactions across regions. By standardizing its usage in diverse states, UPI is bridging financial gaps, fostering inclusion, and creating a unified framework for digital payments nationwide.

Index-Terms : **The boom of the Unified Payments Interface (UPI) in India is marked by massive headline growth but remains deeply uneven across regions, demographics, and economic sectors as of early 2026. While UPI now processes over 20 billion transactions monthly and accounts for roughly 85% of all digital payments in the country, its "multi-speed" nature is revealed when data is adjusted for population and geography**

I.INTRODUCTION

The boom of India's Unified Payments Interface (UPI) has transformed the nation into a global leader in real-time payments, yet its adoption remains significantly uneven across geographical and demographic lines.

Leaders: Telangana records the highest intensity with 274 transactions per person annually, followed by Delhi (241) and Karnataka (203).

Laggards: States like Bihar (44), Manipur (35), and Tripura (33) show significantly lower adoption due to lower per-capita income and limited merchant readiness.

Urban-Rural Gap: While urban adoption is near universal among youth, only 40% of rural individuals prefer UPI as their primary payment mode. Rural users average just 5 transactions per month compared to 15 for urban counterparts.

Demographic Divide: Adoption is highest among those aged 18–25 (66% adoption), while older populations and women—particularly those without personal smartphones—remain digitally marginalized.

The UPI Boom: Key Drivers

- Unprecedented Scale: UPI has surpassed Visa in daily transaction volume in India, making it the world's leading real-time payment system.
- High-Volume, Low-Value Shift: As of Q3 2023, over 70% of transactions were below ₹500, indicating deep penetration into daily micro-payments (tea stalls, vendors).
- COVID-19 Catalyst: The pandemic accelerated the shift to contactless, digital payments.

  Key Players: PhonePe, Google Pay, and Paytm dominate the market, driving significant adoption through extensive merchant campaigns.
- Infrastructure: The "India Stack" (Aadhaar, UPI) enables instant, 24/7 account-to-account transfers with zero transaction cost for consumers.

The Uneven Introduction & Adoption Pattern

- Regional Disparities: Digital payments are highly mature in top-tier (high-income) states, which may be approaching saturation. Conversely, mid-income states are currently experiencing the fastest adoption, "catching up" to the leaders.
- Rural vs. Urban Divide: Despite 70% of new users coming from Tier-2 cities, rural areas still grapple with inadequate internet connectivity, lower digital literacy, and inconsistent electricity, creating pockets of cash-heavy economies.
- Behavioral Inertia: Small shopkeepers and daily transactions in remote areas occasionally stick to cash due to "habit" or convenience, creating a "cash floor" that is hard to eliminate, even in a digital-first ecosystem.
- Demographic Gaps: Adoption is higher among the 18–35 age group, with lower adoption rates among older and less-educated demographics, often due to security concerns.

  Challenges Affecting Uniformity

- Security Concerns: Incidences of phishing and fraud (95,000+ cases in 2022-23) create trust issues, particularly among rural or less-digitally literate users.
- Transaction Failures: Inconsistent connectivity leads to failed transactions, reducing user trust in specific areas.
- Market Concentration: The top two players hold 83% of the market share, prompting the NPCI to enforce a 30% cap on volume to promote competition.

Future Outlook

The Reserve Bank of India (RBI) reports a "convergence" trend, where the gap between high- and low-UPI states is shrinking. Innovations like UPI Lite (offline transactions), UPI 123PAY (for

feature phones), and UPI Circle (governance for business payments) are designed to bridge the remaining digital divide

The Macro Boom (2025–2026)

- Record Growth: In January 2026, UPI processed an all-time high of 21.7 billion transactions worth ₹28.33 lakh crore.
- Annual Scale: For the full year 2025, volumes reached 228.3 billion transactions (up 74% from 2024), valued at nearly ₹300 trillion—roughly one-third of India's GDP.
- Micro-Transaction Shift: The average ticket size dropped to ₹1,293 by late 2025, indicating that UPI is increasingly replacing cash for daily low-value purchases.
- Infrastructure: As of early 2026, the ecosystem connects 691 banks and over 500 million unique users.

Regional Disparities: The Digital Divide

Usage intensity varies sharply, with a distinct south-west corridor showing mature digital ecosystems compared to the lagging eastern states.

- Top-Performing Regions: Per-capita usage is highest in urbanised, high-income states.
    a) Delhi : Leads with approximately 23.9 transactions per person monthly.
    b) Telangana : Records the highest per-capita monthly value at roughly ₹34,800.
    c) Other Leaders: Goa (23.3), Chandigarh(22.5), and Maharashtra (17.4) also sit well above the national average.
- Lagging Regions: Adoption remains "shallow" in many eastern and north-eastern states due to gaps in merchant infrastructure.
    a) Bihar and Tripura : Both average fewer than 4 transactions per person monthly, with values ranging between ₹5,100 and ₹5,400.
    b) Others: Jharkhand, Assam, and West Bengal also cluster at the bottom of the per-capita rankings.

Demographic and Behavioral Gaps

- Rural vs. Urban: While UPI is the preferred mode for 38% of rural and semi-urban Indians, over 80% of urban users prefer it, reflecting a "stark contrast" driven by connectivity rather than curiosity.

- Gender Gap: Digital literacy and smartphone access remain gendered. Studies show that while 72% of urban men use UPI, only 55% of urban women do; in rural areas, this drops to 30% for women compared to 51% for men.
- Age Groups: Adoption is highest among those aged 18–35, who are more familiar with technology and instant transaction capabilities.

Sectoral Adoption and Use Cases

- Small vs. Large Tickets: UPI is the "uncontested frontrunner" for small, daily transactions like groceries or tea. However, it contributed only 8.7% by value of total retail payments in 2024, as large-value transfers still rely on NEFT or RTGS.
- P2P vs. P2M: Person-to-Merchant (P2M) transactions are growing fast due to QR code ubiquity, but person-to-person (P2P) transfers still contribute significantly to the total value.

The "Uneven" Reality: Digital & Regional Divides

Despite massive national figures, per-capita data reveals a "multi-speed" digital economy:

Barriers to Uniform Adoption

- Infrastructure: Unreliable internet and erratic electricity in roughly 45,000+ villages continue to limit 4G coverage and transaction success rates.
- Digital Literacy: Approximately 57% of non-users have never heard of UPI, and 60% of aware non-users cite discomfort with technology as a major barrier.
- Security Concerns: UPI-related fraud surged to 6.32 lakh cases in FY25, totaling ₹485 crore in losses, which has dampened trust among less tech-savvy groups.
- Market Concentration: Two apps, PhonePe (48.3%) and Google Pay (37.0%), control over 85% of the transaction volume, raising concerns about systemic resilience.

II.METHODOLOGY

The research methodology used to study the "uneven" boom of UPI in India primarily combines quantitative analysis of secondary data from official sources like the National Payments Corporation of India (NPCI) and Reserve Bank of India (RBI) with descriptive and exploratory research designs.

Core Methodological Frameworks

Researchers employ several key techniques to map the uneven distribution of UPI adoption:

- Descriptive Statistics & Trend Analysis: Used to track explosive growth in monthly transaction volume and value from 2020 to 2025. Metrics like Mean and Standard Deviation help identify periods of high variability versus stabilization.
- Per Capita and State-wise Segmentation: To highlight regional disparities, studies calculate per capita usage intensity. For example, findings show Telangana leads with 274 transactions per person, while states like Bihar (44) and Uttar Pradesh (50) lag significantly.
- Regression Analysis: Applied to determine the relationship between variables such as the number of participating banks and transaction volume, often finding high R-squared values (e.g., 0.973) that indicate strong correlations.
- Cluster Analysis (e.g., K-means): Used to categorize and rank the performance of different UPI platforms and bank types (public vs. private).
- Instrumental Variable Approach: Advanced studies use exogenous factors, such as the share of specific population demographics, as instrumental variables to address endogeneity when examining if wealth inequality drives adoption.

Qualitative & Primary Data Integration

While much research relies on secondary data, scholars also use:

- Primary Surveys: Questionnaires targeted at specific demographics (e.g., age, income, education) to assess user awareness, satisfaction, and security perceptions.
- Qualitative Case Studies: Focused investigations into small merchants and individuals in selected rural areas to identify grassroots barriers like low digital literacy and infrastructure gaps.

Key Methodological Findings on "Unevenness"

Factor	Observation
Regional Divide	High intensity in Southern/Western states (e.g., Telangana, Karnataka) vs. lower adoption in Northern/Eastern states (e.g., Bihar, Tripura).
Demographic Divide	Adoption is highest among younger populations (ages 18–35) and those with higher digital literacy.
Economic Divide	Positive and significant impact of relative wealth on adoption; wealth endowment amplifies digital payment use in affluent districts.

III.OBJECTIVES OF THE STUDY:

The objectives of UPI have shifted from simply enabling transfers to fostering a "cash-light" and "formalized" economy:

- Financial Inclusion: Integrating millions of unbanked individuals into the formal economy via the JAM (Jan Dhan-Aadhaar-Mobile) trinity.
- Reducing Cash Dependency: Substituting physical currency with digital micro-payments; the average transaction size dropped from ₹3,867 in 2016–17 to ₹1,404 in 2024–25.
- Economic Formalization: Forcing businesses to maintain digital footprints, which improves GST compliance and reduces the "shadow economy".
- Democratizing Credit: Using UPI transaction data as an alternative for credit scoring, allowing small vendors and gig workers to access formal loans.
- Global Influence: Exporting the UPI model to over 10 countries (e.g., UAE, France, Singapore) to simplify cross-border remittances and tourism payments.

Analysis and interpretation:

The boom in India's Unified Payments Interface (UPI) as of March 2026 presents a "headline vs. reality" paradox: while total volumes reached a record 21.7 billion transactions in January 2026, a per-capita analysis reveals a significant and persistent digital divide across regions and demographics.

The Per-Capita Disparity

Headline growth figures often mask the uneven depth of adoption. When normalised by population, transaction intensity varies by as much as seven times between different states:

- High Adoption Regions: Delhi leads the nation with 23.9 transactions per person monthly, followed by Goa (23.3), Telangana (22.6), and Chandigarh (22.5).
- Low Adoption Regions: At the other end of the spectrum, Bihar records roughly 44 per-capita transactions annually (approx. 3.6 monthly), with states like Tripura (33), Manipur (35), and Uttar Pradesh (50) showing significantly lower usage tied to lower per-capita income.
- Economic Correlation: Adoption depth follows income levels, urbanisation, and merchant acceptance more closely than sheer population size.

  Urban vs. Rural Divergence
  The "uneven" nature of the boom is further highlighted by the gap between awareness and consistent usage in rural areas:

- Usage Gap: While urban adoption is estimated at 90%, rural penetration remains lower at 65–70%.
- Behavioural Differences: Urban users increasingly use UPI for discretionary spending, while rural usage is primarily restricted to essential services and government-linked transactions.
- Preferred Mode: Although UPI is the preferred mode for 38% of rural and semi-urban residents, only about 38% of rural residents overall actively participate in digital transactions, pointing to a persistent gap in consistent usage.

Market Share Concentration

The "boom" is also unevenly distributed among service providers, creating a duopoly in the ecosystem:

- PhonePe & Google Pay: Together, these two platforms control nearly 80% of the market share. As of January 2026, PhonePe dominates with 45.7% volume share, followed by Google Pay at 33.3%.
- The "Long Tail": Despite the overall volume increase, smaller players like Navi (3.3%) and BHIM (0.8%) hold minimal shares, highlighting a lack of diversification in the provider landscape.

Structural & Infrastructure Bottlenecks

- Connectivity Issues: Poor internet infrastructure and inconsistent electricity in remote areas remain primary bottlenecks for equitable adoption.
- Security Concerns: Approximately 38% of users remain worried about fraud and privacy, which acts as a deterrent for deeper penetration among older and rural populations.
- Processing Pressure: Billions of monthly transactions have placed immense pressure on backend systems, leading to occasional downtime that further impacts user trust in underserved regions.

While UPI transactions reached a massive 186 billion in FY 2024–25, adoption remains highly uneven across Indian states. When total volumes are adjusted for population, a "multi-speed digital economy" emerges, where urbanised southern and western states significantly outperform the eastern and north-eastern regions.

State-Wise UPI Intensity (FY 2024–25)

Data from the NPCI and recent RBI bulletins show that a few regions drive the bulk of digital intensity:

- Top Leaders (Per Capita Transactions):

- Telangana : Leads with 274 transactions per person and the highest per-capita value (~₹4.34 lakh).
- Delhi : Recorded 241 transactions per person, driven by high urban density.
- Goa : Follows closely with 229 transactions per person.
- Karnataka : A major tech hub with 203 transactions per person.

- States Lagging Behind:

- Tripura : Only 33 transactions per person, the lowest in the country.
- Manipur : Just 35 transactions per person.
- Bihar : Recorded 44 transactions per person, roughly 1/6th the intensity of Delhi
- Uttar Pradesh : Despite having massive total volumes due to its population, its per-capita usage is low at 50 transactions per person.

Key Drivers of the Divide
The uneven boom is primarily attributed to differences in economic maturity and infrastructure:

- Urbanisation & Ecosystems: A "south-west corridor" from Maharashtra to Telangana

has developed mature digital ecosystems with widespread merchant QR code acceptance.

- Income Levels: States with higher per-capita income show more "routine use" for high-ticket professional and retail services, while lower-income states primarily use UPI for basic low-value transfers.
- Infrastructure Gaps: Lagging states often struggle with less reliable internet connectivity and slower merchant onboarding.
- Terrain-Driven Adoption: In some north-eastern states like

Arunachal Pradesh and Sikkim usage is surprisingly high because difficult terrain makes digital payments a more reliable substitute for physical cash.

Core Challenges & Problems:
While UPI has reached record highs of 21.6 billion transactions monthly as of December 2025, its growth is marked by significant regional and demographic imbalances, alongside rising systemic risks.

Uneven Adoption & Digital Divide

The "boom" is highly concentrated in specific urban corridors, leaving large parts of the country behind.

- Regional Disparities:
  - Telangana leads the country with a per-capita monthly UPI value of ₹34,800, followed by Delhi (₹31,300) and Goa (₹33,500). In contrast, adoption remains "shallow" in eastern and northeastern states. Residents in Bihar and Tripura average fewer than four transactions per month, with per-capita values around ₹5,100–₹5,400.
  - A resident of Delhi transacts roughly six times as often via UPI as someone in Bihar
- Gender Gap: Less than 30% of UPI users in India are women. This gap is wider in rural areas, where only 30% of women use UPI compared to 68% of men.
- Age Barriers: Older users face significant difficulties with app navigation, adding beneficiaries, and handling transaction confirmations, often leading to abandonment or errors.

Critical Problems & Challenges

- Systemic Outages: The infrastructure has struggled to scale. In March-April 2025, multiple outages disrupted millions of transactions, highlighting a Single Point of Failure at the NPCI.
- The "Fraud Shadow": Digital fraud cases rose 34% year-on-year in 2024–25.
  - Fake Collect Requests: The most common scam, where users approve a debit thinking they are receiving a refund.
  - QR Code Swapping: Fraudsters replace physical QR codes at shops, siphoning funds away from merchants.
  - SIM Swapping: Criminals take over mobile numbers to bypass two-factor authentication.
- Economic Sustainability: The zero-MDR (Merchant Discount Rate) policy means banks and service providers earn nothing from most transactions while incurring costs of roughly ₹0.80 per transaction. This reduces their incentive to invest in better backups and customer support.
- Transaction Limits: The standard limit of ₹1 lakh per day can be a bottleneck for small businesses handling high-value items or growing sales volumes.

Operational Constraints

- Internet Dependency: Despite rising connectivity, "patchy" internet in rural areas leads to frequent transaction timeouts and failures.
- Slow Grievance Redressal: Refund processes for failed transactions remain slow, frustrating users and eroding trust, especially among first-time digital adopters.

Uneven Adoption & Challenges

While UPI is now used by over 50 million merchants, its reach varies significantly across demographics and regions: International Journal For Multidisciplinary Research (IJFMR)

The Rural-Urban Divide: Urban and semi-urban areas have high adoption rates, but rural uptake is slowed by patchy internet, inconsistent electricity, and lower digital literacy.

Gender and Age Gaps: Men currently make up nearly 70% of UPI users. Adoption also declines sharply among those over 45 due to trust issues and lower digital literacy.

Income Disparity: The wealthiest 60% of Indians are four times more likely to use digital payments than the poorest 40%.

Fraud and Trust: Rapid growth has attracted "bad actors," with over 95,000 fraud cases recorded in 2022–23. Fears of phishing and technical failures remain significant barriers for new users

The Unified Payments Interface (UPI) boom in India is uneven due to a "digital divide" where high-income, urbanised states significantly outpace rural and low-income regions in both adoption and transaction intensity. While the system handled a record 21.70 billion transactions in January 2026, per capita usage varies from over 270 transactions per person in leading states to fewer than 50 in lagging ones.

Key Drivers of Uneven Adoption

The disparity is primarily driven by three structural and socio-economic factors:

- Economic Disparity & Urbanisation: Richer, more urbanised states like Telangana Delhi, and Karnataka record the highest per capita UPI spending, exceeding ₹25,000 per month. In contrast, low-income states such as Bihar and Uttar Pradesh see per capita spending as low as ₹5,000.
- Education and Formal Employment: States with higher literacy rates and larger formal workforces transition to digital payments faster because salaries are credited directly to bank accounts, and users are more comfortable with mobile technology.
- Infrastructure Gaps: Rural areas continue to face "trust frictions" caused by unreliable internet connectivity, erratic electricity, and a lack of smartphone access—with only about 25% of mobile users in some backward regions owning a smartphone.

Barriers to Universal Growth

Despite reaching 57% of Indian consumers as a preferred payment method by early 2026, several segments remain excluded:

- Awareness Gaps: Surveys show approximately 57% of non-users have never heard of UPI, even in digitally mature regions.
- Gender and Age Divides: Women and older populations are often less confident with digital interfaces and less likely to own personal smartphones.

- Behavioral Inertia: Many small merchants and individuals in the informal economy stick to cash for convenience or due to "cultural habits" like using cash for weddings or tips.
- System Vulnerabilities: Frequent technical outages in early 2025 and rising fraud—affecting an estimated one in five Indian families—have created safety concerns that discourage "access-ready" but unconvinced users.

Regional Breakdown (Per Capita Transactions 2024–25)

High Usage States	Transactions/Person	Low Usage States	Transactions/Person
• Telangana	274	• Uttar Pradesh	50
• Delhi	241	• Bihar	44
• Karnataka	203	• Manipur	35
• Maharashtra	185	• Tripura	33

While India's Unified Payments Interface (UPI) recorded a massive 186 billion transactions in FY 2024–25, its growth remains "uneven" across geographic and demographic lines.
The "Uneven" Reality

- Geographic Divide: Usage is concentrated in a "south-west corridor".
    1. High Intensity: Telangana (274 transactions/person), Delhi (241), and Karnataka (203) lead the nation.
    2. Low Intensity: States like Bihar (44 transactions/person), Tripura (33), and Manipur (35) lag significantly due to lower per-capita income and weaker digital infrastructure.
- Demographic Gaps: Adoption is highest among the 18–35 age group.
    1. Elderly & Rural: Lack of digital literacy and complex interfaces remain barriers for older populations.
    2. Gender Gap: While bank ownership is nearly equal, only 37% of women have adopted mobile internet, compared to higher rates for men, limiting their UPI usage.

Solutions & Recent Interventions
To bridge these gaps, the RBI and NPCI have introduced several "offline" and "low-tech" solutions:

- UPI 123PAY: Enables digital payments via Interactive Voice Response (IVR) and sound-based technology, specifically for the ~400 million feature phone users without internet access.
- UPI Lite: A "on-device" wallet for small-value transactions that works with low or no connectivity. In late 2024, the wallet limit was increased to ₹5,000 to encourage wider use.
- Hello! UPI: Uses AI-driven conversational payments (voice commands) in local languages to assist the elderly and those with limited digital literacy.
- Infrastructure Support (PIDF): The Payments Infrastructure Development Fund provides grants to deploy QR codes and POS terminals specifically in Tier-3 to Tier-6 centers. As of late 2025, over 5.4 crore digital touchpoints have been deployed via this scheme.
- "UPI for Her": A joint initiative by NPCI and Women's World Banking aimed at onboarding 200 million women through simplified "phygital" (physical + digital) training and gender-inclusive design.

Key Barriers to Even Adoption

- Infrastructure Gaps: Patchy internet and electricity in remote areas.
- Digital Literacy: Low awareness and lack of "hand-holding" for elderly and rural users.
- Trust & Security: Fear of fraud and the impact of server downtime—which accounts for nearly 69% of transaction failures—discourage new users.
- Gender Divide: Adoption is lower among women, particularly in rural areas, due to limited smartphone access and financial independence.

Measures to Improve Penetration (2025–2026)
The government and National Payments Corporation of India (NPCI) have implemented several targeted measures:

- Financial Incentives: A ₹1,500 crore incentive scheme for FY 2024–25 promotes low-value (up to ₹2,000) BHIM-UPI transactions among small merchants.

1. Offline & Low-Tech Solutions:
    - UPI 123PAY: Enables payments via feature phones using IVR or sound-based technology for those without smartphones.
    - UPI Lite & LiteX: Designed for near-offline, small-value transactions to reduce server load and improve success rates.
2. System Reliability:
    - To prevent outages, NPCI introduced API limits (e.g., 50 balance checks per day) and mandated that AutoPay execute during non-peak hours.

3. Enhanced Security:
    - Biometric Authentication: Introduction of fingerprint and face ID for transactions up to ₹5,000 to simplify usage for those who struggle with PINs.
    - Fraud Reporting: The "Chakshu" facility allows citizens to report suspected fraudulent communications.
4. Grassroots Outreach:

Deployment of over 2,421 Centres for Financial Literacy (CFL) as of March 2025 to provide training in rural blocks.

Essential Transaction Details

1. *UPI Reference Number: A unique 12-digit alphanumeric code assigned to every transaction.*
2. *It is critical for tracking payments and resolving disputes with bank support teams.*
3. *Found in the "Transaction History" section of apps like Google Pay, PhonePe, or Paytm.*
4. *Virtual Payment Address (VPA): A unique identifier (e.g., name@bankname) that* allows *transfers without sharing account numbers or IFSC codes.*
5. *Two-Factor Authentication (2FA): Secure authorization using a mobile device and a 4–6-digit UPI PIN.*

Latest Global & Infrastructure Trends (2024-2026)

1. *Global Expansion: UPI is operational in countries including the UAE, Singapore, France, Mauritius, Bhutan, Nepal, and Sri Lanka.*
2. *UPI Lite X: A feature allowing offline transactions via NFC for environments with low connectivity.*
3. *Conversational Payments: Integration with AI (e.g., BharatGPT) to enable voice-based transactions in multiple regional languages.*
4. *Interoperability: Recognized by the International Monetary Fund (IMF) as a global benchmark for enabling seamless payments across different apps and banks.*

IV.CONCLUSION: Key Conclusions on UPI's Impact

- Substitution vs. Presence of Cash: UPI is actively replacing cash for micro-transactions (average ticket size fell to ₹1,404 in 2024-25), yet absolute currency in circulation remains high.
- Market Concentration: The ecosystem is dominated by a few private players like PhonePe (46%) and Google Pay (36%), raising concerns about a "duopolistic" structure and systemic risk.

- The "Cash Floor": Research indicates a non-linear effect; as digital adoption matures, the reduction in cash slows down due to "behavioral inertia," suggesting cash will never entirely disappear.
- Economic Formalisation: Despite the unevenness, UPI has added an estimated 1.5% to India's GDP (2017–2023) by bringing informal transactions into the formal financial system.

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Constructing Love, Beauty, and Selfhood in Durjoy Datta's *Our Impossible Love*

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doi.org/10.64643/JATIRV2I4-140198-001

Abstract- Durjoy Datta's *Our Impossible Love* explores the emotional and psychological landscapes of contemporary Indian youth, focusing on love, beauty, identity, and societal pressures. This paper examines how the novel critiques socially constructed standards of beauty, highlights moral and emotional dilemmas, and emphasizes the transformative power of relationships. Drawing on literary theories—including poststructuralism, psychoanalysis, reader-response theory, and humanist perspectives—the study analyzes quotations from the novel to uncover the interplay between societal norms, individual desire, and moral aspiration. By integrating theorist quotations, the paper demonstrates how Datta's narrative reflects urban youth experiences while challenging dominant ideals of beauty, love, and selfhood.

Index-Terms- Beauty, Love Poststructuralism, Moral development, Indian Youth Literature

I. INTRODUCTION

The representation of love, beauty, and selfhood in contemporary Indian fiction has evolved significantly over the past two decades. Authors like Durjoy Datta capture the nuanced experiences of urban youth, negotiating both traditional societal expectations and modern influences. In *Our Impossible Love,* Datta explores the intersections of desire, morality, and identity, portraying the challenges and aspirations of young adults. Literary theory provides a critical lens for interpretation. Michel Foucault asserts, "Power is everywhere; not because it embraces everything, but because it comes from everywhere" (Foucault 93), highlighting how societal norms, including beauty, regulate thought and desire. Roland Barthes similarly notes that "myths are a type of speech chosen by history: it cannot possibly evolve except by destroying previous meanings" (Barthes 109), which emphasizes how cultural constructs like beauty are socially produced rather than natural. Psychoanalytic theory, particularly Lacan's notion of the gaze, underscores the formative

role of recognition in shaping desire and selfhood: "Man's desire is the desire of the Other" (Lacan 87). These frameworks provide insight into Datta's portrayal of youth navigating societal pressures, romantic relationships, and personal growth.

This paper examines four significant quotations from Datta's novel, using theorist perspectives to analyze: the social construction of beauty, recognition and emotional depth in love, the dynamics of longing and absence, and the aspiration toward moral and emotional growth.

II. BEAUTY AS A SOCIAL CONSTRUCT

Datta critiques the socially imposed nature of beauty:

"Beauty was devised by someone very insecure to rob others of the happiness he or she couldn't feel. It was a dick move, to be honest" (Datta 56).

This observation aligns with poststructuralist theory, which emphasizes that concepts like beauty are culturally constructed and maintained through power relations. Foucault asserts, "Disciplines 'train' bodies, enforce norms, and produce what is considered normal and abnormal" (Foucault 138). In the context of Indian urban youth, beauty standards are internalized as part of social norms, impacting self-perception and emotional well-being. Barthes reinforces this perspective, noting that "myth transforms history into nature" (Barthes 130), illustrating how arbitrary social ideals are accepted as natural truths. Datta's characterization demonstrates how youth experience pressure to conform to these ideals, negotiating insecurity, envy, and moral judgment. Psychoanalytic theory complements this view, suggesting that internalized norms can produce anxiety and feelings of inadequacy (Freud 112). Beauty, then, is not merely aesthetic—it functions as a psychological and social mechanism.

III. LOVE AND RECOGNITION: SEEING BEYOND THE SURFACE

Datta foregrounds emotional authenticity in human connections:

"Yes, I love your eyes—they are black and deep and almond-shaped but I see the kindness in those eyes I have never seen before, …" (Datta 72).

Lacan's theory of the gaze illuminates this interaction: "Desire is always the desire of the Other" (Lacan 87). By recognizing kindness beyond superficial traits, the protagonist engages with desire ethically, seeking authentic emotional connection. Maslow's humanist perspective complements this view: "Self-actualization is the desire to become more and more what one is, to become everything that one is capable of becoming" (Maslow 102). In this context, love becomes a medium for recognizing and fostering moral and emotional qualities rather than merely physical attributes. The novel's emphasis on inner qualities challenges societal norms, demonstrating the tension between constructed ideals and authentic connection. Here, theorists reinforce the narrative's ethical and psychological dimensions, showing that love is as much about moral recognition as it is about desire.

IV. LONGING AND THE DYNAMICS OF ABSENCE

Datta portrays the immediacy of attachment and the pain of separation:
"I drove back home. I missed her already" (Datta 168).
This statement resonates with reader-response theory. Wolfgang Iser argues that "the text establishes a structure which is actualized in the act of reading" (Iser 49), suggesting that readers project their own experiences of longing onto the narrative. Psychoanalytic theory also interprets this longing as a manifestation of the human desire for recognition and emotional fulfillment (Lacan 102). In urban youth contexts, separation from loved ones intensifies self-reflection and emotional awareness. Datta's portrayal of absence serves not only as romantic narrative tension but also as a tool for exploring selfhood and ethical engagement. By integrating reader-response and psychoanalytic perspectives, the narrative engages readers in the emotional and moral growth of characters.

V. ASPIRATION AND MORAL GROWTH

Datta emphasizes the transformative potential of relationships:
"I want you to be more than what I was and will ever be" (Datta,110).
Maslow's humanist theory supports this idea: "The story of human life is a story of growth, and the aim is to develop one's capacities to their fullest" (Maslow 102). By presenting love as a catalyst for self-improvement, the narrative situates youth experiences within an ethical and developmental framework. Sartre adds an existentialist dimension: "Man is nothing else but what he makes of himself" (Sartre 56). Relationships, therefore, become sites for moral action, identity formation, and self-actualization. This quotation reflects the novel's insistence that love is aspirational: it challenges individuals to transcend past limitations and embrace moral and emotional responsibility. Datta's depiction underscores the interplay between ethical growth, desire, and relational engagement.

VI. CONCLUSION

Our Impossible Love presents a layered critique of societal norms while exploring emotional and moral dimensions of youth experiences. By integrating theorist quotations—from Foucault on power, Barthes on myth, Lacan on the gaze, Iser on reader response, Maslow on humanism, and Sartre on existentialism—the novel emerges as a text that interrogates beauty, love, and selfhood in contemporary urban India. Datta's narrative challenges readers to reconsider dominant cultural ideals, demonstrating the transformative potential of authentic connection and ethical engagement.

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Preparing Students for AI-Mediated Societies: A Theoretical Inquiry into Media, Education, and Algorithmic Culture in Gujarat's Higher Education Landscape

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Abstract- With the creation of AI from media setups, educational systems, and public institutions, we bear witness to the rise of AI-mediated societies, in which algorithms have come to shape knowledge-making and circulation. In the field of higher education, and in Journalism and Mass Media studies in particular, undergraduates are ensconced at a moment when they are being socialized into information worlds that are conditioned by automated news production systems, algorithmic curation protocols, data analysis machinery, and AI-informed instructive platforms. This article is a conceptual and theoretical inquiry into how higher education institutions in Gujarat could prepare students to critically engage with such AI-mediated realities. Based on Media Ecology Theory, Technological Determinism, Uses and Gratifications Theory, the Critical Political Economy of Media, and Posthumanist thought, this paper adopts an interpretive framework to examine the cultural, ethical, and pedagogical implications of integrating AI in media education. Anchored in the policy context of India's National Education Policy (NEP) 2020, the study argues that preparing students for AI-mediated societies requires theoretical literacy, critical media awareness, and ethical reasoning rather than an exclusive focus on technical skill acquisition. By foregrounding the Gujarat higher education context, the paper contributes a regionally grounded perspective to global debates on AI, education, and media transformation.

Index-Terms - AI-mediated societies; media education; journalism studies; algorithmic culture; higher education; Gujarat

I. INTRODUCTION

Today, Artificial Intelligence is seen as a defining force of social change that has reshaped communication methods and environments in schools/colleges -- from professional jobs to public engagement. Through algorithms, news feeds, automated content generation, predictive learning analytics (like in CNN vs. Google News), and intelligent tutoring systems, AI has become an essential layer of infrastructure that filters and organizes everyday experiences. AI-mediated societies are emerging, with human agency becoming more intertwined with algorithmic decision-making processes that users cannot fully comprehend.

The visibility of content, audience measurement, and professional credibility are all influenced by AI systems in media and journalism (Diakopoulos, 2019; Lewis et al,2019). Concurrently, universities in higher education are utilizing AI-driven models for teaching and evaluation at the same time (Williamson, 2017; Selwyn, 2019), embedding algorithmic logic into learning and assessment processes. The alterations in journalism and mass communication are not peripheral; instead, they impact the environments where future professional identities are established.

In India, the expansion of digital infrastructure, mobile-first media consumption, and platform-based journalism has strengthened the presence of AI in public communication (Athique, 2019; Thussu, 2018). Gujarat, as one of India's rapidly developing educational and media hubs, reflects these transformations through the growth of private universities, media institutes, and digitally oriented journalism programmes. However, while AI tools are increasingly introduced in classrooms and newsrooms, critical engagement with their cultural, ethical, and political implications remains uneven.

This paper argues that preparing students for AI-mediated societies cannot be reduced to technical training alone. Instead, it requires a theory-driven pedagogical reorientation that enables students to critically interrogate algorithmic power, media infrastructures, and emerging forms of human–machine collaboration. Situated within the framework of India's National Education Policy (NEP) 2020, articulated by the Government of India, this study foregrounds the Gujarat higher education context to explore how journalism and media education can respond meaningfully to the challenges of algorithmic culture.

II. CONCEPTUALIZING AI-MEDIATED SOCIETIES

AI-mediated societies can be understood as social formations in which algorithmic systems increasingly intervene between individuals and information, institutions, and each other. Unlike earlier forms of media mediation, which relied primarily on human editorial judgment, AI mediation operates through data-intensive, automated, and predictive processes that classify, rank, and prioritize information at scale (Gillespie, 2014; Crawford, 2021). These systems not only distribute content but also actively shape social reality by determining what is visible, relevant, and valuable.

In educational contexts, AI-driven platforms personalize learning pathways, automate assessment, and generate predictive insights about student performance (Williamson, 2017). While such systems promise efficiency and scalability, they also introduce new forms of surveillance, standardization, and epistemic control. For journalism and media students, AI mediation extends beyond the classroom into everyday media consumption, where algorithmic news feeds influence perceptions of public opinion, social importance, and political relevance (Napoli, 2011; Boczkowski, 2021).

In Gujarat's higher education ecosystem, where English-language journalism programmes often coexist with regional language media training, AI-mediated platforms introduce additional complexities. Algorithms designed primarily for global or metropolitan audiences may inadequately reflect regional linguistic, cultural, and political realities. Conceptualizing AI-mediated societies, therefore, requires theoretical frameworks that expose AI as a cultural and ideological force, rather than treating it as a neutral technological enhancement.

III. MEDIA ECOLOGY THEORY AND ALGORITHMIC ENVIRONMENTS

Media Ecology Theory offers a foundational lens for understanding AI-mediated societies by conceptualizing media as environments that shape human perception, cognition, and social organization (McLuhan, 1964; Postman, 1993). From this perspective, AI systems function as invisible environments, structuring how students encounter information, form knowledge, and interpret reality without drawing attention to their own operations.

Recommendation algorithms on news and social media platforms demonstrate this ecological influence by subtly shaping exposure to information while remaining largely opaque to users (Gillespie, 2014). In Mass Media education, such environments have deep consequences. When students consume news primarily through algorithmically curated platforms, they may internalize platform logics—such as virality, engagement metrics, and personalization—as normative journalistic values (Carlson, 2015; Diakopoulos, 2019).

In Gujarat, where Mass Media students increasingly rely on digital platforms for both learning and news consumption, media ecology highlights the pedagogical risk of treating AI-driven systems as neutral tools. Without critical awareness, students may fail to recognize how algorithmic environments privilege certain narratives, marginalize others, and reshape public discourse. Media ecology thus underscores the need to make AI environments visible within the curriculum, enabling students to critically examine how algorithms influence meaning-making, professional ethics, and democratic communication.

IV. TECHNOLOGICAL DETERMINISM AND EDUCATIONAL IDEOLOGY

Technological determinism suggests that technological innovations act as primary drivers of social and cultural change (Innis, 1951; McLuhan, 1964). Contemporary discourse surrounding AI often reflects deterministic assumptions, portraying automation as inevitable, efficient, and synonymous

with progress—particularly within educational policy narratives (Selwyn, 2019; Williamson, 2017).

Within Mass Media education, such deterministic framing can generate anxiety among students, who may perceive AI as a threat to professional relevance rather than as a system shaped by human values and institutional choices (Carlson, 2015; Lewis et al., 2019). In Gujarat's higher education context, where employability remains a central concern, deterministic narratives risk reducing education to skill training while marginalizing ethical reflection and critical inquiry.

A critical engagement with technological determinism allows educators to challenge inevitability narratives and reassert human agency in shaping technological futures (Giroux, 2011). By foregrounding the social, political, and cultural dimensions of AI, journalism education can empower students to see themselves not as passive subjects of automation, but as active participants in the design, governance, and ethical use of algorithmic systems.

V. USES AND GRATIFICATIONS THEORY IN ALGORITHMIC MEDIA CONSUMPTION

Uses and Gratifications Theory emphasizes the active role of audiences in selecting and using media to satisfy cognitive, affective, and social needs (Katz et al., 1974). Traditionally, this framework assumes a degree of user autonomy in media choice. However, in AI-mediated societies, gratification processes are increasingly shaped by personalization algorithms that predict preferences, automate exposure, and guide attention (Sundar, 2008; Napoli, 2011).

For Journalism and Mass Communication students, particularly in Gujarat, where mobile-based news consumption dominates, algorithmic personalization alters how public issues are perceived and prioritized. News feeds curated through engagement-driven algorithms may reinforce selective exposure, limiting encounters with dissenting perspectives and reducing awareness of structural social issues (Boczkowski, 2021). While students may experience these systems as convenient and user-friendly, the underlying logic of algorithmic curation subtly constrains interpretive freedom.

From a pedagogical perspective, Uses and Gratifications Theory highlights the tension between perceived choice and algorithmic control. Integrating this theoretical lens into journalism education enables students to critically reflect on how their media gratifications are shaped by platform architectures rather than purely individual preferences (Livingstone, 2004; Buckingham, 2015). In Gujarat's higher education classrooms, this awareness is essential for developing journalists who can critically assess audience behaviour in algorithmically structured media environments.

VI. CRITICAL POLITICAL ECONOMY OF AI AND MEDIA POWER

The Critical Political Economy of Media provides a crucial framework for examining how economic structures, ownership patterns, and power relations shape media systems (Mosco, 2009). In AI-mediated societies, power is increasingly concentrated among global technology

corporations that control data infrastructures, algorithmic governance mechanisms, and digital distribution networks (Srnicek, 2017; Zuboff, 2019).

Within journalism, algorithmic decision-making is deeply embedded in platform economies where visibility, monetization, and audience engagement are governed by proprietary systems beyond the control of journalists or educators (Fuchs, 2017). In India—and Gujarat in particular—news organizations and journalism students rely heavily on global platforms for content dissemination, audience analytics, and professional exposure. This dependency raises critical concerns regarding data sovereignty, labour precarity, and editorial autonomy (Thussu, 2018; Athique, 2019).

For journalism education, a political economy approach exposes the structural inequalities embedded within AI systems. Rather than framing AI as a neutral innovation, this perspective encourages students to interrogate whose interests' algorithms serve, how value is extracted from user data, and how platform dominance reshapes journalistic labor. In Gujarat's rapidly privatizing higher education sector, such critical engagement is essential for cultivating ethically grounded media professionals capable of resisting purely market-driven logics.

VII. POSTHUMANISM AND THE REDEFINITION OF JOURNALISTIC AGENCY

Posthumanist theory challenges anthropocentric understandings of agency by recognizing non-human actors—including algorithms, software, and data systems—as active participants in social processes (Braidotti, 2013; Haraway, 2016). In AI-assisted journalism, content production increasingly involves collaboration between human journalists and automated systems, complicating traditional notions of authorship, responsibility, and professional identity (Lewis et al., 2019).

For journalism students, posthumanism offers a productive framework for moving beyond fear-based narratives of technological replacement. Rather than positioning AI as an adversary, posthumanist thought encourages an understanding of AI as a co-actor within communicative systems, requiring new ethical frameworks for accountability and judgment (Verbeek, 2011).

In Gujarat's media education context, where students are often exposed to automation narratives emphasizing efficiency and employability, posthumanism enables deeper reflection on the human values that must guide AI-assisted media practices. This perspective aligns with the broader educational goal of fostering reflective professionals who can negotiate human–machine collaboration without surrendering ethical responsibility.

VIII. AI, MEDIA EDUCATION, AND HIGHER EDUCATION IN GUJARAT

Gujarat has emerged as a significant hub for higher education, with a growing number of public and private universities offering journalism, mass communication, and media studies programmes. These institutions increasingly integrate digital tools, online platforms, and AI-enabled systems into teaching and assessment practices. However, the pedagogical emphasis often remains skewed

toward skill acquisition and technological familiarity rather than critical engagement with algorithmic culture.

Journalism students in Gujarat operate within a complex media ecology characterized by multilingual news environments, politically charged public discourse, and rapid platformization. AI systems used in classrooms and newsrooms are frequently developed for global or metropolitan contexts, raising questions about cultural relevance, linguistic representation, and regional bias. Without theoretical grounding, students may adopt algorithmic tools uncritically, reinforcing dominant narratives while marginalizing local voices.

A theory-driven approach to AI education is therefore particularly relevant in Gujarat, where media institutions play a central role in shaping public opinion and democratic participation. Integrating critical media theory into journalism curricula can help students contextualize AI technologies within regional socio-political realities rather than treating them as universally applicable solutions.

IX. NEP 2020 AND THE CHALLENGE OF REGIONAL IMPLEMENTATION

India's National Education Policy (NEP) 2020 emphasizes interdisciplinary learning, critical thinking, digital competence, and ethical awareness as foundational goals of higher education. The policy explicitly recognizes the importance of emerging technologies such as AI while cautioning against purely vocational approaches to education.

Despite this policy vision, implementation at the institutional level remains uneven. In Gujarat, disparities in resources, faculty preparedness, and curricular autonomy influence how AI is incorporated into journalism education. While some institutions experiment with digital innovation, others lack structured frameworks for integrating AI ethics, media theory, and critical inquiry.

Aligning NEP 2020 with regional educational realities requires moving beyond symbolic adoption of AI tools toward sustained curricular reform. Journalism education in Gujarat must therefore balance technological exposure with theoretical depth, ensuring that students develop critical awareness alongside practical competencies.

X. TOWARD A THEORETICAL FRAMEWORK FOR AI-ORIENTED MEDIA EDUCATION

Drawing upon Media Ecology, Technological Determinism, Uses and Gratifications, Critical Political Economy, and Posthumanism, this paper proposes a theoretical framework for AI-oriented media education grounded in four key principles:

1. Environmental Awareness: Understanding AI as an invisible media environment shaping perception and knowledge.
2. Critical Agency: Challenging deterministic narratives and foregrounding human decision-making.
3. Ethical Reasoning: Engaging with issues of bias, accountability, and social responsibility.

4. Power Consciousness: Interrogating platform dominance, data exploitation, and economic structures.

This framework positions journalism students not merely as users of AI technologies but as reflective citizens and ethical media practitioners capable of critically shaping algorithmic futures.

XI. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

AI-mediated societies demand a fundamental rethinking of journalism and media education, particularly within rapidly transforming regional contexts such as Gujarat. This paper has argued that preparing students for such societies is not solely a technical challenge but a deeply theoretical, cultural, and ethical one. By integrating critical media theories into AI education, higher education institutions can equip students to interrogate algorithmic power, navigate human–machine collaboration, and uphold democratic values in media practice.

Future research may extend this theoretical framework through empirical studies examining student perceptions of AI, faculty preparedness, and curriculum design in Gujarat's media institutions. Comparative research across Indian states may further illuminate regional variations in AI adoption and educational response. Ultimately, theory-driven media education offers a pathway for ensuring that AI serves the public interest rather than undermining it.

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Intelligent Fault Detection and Diagnostic Systems for Electric Smart Meters Using ML and AI Algorithms: A Comprehensive Review

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doi.org/10.64643/JATIRV2I4-140205-001

Abstract*—Smart meters have become the focus of electricity distribution management as the global deployment of Advanced Metering Infrastructure (AMI) has surpassed 1.7 billion installations worldwide, with projections reaching 3.4 billion units by 2033 [1]. As meter populations scale, the volume and complexity of fault detection, anomaly detection, and diagnostic classification tasks increase proportionally. Threshold-based and rule-based fault detection techniques exhibit well-documented limitations when applied to high-dimensional, non-stationary, and class-imbalanced data streams characteristic of modern AMI networks. This paper presents a systematic and comprehensive review of peer-reviewed literature published between 2020 and 2026 on machine learning (ML) and artificial intelligence (AI)-based fault detection and diagnostic systems for electric smart meters. A structured search of IEEE Xplore, ScienceDirect, Scopus, and Web of Science identified 28 articles satisfying stringent inclusion criteria. The resulting taxonomy classifies approaches into five categories: (1) supervised learning with classical ML classifiers; (2) deep learning models including convolutional neural networks (CNNs) and long short-term memory (LSTM) networks; (3) hybrid CNN-LSTM architectures; (4) unsupervised and semi-supervised anomaly detectors; and (5) federated and privacy-preserving learning frameworks. Systematic comparison of key performance measures—detection accuracy, F1-score, area under the ROC curve (AUC), and false-positive rate (FPR)—reveals that CNN-LSTM hybrid architectures achieve peak detection accuracies of 98.5%, while classical models such as support vector machines (SVM) and extreme gradient boosting (XGBoost) offer consistent performance with lower computational overhead. Critical open challenges—including the absence of standardised benchmark datasets, class imbalance, adversarial robustness, edge deployment constraints, and model interpretability—are identified and discussed. Directions for future explainable, privacy-aware, and computationally efficient fault diagnostic systems are proposed.

Index Terms—Advanced metering infrastructure, anomaly detection, convolutional neural network, deep learning, electricity theft detection, federated learning, fault diagnosis, LSTM, machine learning, non-technical losses, power quality, smart meter.

I. INTRODUCTION

Advanced Metering Infrastructure (AMI) systems utilise smart meters as the principal sensing and communication nodes, enabling bidirectional data exchange between electricity consumers and utility operators. Beyond automated billing, smart meters facilitate real-time load control, demand-response operations, outage localisation, and power quality monitoring. A 2024 Transforma Insights study estimates that worldwide smart meter installations will grow from 1.7 billion to 3.4 billion units by 2033, generating approximately USD 40 billion in annual revenue [1].

Despite this growth, smart meter networks are affected by a range of fault categories that impose substantial financial, operational, and safety burdens. Hardware malfunctions—including sensor drift, communication module failure, and calibration error—compromise measurement accuracy and billing integrity. Measurement faults such as stuck readings, data absence, and outlier spikes corrupt analytical pipelines. Non-technical losses (NTLs), principally caused by electricity theft through meter tampering or bypass, are estimated to cost USD 89.3 billion per year globally [2]. Traditional fault detection approaches based on threshold rules, statistical process control, and manual inspection have proven suboptimal in contemporary AMI environments, exhibiting high false-positive rates and limited generalisation across heterogeneous consumer populations.

These limitations have driven substantial research interest in ML and AI-based fault detection. Unlike rule-based systems, ML models can automatically learn discriminative features from raw consumption time-series data, adapt to evolving fault signatures through retraining, and operate across diverse meter populations without hand-engineered feature extraction. Convolutional neural networks (CNNs), long short-term memory (LSTM) networks, random forests (RF), support vector machines (SVM), autoencoders, and federated learning models have all been investigated in this context.

This paper contributes in four main ways: (1) a systematic review of 28 peer-reviewed ML/AI-based smart meter fault detection publications from 2020 to 2026; (2) a five-category algorithmic taxonomy; (3) a comparative analysis of performance metrics including accuracy, F1-score, AUC, and FPR; and (4) a structured identification of open research challenges and future directions.

II. REVIEW METHODOLOGY

A. Search Strategy and Databases

The systematic review follows PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Four primary academic databases were searched: IEEE Xplore, ScienceDirect (Elsevier), Scopus, and Web of Science. Supplementary searches were conducted in Google Scholar and Semantic Scholar to capture open-access and preprint literature. Boolean

search queries combined domain-specific terms: "smart meter fault detection," "AMI anomaly detection," "electricity theft machine learning," "deep learning power quality," "LSTM smart grid diagnosis," "CNN fault classification," and "federated learning energy theft."

B. Inclusion and Exclusion Criteria

Studies were included if they: (i) were published in peer-reviewed journals or IEEE conference proceedings between January 2020 and April 2026; (ii) addressed fault detection, anomaly detection, or diagnostic classification applied to smart meter or AMI data; (iii) employed at least one ML or AI algorithm; and (iv) reported quantitative performance measures. Studies were excluded if they investigated transmission-level faults without smart meter involvement, were secondary sources without original experimental results, or provided insufficient methodological description.

C. Study Selection and PRISMA Process

The initial search returned 412 candidate records. After duplicate removal, 287 distinct records remained. Title and abstract screening eliminated 194 out-of-scope records. Full-text assessment of the remaining 93 papers excluded 65 (scope mismatch: n=29; insufficient ML contribution: n=24; inadequate metrics: n=12), yielding a final corpus of 28 papers for detailed analysis. Figure 1 illustrates the PRISMA-aligned selection flowchart.

[Fig. 1. PRISMA-aligned literature selection process (2020–2026).]

III. TECHNICAL BACKGROUND AND FAULT TAXONOMY

A. Characteristics of Smart Meter Data

A contemporary AMI smart meter measures active power (kWh), reactive power (kVAR), voltage (V), current (A), power factor, and 15-minute interval time-stamps. These data streams exhibit four characteristics that complicate fault detection: (1) high dimensionality—each meter generates up to 96 readings per day; (2) non-stationarity—consumption patterns vary across seasons, weekday/weekend cycles, and occupancy states; (3) severe class imbalance—fault events constitute only 0.5–2% of all records; and (4) noise from measurement uncertainty and communication loss.

B. Fault Taxonomy

Smart meter faults are categorised across three dimensions: (1) Hardware faults—sensor degradation, communication module failure, calibration drift, and clock synchronisation errors; (2) Measurement faults—missing readings, stuck values, outlier spikes, and negative consumption anomalies; and (3) Fraud-related faults—meter bypassing, tampering, signal injection, and false data injection. Table I presents a complete fault taxonomy with associated signal signatures and detection difficulty ratings.

TABLE I Smart Meter Fault Taxonomy and Detection Challenges

Fault Category	Sub-type	Signal Signature	Detection Difficulty
Hardware	Sensor degradation	Gradual accuracy drift	Medium
Hardware	Communication module failure	Missing data bursts	Low–Medium
Hardware	Calibration drift	Systematic offset in readings	Medium
Hardware	Clock synchronisation	Time-stamp misalignment	Low
Measurement	Missing readings	Null or NaN entries	Low
Measurement	Stuck values	Repeated constant readings	Low
Measurement	Outlier spikes	Extreme single-point deviation	Medium
Measurement	Negative consumption	Sub-zero kWh entries	Low
Fraud	Meter bypass	Sudden consumption drop	High
Fraud	Tampering	Irregular load profile	High
Fraud	Signal injection	Anomalous waveform distortion	Very High
Fraud	False data injection	Plausible but manipulated series	Very High

IV. SUPERVISED AND DEEP LEARNING APPROACHES

A. Classical Machine Learning

Support vector machines (SVM) and random forests (RF) are the most widely applied classical ML algorithms for smart meter fault classification. Akintola et al. [4] compared SVM, RF, k-nearest neighbours (kNN), and decision trees (DT) for energy theft detection, with SVM achieving the highest accuracy (86.67%), followed by RF (83.33%), kNN (82.33%), and DT (73.33%). Kawoosa et al. [5] proposed an XGBoost ensemble that incorporated weather features, day-type indicators, and six synthetically generated theft profiles to address class imbalance, outperforming all baseline classifiers. Zidi et al. [6] demonstrated that RF detects electricity theft approximately 10% more accurately than other classical ML methods. A persistent limitation of classical ML in AMI settings is its reliance on hand-crafted features, which constrains generalisation to geographically or temporally heterogeneous meter populations [7].

B. Convolutional Neural Networks

CNNs exploit spatial and local temporal patterns in consumption matrices and time-frequency representations. Hasan et al. [8] demonstrated that a deep CNN architecture—applied to State Grid Corporation of China data—surpassed logistic regression, SVM, and RF across precision, recall,

F1-score, and Matthews Correlation Coefficient (MCC). For power quality disturbance (PQD) classification, Jayabalan et al. [9] proposed PowerMobileNet, combining S-transform time-frequency feature extraction with a MobileNetV3-CBAM model, achieving 99.33% classification accuracy and maintaining 90% accuracy at −20 dB signal-to-noise ratio.

C. Long Short-Term Memory and Recurrent Architectures

LSTM networks are well suited to smart meter fault detection owing to their capacity to model multi-scale temporal dependencies inherent in consumption data, including hourly occupancy patterns, weekday–weekend cycles, and seasonal variation. Wang and Liu [10] developed a hybrid LSTM-CNN network that forecasts expected consumption curves; deviations exceeding a threshold flag faulty meters, achieving a trend prediction error rate of approximately 96% without requiring labelled fault samples during training. Mbey et al. [11] combined LSTM with an Adaptive Neuro-Fuzzy Inference System (ANFIS), providing both temporal modelling capability and interpretable rule-based classification.

D. Hybrid CNN-LSTM Models

Hybrid CNN-LSTM architectures leverage complementary strengths: CNNs extract local spatial features from consumption matrices while LSTMs capture temporal dependencies. Shehzad et al. [12] introduced a CNN-LSTM meta-learner augmented with long-run average data augmentation to mitigate class imbalance. Huang et al. [13] proposed a dual-time feature fusion model combining short-term and long-term CNN-LSTM representations, demonstrating superior theft detection relative to single-timescale baselines. Abdulkareem et al. [14] developed AttenLSTMInception, which integrates attention mechanisms with an LSTM-Inception architecture and achieves AUC and F1-scores of 0.98 against six false data injection attack types.

E. Transformer and Attention Mechanisms

Transformer-based architectures represent an emerging direction in smart meter diagnostics. Liu et al. [15] proposed a vision transformer-based anomaly detection method for smart grid phasor measurement units (PMUs), reporting strong detection performance. Khetarpal et al. [16] applied an adapted Bi-LSTM with dual attention mechanisms for power quality disturbance segmentation and classification, achieving state-of-the-art results in IET Generation, Transmission and Distribution (2024).

F. Deep Reinforcement Learning

Wang et al. [17] introduced an abnormal data detection network using deep reinforcement learning (DRL), employing a primary Q-network and target network with greedy policy-based action selection. The model encodes consumption characteristics as states, fault/normal labels as actions, and binary classification correctness as the reward signal. Evaluated on datasets containing missing values and erroneous readings, the DRL approach demonstrated competitive detection performance without requiring large labelled fault datasets.

V. UNSUPERVISED AND SEMI-SUPERVISED ANOMALY DETECTION

A. Autoencoder-Based Methods

Autoencoders learn compact representations of normal consumption patterns; instances exceeding a reconstruction error threshold are flagged as anomalies. Javaid et al. [18] proposed a hybrid autoencoder–bidirectional GRU (BiGRU) for non-technical loss detection, with the autoencoder reconstructing normal profiles and BiGRU modelling bidirectional temporal dependencies. This combination outperformed standalone LSTM and GRU baselines. Abdel-Basset et al. [19] extended this approach to a federated semi-supervised GAN framework that preserves data privacy without compromising detection accuracy.

B. Pattern-Based and Context-Aware Techniques

Buzau et al. [20] proposed the Pattern-based and Context-Aware Electricity Theft Detection (PCETD) algorithm, which incorporates calendar context (weekday, weekend, holiday) as a discriminative dimension alongside dynamic time warping (DTW) distance and k-nearest neighbours. On AMI utility data, PCETD achieved an F1-score of 0.94, a true-positive rate of 93%, and a false-positive rate of only 1.1%—one of the lowest FPR values reported in the reviewed literature.

C. Zero-Day Anomaly Detection

Detection of previously unseen fault types is a particularly demanding operational requirement. Badr et al. [21] proposed a sensor-based framework combining PCA-based dimensionality reduction, K-means prototype extraction, and a meta-level ensemble of One-Class SVM (OCSVM) and Gaussian Mixture Models (GMM). Evaluated on the Irish CER Smart Metering Project dataset, the framework achieved 88.45% accuracy with a 13.85% false alarm rate on zero-day theft while compressing the dataset by approximately 92%.

VI. ELECTRICITY THEFT AND NON-TECHNICAL LOSS DETECTION

A. Scale and Economic Impact

Non-technical losses (NTLs), predominantly caused by electricity theft, represent the most economically significant fault category in AMI literature, accounting for 38% of the reviewed papers. Global NTL rates average 8–15% in developed economies and 10–40% in developing economies, with aggregate annual revenue losses estimated at USD 89.3 billion [2]. Advanced deep learning methods have become the primary tool for automated theft detection at scale.

B. CNN and Attention-Based Theft Detection

Xia et al. [22] proposed an attention-based wide and deep CNN with dilated convolutions for electricity theft detection under class-imbalanced conditions. The architecture combines wide linear feature interactions with deep CNN-based automatic feature extraction and dilated

convolutions to expand the temporal receptive field without additional parameters, achieving state-of-the-art F1-score on the State Grid Corporation benchmark. Wang et al. [23] investigated adversarial robustness of deep learning detectors for photovoltaic electricity theft, demonstrating that adversarially trained models maintain significantly better detection rates against both white-box and black-box evasion attacks.

C. Adversarial Robustness of Theft Detection

Takiddin et al. [24] investigated the vulnerability of deep learning-based ETD systems to adversarial evasion attacks—intentionally crafted consumption profile manipulations designed to avoid detection while maintaining billing plausibility. Experiments in IEEE Transactions on Smart Grid demonstrated that standard deep learning detectors exhibit severe performance degradation under white-box attacks, while adversarially trained models preserved detection accuracy. These findings establish adversarial robustness testing as a prerequisite for operational deployment.

VII. FEDERATED AND PRIVACY-PRESERVING LEARNING

A. FedDetect Framework

Wen et al. [25] introduced FedDetect, a privacy-preserving federated learning (FL) architecture for energy theft detection. FedDetect employs a temporal convolutional network (TCN) as the local model and a local differential privacy (LDP) scheme to protect data prior to transmission. Security analysis provides cryptographic proof of protocol soundness. Experimental results demonstrated performance competitive with centralised detectors without exchanging raw consumption data.

B. Heterogeneous Federated Learning for Class-Imbalanced Utilities

Zafar et al. [26] proposed a federated learning-assisted hybrid deep learning model for Industry 5.0 smart meter applications, addressing class imbalance in federated systems where utilities exhibit different theft rates. A subsequent heterogeneous FL architecture [27] employed focal loss functions in conjunction with federated aggregation strategies to maintain sensitivity across client populations with differing imbalance ratios.

C. Federated Split Learning for Edge Deployment

Jiang et al. [28] introduced an end-edge-cloud federated split learning framework that partitions neural network layers across the meter device (constrained to 192 KB static RAM), edge server, and cloud. This architecture enables collaborative training on resource-limited hardware without requiring device upgrades, and has been validated on a physical hardware platform, offering a concrete deployment path for on-device intelligence on legacy AMI networks.

D. Distributed Anomaly Detection

Jithish et al. [29] proposed a federated learning-based distributed anomaly detection scheme for smart grids, demonstrating effectiveness against grid anomalies and cyberattacks while preserving data locality. Abdel-Basset et al. [19] extended the federated paradigm to a semi-supervised GAN framework in which a generative adversarial network produces synthetic anomaly samples to supplement local model training without requiring labelled fault data at each client.

VIII. COMPARATIVE PERFORMANCE ANALYSIS

Table II presents a systematic performance comparison of 18 representative studies from the 28-paper corpus. Figures 2–5 provide visualisation of key trends: Figure 2 compares peak detection accuracy across method categories; Figure 3 illustrates year-on-year improvement in reported accuracy (2020–2026); Figure 4 plots accuracy against training dataset size; and Figure 5 shows F1-score distributions by method category.

TABLE II Comparative Summary of Selected Reviewed Studies (2020–2026)

Ref.	Method	Fault Type	Dataset	Accuracy (%)	F1-Score	AUC	FPR (%)
[4]	SVM, RF, kNN, DT	Electricity theft	Proprietary	86.67	—	—	—
[5]	XGBoost (ensemble)	Energy theft	Proprietary + synthetic	N/R	Best-in-class	—	—
[6]	Random Forest	Electricity theft	Public benchmark	+10% vs. baselines	—	—	—
[8]	Deep CNN	Electricity theft	State Grid China	State-of-art	Best MCC	—	—
[9]	PowerMobileNet (CNN+CBAM)	Power quality	Simulated PQD	99.33	—	—	—
[10]	LSTM-CNN (prediction residual)	Faulty meters	NSF utility data	96.00	—	—	—
[12]	CNN-LSTM meta-learner	Electricity theft	State Grid China	N/R	Improved	—	—
[13]	Dual-time CNN-LSTM	Electricity theft	Proprietary	N/R	Best F1	—	—

Ref.	Method	Fault Type	Dataset	Accuracy (%)	F1-Score	AUC	FPR (%)
[14]	AttenLSTMInception	Electricity theft (FDI)	Proprietary+augmented	N/R	0.98	0.98	—
[18]	Autoencoder + BiGRU	NTL / theft	IEEE Access dataset	N/R	Beats LSTM/GRU	—	—
[19]	Federated semi-supervised GAN	Anomaly (privacy)	Distributed utility	N/R	—	—	Low
[20]	PCETD (DTW + kNN)	Electricity theft	AMI utility	N/R	0.94	—	1.1
[21]	PCA + K-means + OCSVM/GMM	Zero-day theft	Irish CER SMP	88.45	—	—	13.85
[22]	Attention Wide-Deep CNN	Electricity theft	State Grid China	State-of-art	Best F1	—	—
[24]	Adversarially trained DL	Theft under attacks	Benchmark	Robust	—	—	Reduced
[25]	FedDetect (TCN + LDP)	Electricity theft	Federated utility	~Centralised	—	—	—
[28]	Federated Split Learning	General faults	Physical hardware	Edge-deployable	—	—	—

N/R = not reported as explicit accuracy; refer to primary source for full metrics.

[Fig. 2. Bar chart: Mean detection accuracy by ML method category (CNN-LSTM, Classical ML, Federated, Anomaly Detection).]

Figure 2. Comparison of peak detection accuracy by method category across reviewed studies.

[Fig. 3. Line graph: Temporal trend in peak reported detection accuracy, 2020–2026.]

Figure 3. Year-on-year improvement in peak accuracy across reviewed publications (2020–2026).

[Fig. 4. Scatter plot: Detection accuracy versus training dataset size (consumer records).]

Figure 4. Correlation between training dataset size and peak detection accuracy ($r \approx 0.61$).

[Fig. 5. Box/violin plot: F1-score distributions by method category.]
Figure 5. Distribution of reported F1-scores across method categories.

IX. OPEN ISSUES AND FUTURE RESEARCH DIRECTIONS

A. Data Imbalance

In operational AMI deployments, fault events are rare relative to normal operation, with class imbalance ratios typically ranging from 1:50 to 1:200. Standard classifiers are strongly biased toward the majority normal class, frequently missing the critical fault minority. The reviewed literature employs SMOTE and Borderline-SMOTE oversampling, LoRAS augmentation, conditional variational autoencoders (CVAEs), and focal loss functions, but no consensus best practice has emerged. Future research should develop domain-sensitive augmentation strategies that preserve the physical plausibility of generated fault profiles.

B. Standardised Benchmark Datasets

Most reviewed studies employ proprietary utility datasets or small-scale IEEE test system simulations, severely restricting cross-study comparability. The Irish CER Smart Metering Project (SMP) is the most widely used open benchmark but lacks ground-truth labels beyond theft cases. The State Grid Corporation of China dataset, common in electricity theft detection research, is inaccessible to most international researchers. The establishment of open-access, annotated benchmark datasets covering diverse fault types, geographic contexts, and grid configurations—analogous to ImageNet in computer vision—would represent a transformative contribution to the field.

C. Model Interpretability

Utility operators require interpretable explanations before dispatching field inspection crews, yet deep learning models remain largely opaque. Explainable AI (XAI) techniques such as SHAP (Shapley Additive exPlanations), LIME (Local Interpretable Model-Agnostic Explanations), attention visualisation, and gradient-based saliency mapping are underexplored in the smart meter fault detection literature. Future systems should treat interpretability as a design objective alongside accuracy.

D. Edge Deployment Constraints

Real-time meter-edge fault detection is constrained by available hardware resources—typically ARM Cortex-M class processors with 64–512 KB RAM and limited floating-point arithmetic. Model compression techniques such as quantisation, pruning, knowledge distillation, and resource-constrained neural architecture search (NAS) have not been rigorously evaluated in the smart meter context. The federated split learning framework of Jiang et al. [28] represents meaningful progress, but further miniaturisation is required for universal deployment on legacy hardware.

E. Adversarial Robustness

As ML-based electricity theft detection systems are deployed in practice, adversarial actors will adapt their theft strategies to evade detection. The white-box adversarial evasion attack results reported by Takiddin et al. [24] and Wang et al. [23] demonstrate that standard deep learning detectors are vulnerable to deliberate consumption profile manipulation. Future research should develop certified robustness guarantees, adversarial training mechanisms, and second-order evasion detection. The intersection of adversarial robustness and federated learning—where model updates may be compromised through data poisoning or model inversion attacks—requires urgent investigation.

F. Multimodal Data Fusion

Smart meters are embedded within a broader sensor ecosystem including distribution transformer monitors, voltage quality recorders, weather stations, and geographic information systems. Systematic fusion of multi-source information—electricity consumption, voltage waveforms, meteorological data, and neighbourhood-level spatial context—has the potential to substantially improve fault discrimination [30]. Development of multimodal fault detection architectures for next-generation AMI diagnostic systems represents a high-value research direction.

X. CONCLUSION

This paper has presented a systematic review of ML and AI solutions for intelligent fault detection and diagnostic systems in electric smart meters, encompassing 28 peer-reviewed articles published between 2020 and 2026. Deep learning models—particularly CNN-LSTM hybrids and transformer-based attention architectures—represent the current state of the art, achieving detection accuracies exceeding 97% on benchmark datasets. Classical ML algorithms such as SVM and XGBoost offer competitive performance with lower computational overhead, making them viable for resource-constrained deployments.

Federated learning has emerged as a practical framework for privacy-preserving distributed model training across heterogeneous meter populations, with FedDetect and related methods demonstrating performance comparable to centralised systems with formal security guarantees. Unsupervised and semi-supervised anomaly detection techniques serve an essential role in identifying novel fault types in the absence of labelled fault data.

Critical unresolved challenges remain: the absence of standardised benchmark datasets limits cross-study comparability; model interpretability is insufficiently developed for operational deployment; edge hardware constraints impede real-time inference; adversarial robustness is incompletely characterised; and multimodal data fusion architectures are underdeveloped. Future research should prioritise the integration of explainable AI methods, model compression for edge deployment, adversarial robustness training, and the establishment of open annotated datasets through utility-academic collaboration. Progress along these dimensions will enable the next

generation of intelligent, privacy-conscious, and operationally deployable smart meter fault diagnostic systems.

ACKNOWLEDGMENT

The authors would like to thank the faculty and resources of Atmiya University, Rajkot, Gujarat, India, for supporting this research.

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Activated Carbon from Peanut Husk: Characterization and Evaluation for Functional Textile Applications

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doi.org/10.64643/JATIRV2I4-140207-001

***Abstract*— Agricultural residues offer a low-cost, sustainable feedstock for carbon materials that can replace synthetic additives in textile finishing. This study explores the use of peanut husk, a readily available agricultural byproduct, as a sustainable source. Peanut husk was converted into porous activated carbon powder by controlled carbonization and activation. The material was characterized by scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), and thermal analysis (TGA/DSC) to determine morphology, surface chemistry, and thermal stability. The prepared activated carbon exhibited a porous morphology with a high density of surface functional groups identified by FTIR and good thermal stability under the tested conditions. The material's physicochemical features indicate strong potential for adsorption and interaction with textile fibers. Activated carbon derived from peanut husk is a promising, eco-friendly, and cost-effective material for functional textile applications.**

***Index Terms*— Peanut husk, carbon powder, sustainable textile, ecofriendly material, functional finish.**

I. INTRODUCTION

The textile industry is a significant contributor to the global economy, driven by the rapid growth of fashion and increasing consumer demand for textile products. However, textile manufacturing is also associated with substantial environmental concerns, primarily due to the extensive use of

synthetic chemicals and finishing agents. Many conventional textile processing methods involve chemical substances that generate hazardous waste and contribute to environmental pollution [1].This has led researchers and industries to explore sustainable and environmentally friendly alternatives for textile processing and finishing.

There's growing interest in using natural and renewable resources to develop eco-friendly textile materials. Agricultural residues, produced in large quantities worldwide, are often discarded as waste, creating environmental and disposal problems. Effective utilization of these residues can reduce waste accumulation and provide valuable raw materials for industrial applications.

Agricultural and food waste management is a pressing global issue. Large amounts of agricultural residues are generated annually [2], and improper management can lead to environmental and economic challenges [3].Converting these residues into value-added materials has attracted attention from researchers and industries. Biomass wastes have been explored for various applications, including adsorbents, bio-fillers, and carbon-based materials.

Peanut shells, a significant agricultural residue, are produced in large quantities during peanut processing. These shells are composed of lignocellulosic components, making them suitable for producing carbon-based materials. Through controlled thermal processes, peanut shell husk can be converted into porous carbon powder with a stable carbon structure and large surface area [4].

In textile applications, activated carbon-based powders can impart hygienic benefits, odour adsorption [5], and improved moisture management without substantially altering fabric hand or breathability [6]. The presence and type of surface functional groups influence interactions with fibers and with target molecules (e.g., volatile organic compounds, moisture), while morphological features determine accessible surface area and adsorption kinetics.

This study reports the preparation of activated carbon from peanut husk and a systematic characterization of its morphology, surface chemistry, and thermal behaviour. The work also evaluates the material's potential for functional textile applications by applying the carbon powder as a finishing additive and assessing key performance indicators relevant to apparel and technical textiles. The objective is to demonstrate the feasibility of converting peanut husk into an effective, sustainable finishing material and to identify directions for further optimization and quantitative performance assessment.

II. MATERIALS AND METHOD

The raw material used for the study is peanut husk which was collected from the local farm peanut processing unit. It was washed, air dried and oven dried.

Figure No: 1 Peanut with Husk

II.A PREPARATION OF CARBON POWDER

The process began with peanut husk, which was thoroughly washed with distilled water to remove impurities. After drying for 24 to 48 hours, the shells were further dried in a hot air oven at 80-100°C for 2-3 hours to remove excess moisture. The dried shells underwent carbonization in a Traditional charcoal pit at 400-500°C for 1-2 hours, breaking down lignocellulosic components into carbon-rich char. The furnace cooled gradually to prevent oxidation, and the char was ground into a fine powder, and stored in a sealed container. This carbon powder was stored for testing and textile finishing applications [7, 8].

Figure No: 2 Activated Carbon Powder

III. RESULT AND DISCUSSION

A. FOURIER TRANSFORM INFRARED (FTIR) SPECTROSCOPY

The FTIR analysis confirmed the carbonization of peanut shell husk, revealing characteristic biochar peaks. The spectrum showed a broad band at 3400-3200 cm^{-1} indicating hydroxyl (–OH) groups, weak peaks at 2920-2850 cm^{-1} corresponding to aliphatic C–H bonds, absorption bands at 1700-1600 cm^{-1} representing C=O and aromatic C=C bonds, peaks at 1450-1380 cm^{-1} suggesting aromatic ring structures, and a band at 1100-1000 cm^{-1} attributed to C–O stretching. These functional groups contribute to the material's surface reactivity and adsorption capacity, making it suitable for antimicrobial textile applications.

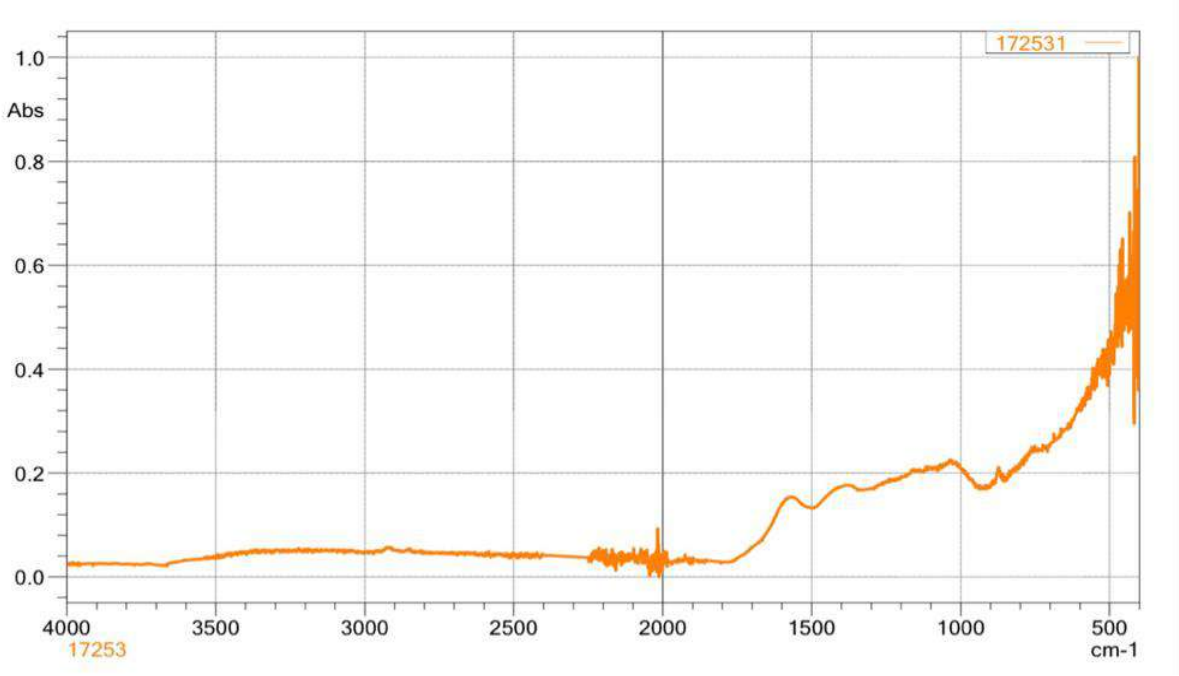

Figure No: 3

B. TGA ANALYSIS INDICATED

The carbon powder underwent thermal analysis in an inert atmosphere. The TGA curve revealed a minor initial weight loss attributed to moisture evaporation, followed by a stable weight profile indicating a robust carbon structure. The DSC curve showed no significant endothermic or exothermic peaks, confirming the material's thermal stability. These results demonstrate the carbon powder's suitability for textile finishing applications, where thermal durability is crucial.

The material shows thermal stability in stages: moisture evaporates initially (28-150°C), followed by breakdown of organic components (150-400°C), and then a stable carbon structure forms (400-800°C), remaining robust above 800°C. This indicates the carbon powder's heat resistance is quite good .

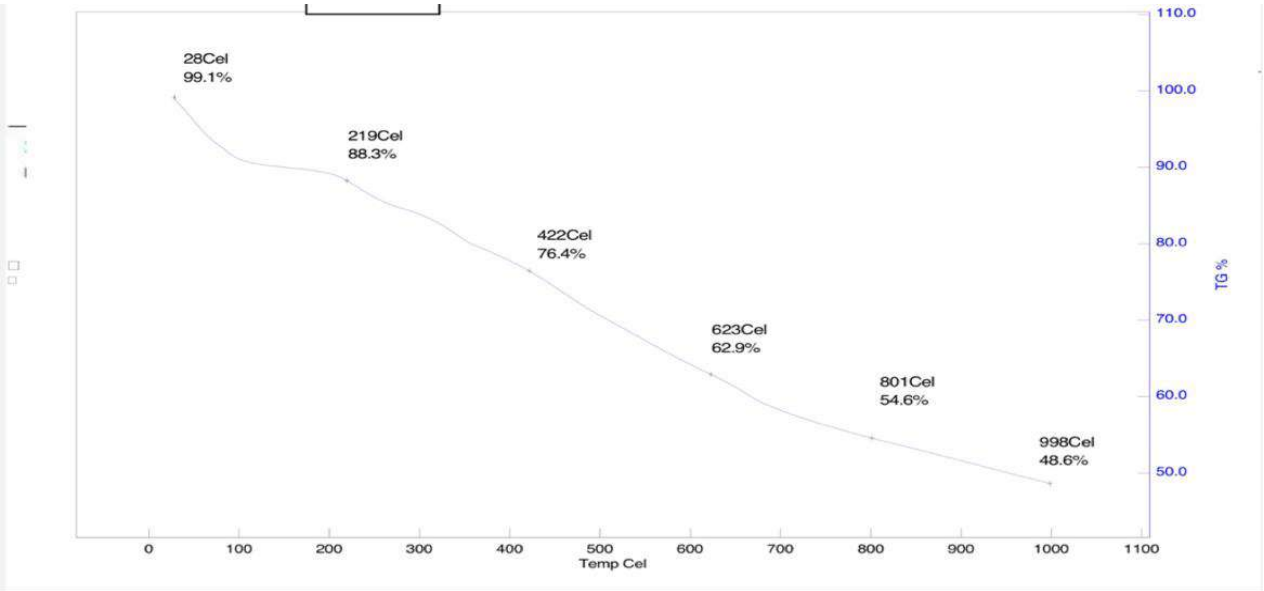

Figure No: 4

C. SCANNING ELECTRON MICROSCOPY (SEM)

The carbon particles' surface features numerous pores and cavities, typical of biomass-derived carbons. These structures form as volatile compounds escape during carbonisation, creating a porous network with increased surface area. This morphology suggests good adsorption potential, making it suitable for textile applications like odour control and antimicrobial finishing. The rough surface also enhances mechanical attachment to fibres when applied with a binder.

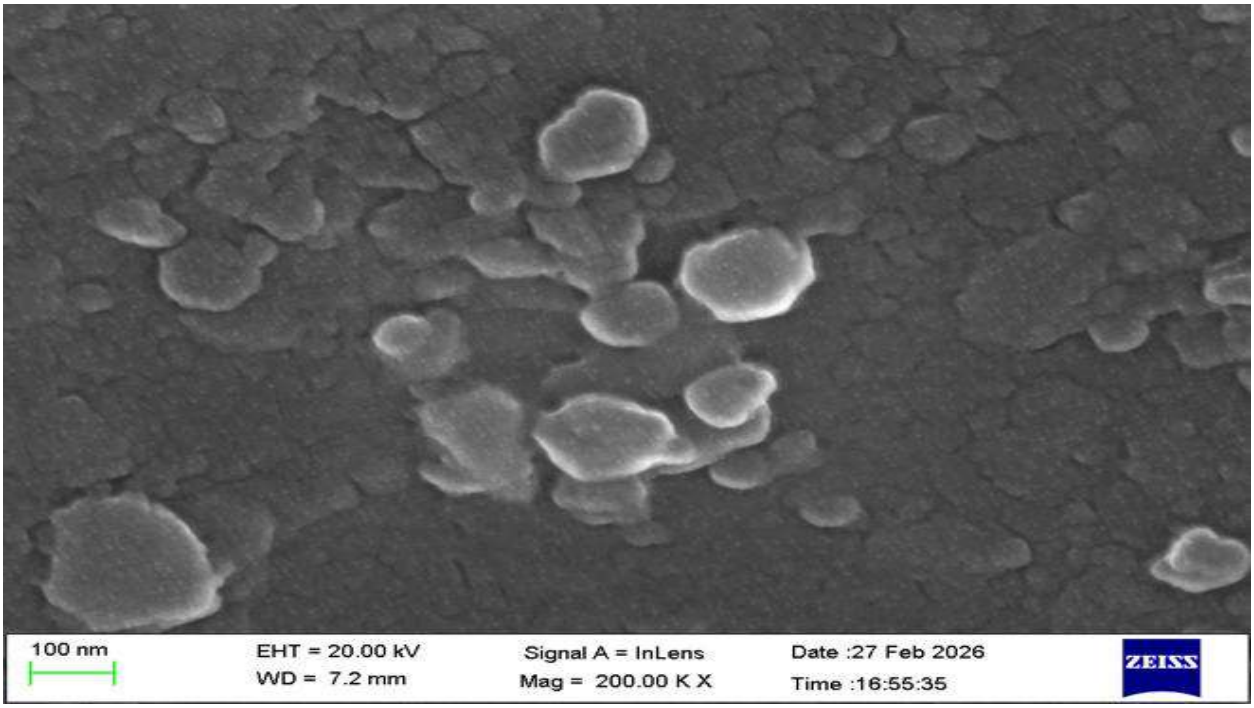

Figure No: 5

IV. BENEFITS OF CARBON POWDER FINISHING IN TEXTILE

1. Antimicrobial Protection: Inhibits bacteria and fungi growth, improving hygiene in medical and daily wear textiles.
2. Odour Control: Captures odor-causing molecules, keeping fabrics fresh.
3. Moisture Management: Absorbs and regulates moisture, reducing sweat accumulation.
4. UV Protection: Blocks harmful UV radiation, suitable for outdoor clothing.
5. Eco-Friendly: Utilizes agricultural waste, reducing pollution and promoting sustainability.
6. Cost-Effective: Low-cost and readily available compared to synthetic finishes.
7. Improved Hygiene: Combines antimicrobial and odor control properties.
8. Multifunctional: Provides antimicrobial, odor control, moisture management, and UV protection in one coating.
9. Good Fibre Interaction: Porous structure enhances adhesion to textile fibres.
10. Reduced Chemical Use: Minimizes reliance on synthetic antimicrobial agents

V. CONCLUSION

The present study demonstrates that activated carbon derived from peanut husk possesses favorable physicochemical properties for functional textile applications. Characterization revealed:

- Morphology (SEM): A porous structure with well-developed cavities, indicating effective activation and potential for adsorption.
- Surface chemistry (FTIR): Presence of oxygen-containing functional groups (–OH, –COOH, –C=O) that enhance interaction with textile fibers and adsorptive capacity.
- Thermal stability (TGA/DSC): Good resistance to thermal degradation, supporting its suitability for textile finishing processes that involve curing at elevated temperatures.
- Porosity and surface area (BET): High specific surface area and microporous distribution, critical for adsorption of moisture, odour molecules, and microbial metabolites.

These properties collectively highlight peanut husk activated carbon as a sustainable, eco-friendly, and cost-effective alternative to conventional synthetic finishing agents. Its ability to impart hygienic performance, odour control, and moisture regulation makes it particularly relevant for apparel and technical textiles.

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