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CAUSE ANALYSIS OF RISK FACTORS, DRUG RESSISTENCE AND CO MORBIDITIES OF TUBERCULOSIS (TB) PATIENTS

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Abstract:
Tuberculosis (TB) remains a major global public health concern, significantly influenced by multiple risk factors, drug resistance, and associated co-morbidities. The present study titled "Cause Analysis of Risk Factors, Drug Resistance and Co-morbidities of Tuberculosis (TB) Patients" *was conducted to evaluate the epidemiological, clinical, and behavioral determinants affecting TB patients. A cross-sectional observational study was carried out at G. G. Rathi Tuberculosis Hospital over a period of eight months (October 2023 to May 2024), including 119 patients diagnosed with pulmonary TB, extra-pulmonary TB, and multidrug-resistant TB. Data were collected from patient case records and direct interviews using a structured data collection form and the Morisky Medication Adherence Questionnaire (MMAS-8). Descriptive statistical analysis was performed using SPSS. The results showed a higher prevalence of TB among males (68%) and rural populations (60%). Most patients were married (93%) and belonged to the middle socio-economic class (75%). Occupational analysis revealed that daily wage workers (50%) were more affected. Substance abuse was reported in 61% of patients, with alcohol being the most common (46%). Clinically, 90% of patients had drug-sensitive TB, while 10% had MDR-TB. Pulmonary TB was the most prevalent form (95%). Drug resistance was observed in 23% of patients, with rifampicin resistance and MDR each accounting for 37% of resistant cases. The majority of patients were in the disease control phase (64%) and received first-line therapy (75%). Co-morbidities were present in 46% of patients, with diabetes mellitus (26%) being the most common. Medication adherence assessment revealed that 62% of patients had high adherence, while 15% exhibited poor adherence.*
In conclusion, the study highlights that tuberculosis is influenced by a combination of socio-demographic, behavioral, and clinical factors. Early diagnosis, improved patient education, adherence to therapy, and targeted interventions for high-risk populations are essential for effective TB control and prevention of drug resistance.

KEYWORDS: *Tuberculosis; Risk factors; Drug resistance; Multidrug-resistant TB (MDR-TB); Co-morbidities; Medication adherence; MMAS; Socio-economic factors; Substance abuse; Pulmonary tuberculosis.*

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INTRODUCTION:

Tuberculosis (TB) remains one of the most significant infectious diseases worldwide, posing a major threat to global public health despite decades of control efforts. It is a chronic granulomatous disease caused primarily by *Mycobacterium tuberculosis*, an acid-fast bacillus that predominantly affects the lungs but can involve multiple organ systems.[1] The discovery of the causative organism by Robert Koch in 1882 marked a milestone in medical microbiology, and TB continues to be referred to as "Koch's disease." The disease spreads mainly through airborne transmission via droplet nuclei expelled during coughing, sneezing, or speaking by infected individuals.[2]

Globally, tuberculosis continues to impose a substantial burden, particularly in developing countries. According to epidemiological estimates, millions of new cases are reported annually, with a high mortality rate despite the availability of effective treatment regimens. Countries such as India, China, Indonesia, and South Africa account for a significant proportion of global TB cases, with India alone contributing nearly one-quarter of the global burden. The disease predominantly affects individuals in their most productive age group, thereby exerting profound socio-economic consequences.[3]

The persistence and resurgence of TB are strongly influenced by a complex interplay of risk factors, including demographic, environmental, behavioral, and clinical determinants. Natural factors such as age, gender, and nutritional status play a crucial role in susceptibility. Young adults and elderly individuals are particularly vulnerable, while malnutrition significantly compromises host immunity, increasing disease risk. Lifestyle-related factors such as smoking, alcohol consumption, overcrowding, and occupational exposure further facilitate transmission and disease progression. Additionally, inadequate living conditions and poverty contribute substantially to increased TB incidence due to poor sanitation and limited access to healthcare services.[4]

Medical co-morbidities are among the most critical contributors to TB pathogenesis and severity.[5] Conditions such as HIV/AIDS, diabetes mellitus, chronic kidney disease, and malignancies weaken the immune system, thereby increasing susceptibility to infection and progression from latent to active TB.[6] Notably, HIV infection is recognized as the most potent risk factor for the development of active tuberculosis, while diabetes has been shown to increase the risk by several folds. Immunosuppressive therapies and conditions such as silicosis also significantly elevate the likelihood of TB infection and its complications.[7]

A growing concern in TB management is the emergence of drug-resistant strains of *Mycobacterium tuberculosis*. Drug-resistant TB arises primarily due to inappropriate use of anti-tubercular medications, including incomplete treatment, incorrect dosing, and poor adherence to therapy.[8] Multidrug-resistant TB (MDR-TB), characterized by resistance to at least isoniazid and rifampicin, and extensively drug-resistant TB (XDR-TB), which shows additional resistance to second-line drugs, represent major challenges to TB control programs.[9] These resistant forms not only complicate treatment but also increase transmission risk, morbidity, and mortality.[10]

The pathophysiology of tuberculosis involves a complex host immune response, primarily mediated by cell-mediated immunity. Upon infection, macrophages engulf the bacilli; however, *M. tuberculosis* possesses mechanisms to evade destruction, allowing intracellular survival and replication.[11] The formation of granulomas represents the host's attempt to contain the infection, but failure of immune control can lead to active disease and dissemination. The disease may manifest as pulmonary TB or extrapulmonary TB, affecting organs such as lymph nodes, bones, central nervous system, and genitourinary tract.[12]

Given the multifactorial nature of tuberculosis, understanding the underlying causes of risk factors, drug resistance, and associated co-morbidities is essential for effective disease management and control. A comprehensive analysis of these determinants can aid in identifying vulnerable populations, improving therapeutic strategies, and strengthening public health interventions.[13] Therefore, the present study aims to systematically evaluate the causative factors contributing to TB risk, the patterns of drug resistance, and the role of co-morbid conditions in influencing disease outcomes.

Table 1: Classification and Impact of Risk Factors, Drug Resistance, and Co-morbidities in Tuberculosis Patients

Category	Key Factors	Impact on TB
Demographic Factors	Age, Gender, Ethnicity	Increased susceptibility in productive age group; male predominance
Lifestyle Factors	Smoking, Alcohol, Drug abuse, Poverty	Weakens immunity and enhances transmission
Environmental Factors	Overcrowding, Poor housing, Occupational exposure	Facilitates airborne spread
Medical Co-morbidities	HIV/AIDS, Diabetes, CKD, Cancer	Increases risk of active TB and complications
Nutritional Status	Malnutrition, Low body weight	Reduces immune defense
Drug-related Factors	Poor adherence, Incorrect dosage, Incomplete treatment	Leads to drug resistance
Types of Drug Resistance	Mono, Poly, MDR, XDR	Complicates treatment and increases mortality

MATERIALS AND METHODS:

Study Materials

The study utilized standardized tools including a structured patient data collection form, an informed consent form, and the Morisky Medication Adherence Questionnaire (MMAS-8). These instruments were used to systematically collect demographic, clinical, and behavioral information, as well as to assess patient adherence to anti-tubercular therapy.

Study Site

The present study was conducted at G. G. Rathi Tuberculosis Hospital, a dedicated tertiary care center specializing in the diagnosis and management of tuberculosis. The hospital caters to a large number of TB patients from urban and rural regions, making it an appropriate setting for evaluating disease patterns and associated factors.[14]

Study Design and Duration

A cross-sectional observational study design was adopted to assess the risk factors, drug resistance, and co-morbidities among tuberculosis patients. The study was carried out over a period of eight months, from October 2023 to May 2024, ensuring adequate sample representation and data reliability.[15]

Source of Data

Data for the study were collected from both primary and secondary sources. Primary data were obtained through direct patient interviews using a structured questionnaire, while secondary data were collected from patient case records maintained at the hospital. This combined approach enabled comprehensive evaluation of clinical and behavioral parameters.[16]

Study Population and Selection Criteria

The study population included patients diagnosed with pulmonary tuberculosis (PTB), extra-pulmonary tuberculosis (EPTB), and multidrug-resistant tuberculosis (MDR-TB) who were receiving anti-tubercular therapy during the study period. Patients were selected based on predefined inclusion and exclusion criteria. Individuals diagnosed with TB, willing to participate, having a history of TB infection, presenting with co-morbid conditions, or exhibiting lifestyle-related risk factors such as smoking and alcohol consumption were included in the study. Conversely, patients who were unwilling to participate or those with unreliable or improper medication adherence data were excluded to maintain data accuracy and validity.[17]

Study Procedure

All eligible patients attending or admitted to the study site during the study period were enrolled after obtaining informed consent. Detailed demographic and clinical information was recorded through patient interviews and hospital records.[18] Inpatients were monitored daily for the occurrence of adverse drug reactions (ADRs) from the initiation of treatment until discharge. Medication adherence was evaluated using the Morisky scale prior to counseling.[19] subsequently, patients were counseled regarding the importance of adherence to therapy, possible adverse drug reactions, and general health practices. Follow-up interactions were conducted to reassess adherence and reinforce patient education, thereby improving treatment outcomes.[20]

Data Collection Parameters

Comprehensive data were collected covering multiple domains. Demographic details included age, gender, body weight, occupation, socio-economic status, and contact information.[21] Clinical and treatment-related data included type of TB, prescribed drug regimen, dosage, route, frequency, and duration of therapy. Information regarding co-morbidities such as diabetes and other chronic

conditions, as well as lifestyle habits like smoking and alcohol consumption, was also recorded.[22] Adverse drug reactions were carefully documented, including their onset, severity, suspected causative drugs, and management strategies.[23] Diagnostic investigations such as sputum smear microscopy, chest X-ray, CBNAAT, and laboratory tests including complete blood count (CBC), kidney function test (KFT), and liver function test (LFT) were considered for confirmation and monitoring of the disease.[24]

Informed Consent

Prior to participation, written informed consent was obtained from all patients. In cases where patients were unable to provide consent, it was obtained from their legally authorized representatives. Ethical considerations such as confidentiality, anonymity, and voluntary participation were strictly maintained throughout the study.[25]

Medication Adherence Assessment

Medication adherence was evaluated both before and after patient counselling to determine the effectiveness of counselling interventions on improving adherence to anti-tubercular therapy. This comparative assessment enabled the identification of behavioral changes in patients and highlighted the importance of structured counselling in enhancing treatment compliance.[26]

Assessment Tool: C-MMAQ (Pre- and Post-Counselling)

Medication adherence was measured using the Chinese Morisky Medication Adherence Questionnaire (C-MMAQ), a modified version of the Morisky scale specifically adapted for tuberculosis patients.[27] The questionnaire consists of eight structured questions designed to assess patient behavior related to medication-taking practices, including forgetfulness, discontinuation, and irregular intake. The questionnaire was administered twice once before counselling and again after counseling to evaluate changes in adherence levels.[28]

Scoring of Medication Adherence

The adherence level was categorized based on the total C-MMAQ score. Patients scoring 8 were considered to have high adherence, those scoring 6–7 were categorized as having medium adherence, and those with a score of less than 6 were classified as having low adherence.[29] This classification provided a clear understanding of adherence patterns and helped in evaluating the impact of counselling interventions.[29]

Patient Counselling

Structured patient counselling was conducted to improve awareness and promote adherence to treatment. The counselling sessions focused on multiple key aspects related to tuberculosis management. Patients were educated about their medication regimen, including the importance of regular intake and completion of therapy. Information regarding common adverse drug reactions (ADRs) and their management was provided to reduce fear and improve compliance. Guidance on dietary practices and lifestyle modifications, such as avoiding smoking and alcohol consumption, was also emphasized.[30] Additionally, patients were informed about risk factors associated with tuberculosis, the importance of regular follow-up and timely check-ups, and the critical role of medication adherence in achieving successful treatment outcomes and preventing drug resistance. Counselling was also extended to family members when necessary to ensure a supportive environment for the patient.[31]

PATIENT DATA COLLECTION FORM

All information contained in this form is confidential and will become part of your medical record.[32]

Name:	Address:
Age:	Occupation:
Gender:	D.O.A:
Reg. No :	D.O.D:
Marital Status:	Contact No:
Chief Complaints:	
Past Medical History:	
Past Medication History:	
Diagnosis:	
Active / Latent	

DETERMINANTS

Factors		Duration	Factors		Duration
Economical status			Low Body Wt.		
Malnutrition			Organ Transplant		
HIV			Cancer		
Substance abuse			Severe Kidney Disease		
Diabetes Mellitus			Other		

SOCIAL HISTORY:

	Smoker:	Tobacco:	Alcoholic:	Allergies:
Duration				
Quantity				
Family history				

CLINICAL INFORMATION

Category:					
T/T Category:					
Phase of T/T:					
Duration of T/T:					
Line of treatment:					
Any comorbidity:					
Factor		**Duration**	**Factor**		**Duration**
HIV/AIDS			Epilepsy		
Hepatitis			Malaria		
Diabetes mellitus			Influenza		
Cancer			Helminths		
Cardiovascular disease			COVID		
Hypertension			Other		

LABORATORY AND OTHER TESTS

TEST	DATE	RESULT	TEST	DATE	RESULT
Sputum smear			Haemoglobin		
Drug susceptibility			SGPT (ALT)		
Line probe assay			SGOT(AST)		
Nucleic acid testing			Creatinine		
HIV antibody			Creatinine Clearance		
Hepatitis markers			Glucose		
CD4 count			Thyroid Function		
Chest X ray			ECG		
Other					

DRUGS PRESCRIBED:

Sr. No	Drugs	Indication	Dose	Route	Frequency	Start date	Anticipated stop date	Outcomes of t/t
1								
2								
3								

MORISKY MEDICATION ADHERENCE SCALE (MMAS)

Sr no		YES	NO
1	Do you sometimes forget to take your medication?		
2	People sometimes miss their medication for some reason other than forgetting. Over past 2 weeks, were there any days when you did not take your medicine?		
3	Have you ever cut back or stopped taking your medication without telling your doctor because you felt worse when you took it?		

4	When you travel or leave home , do you sometimes forget to bring your medication?		
5	Did you take all your medications yesterday?		
6	When you feel like your symptoms are under control, do you Sometimes stop taking your medication?		
7	Taking medication every day is real inconvenience for some people; do you feel hassled about sticking to your treatment plan?		
8	How often do you have difficulty remembering to take all your medication? a. Never/rarely……. b. Once in a while……. c. Sometimes……..... d. Usually……. e. All the time……...		

Score: High, Medium and Low

RESULTS:

Demographic Characteristics of Study Population

The present study included a total of 119 tuberculosis patients attending the Government TB Hospital, Amravati. The analysis of demographic parameters revealed that the majority of patients were male (68%), whereas females constituted 32% of the study population, indicating a higher burden of TB among males.

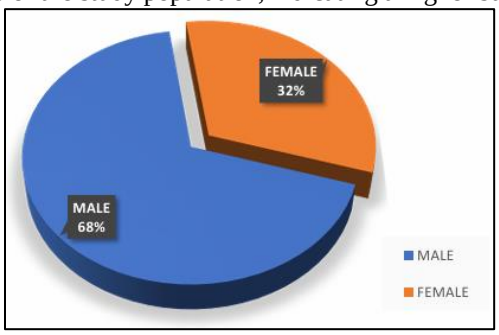

Figure 1: Distribution according to gender

Locality Distribution

Based on geographical distribution, a greater proportion of patients belonged to rural areas (60%), while 40% were from urban regions. This suggests that TB prevalence is comparatively higher in rural populations, possibly due to limited healthcare access and socio-economic challenges.

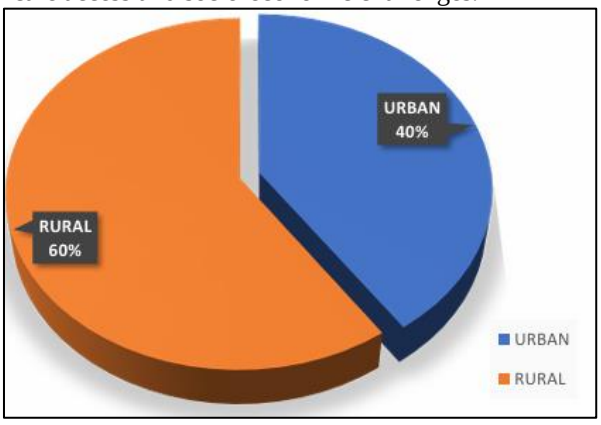

Figure 2: Distribution according to locality

Marital Status
The distribution of patients according to marital status showed that 93% of the study population were married, whereas only 7% were unmarried, indicating a higher occurrence of TB among married individuals, which may be associated with age and family exposure factors.

Educational Status
The study revealed that a significant proportion of patients were educated (89%), while 11% were uneducated. This finding suggests that TB affects individuals across different educational backgrounds and highlights the need for continuous awareness programs irrespective of literacy levels.

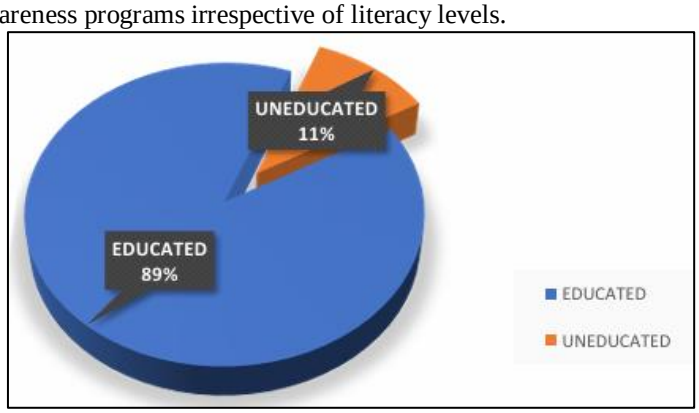

Figure 3: Distribution according to educational status

Economic Status
Analysis based on socio-economic status indicated that the majority of patients belonged to the middle-class group (75%), followed by poor (23%) and rich (2%) categories. This reflects the substantial burden of TB among economically moderate populations.

Nutritional Status (BMI)
Assessment of nutritional status showed that 75% of patients were healthy, whereas 25% were malnourished. Although most patients had normal nutritional status, a considerable proportion of malnourished individuals indicates the role of nutrition in TB susceptibility.

Table 2: Combined Distribution of Study Population (n = 119)

Parameter	Category	Frequency (n)	Percentage (%)
Gender	Male	81	68
	Female	38	32
Locality	Urban	48	40
	Rural	71	60
Marital Status	Married	111	93
	Unmarried	8	7
Educational Status	Educated	106	89
	Uneducated	13	11
Economic Status	Rich	3	2
	Middle	89	75
	Poor	27	23
BMI Status	Healthy	89	75
	Malnourished	30	25

Occupation Distribution
The analysis of occupational status revealed that daily wage workers constituted the largest proportion (50%) of the study population, followed by farmers (28%) and housewives (22%). This indicates that individuals engaged in daily wage labor are comparatively more susceptible to tuberculosis, possibly due to unstable income, poor living conditions, and higher exposure risks.

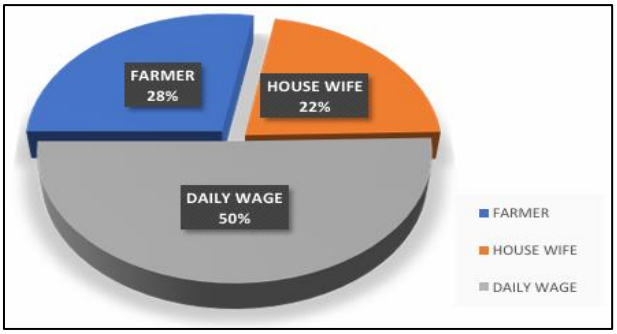

Figure 4: Distribution according to occupation

Substance Abuse Status

A significant proportion of patients reported substance abuse (61%), while 39% had no history of substance use. This finding highlights substance abuse as an important behavioral risk factor associated with tuberculosis in the study population.

Type of Substance Abuse

Among individuals with substance use, alcohol consumption was the most prevalent (46%), followed by smoking (31%) and tobacco chewing (23%). These habits are known to impair immunity and may contribute to increased susceptibility and poor treatment outcomes in TB patients.

Family History

The majority of patients did not report any family history of tuberculosis (86%), whereas 14% had a positive family history. This suggests that although familial transmission exists, most cases may be attributed to environmental and social exposure factors.

Table 3: Combined Socio-Behavioral Distribution of Study Population (n = 119)

Parameter	Category	Frequency (n)	Percentage (%)
Occupation	Daily wage	60	50
	Farmer	33	28
	Housewife	26	22
Substance Abuse	Having	72	61
	Not having	47	39
Type of Substance Abuse	Alcohol	99	46
	Tobacco	49	23
	Smoking	68	31
Family History	Having history	17	14
	Not having history	102	86

Past Medical History

In the present study, 39% of patients had a past medical history, whereas 61% had no prior medical history, indicating that a substantial proportion of TB cases occurred without previously documented illnesses.

Type of Tuberculosis (MTB vs MDR-TB)

Out of 119 patients, the majority were diagnosed with drug-sensitive Mycobacterium tuberculosis (MTB) (90%), while 10% were diagnosed with multidrug-resistant TB (MDR-TB), highlighting the presence of drug resistance within the study population.

Clinical Type of TB

The distribution based on clinical presentation showed that pulmonary TB was predominant (95%), followed by abdominal TB (2%), miliary TB (2%), and meningeal TB (1%), indicating that pulmonary involvement remains the most common manifestation.

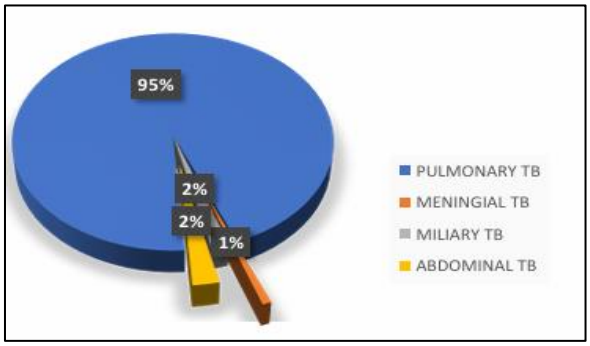

Figure 5: Distribution according to type of TB

Stage of Therapy

Most patients were found to be in the active stage of therapy (92%), while 5% were in relapse stage and 3% in latent stage, suggesting that the majority of cases were undergoing active treatment.

Drug Susceptibility Pattern

The study revealed that 77% of patients were drug susceptible, whereas 23% exhibited drug resistance, emphasizing the emerging concern of resistant TB cases.

Type of Drug Resistance

Among drug-resistant cases, rifampicin resistance (37%) and multidrug resistance (37%) were equally prevalent, followed by isoniazid resistance (19%) and mono-drug resistance (7%).

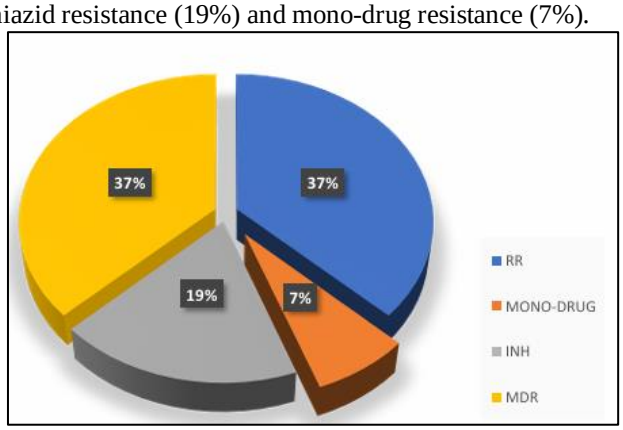

Figure 6: Distribution according to type of resistance

Phase of Treatment

The majority of patients were in the disease control phase (64%), followed by restorative phase (20%), maintenance phase (9%), and diagnosis phase (7%), indicating effective progression of treatment in most patients.

Line of Treatment

Most patients were treated with first-line anti-tubercular drugs (75%), while 25% required second-line therapy, reflecting the proportion of complicated or resistant cases.

Co-morbidities

More than half of the patients (54%) had no co-morbid conditions, whereas 26% had diabetes mellitus, followed by asthma (8%), HIV (7%), and hypertension (5%), highlighting diabetes as the most common co-morbidity.

Other Risk Factors

The majority of patients (83%) had no additional risk factors, while 17% showed associated conditions, including asthma (8%), hypothyroidism (3%), and malaria, ischemic heart disease (IHD), and cerebrovascular events (CVE) (2% each).

Medication Adherence (MMAS Score)

Assessment of medication adherence revealed that 62% of patients showed high adherence, 23% had moderate adherence, and 15% had low adherence, indicating generally good compliance but with scope for improvement.

Table 4: Combined Clinical and Treatment Distribution (n = 119)

Parameter	Category	Frequency (n)	Percentage (%)
Past Medical History	Having	47	39
	Not having	72	61
Type of TB (Diagnosis)	MTB	107	90
	MDR-TB	12	10
Clinical Type of TB	Pulmonary TB	113	95
	Meningeal TB	1	1
	Miliary TB	2	2
	Abdominal TB	3	2
Stage of Therapy	Active	109	92
	Latent	4	3
	Relapse	6	5
Drug Susceptibility	Drug susceptible	92	77
	Drug resistant	27	23
Type of Resistance (n=27)	Rifampicin resistance	10	37
	Mono-drug resistance	2	7
	INH resistance	5	19

	MDR	10	37
Phase of Treatment	Diagnosis	8	7
	Disease control	76	64
	Maintenance	11	9
	Restorative	24	20
Line of Treatment	1st line	89	75
	2nd line	30	25
Co-morbidities	Diabetes mellitus	31	26
	Hypertension	6	5
	HIV	8	7
	Asthma	10	8
	None	64	54
Other Risk Factors	None	55	83
	Asthma	10	8
	Malaria	2	2
	Hypothyroidism	4	3
	IHD	2	2
	CVE	2	2
Medication Adherence (MMAS)	High	74	62
	Medium	27	23
	Low	18	15

DISCUSSION:

The present study provides important insights into the demographic, socio-economic, and clinical determinants influencing Tuberculosis (TB) among patients enrolled at G. G. Rathi Tuberculosis Hospital. One of the notable findings was the high proportion (89%) of educated individuals within the study population. This observation may be interpreted in multiple ways. Higher educational status is generally associated with better health literacy, improved awareness of symptoms, and increased likelihood of seeking timely medical care, which could explain greater representation in hospital-based data. Conversely, it also suggests that TB is not restricted to uneducated or socioeconomically disadvantaged groups, but rather affects individuals across all educational strata. Additionally, educated individuals may have better access to diagnostic facilities, leading to higher detection rates compared to less educated populations who may remain underdiagnosed.

Occupational status emerged as another significant determinant, with daily wage workers showing increased susceptibility to TB infection. This may be attributed to adverse living and working conditions, including overcrowding, poor ventilation, malnutrition, and occupational exposure to dust and pollutants. These findings emphasize the role of socioeconomic vulnerability in TB transmission and highlight the need for targeted occupational health interventions and workplace-based screening programs.

From a statistical perspective, although the study primarily utilized descriptive analysis, inferential statistical approaches such as Chi-square tests could be applied to evaluate associations between categorical variables like education, occupation, and TB prevalence. Furthermore, logistic regression analysis may help identify independent predictors of TB risk, drug resistance, and co-morbidities. Incorporating such analyses in future studies would strengthen causal interpretations and provide more robust evidence for risk factor identification.

The distribution of patients according to treatment phase revealed that a considerable proportion were in the disease control phase. This suggests effective implementation of treatment protocols and reflects the success of TB control programs at the institutional level. However, it also underscores the importance of sustained adherence, regular follow-up, and early intervention to prevent relapse and the emergence of drug resistance.

Co-morbid conditions such as diabetes and immunocompromised states play a critical role in TB progression and treatment outcomes. These conditions weaken host immunity, thereby increasing susceptibility to infection and complicating therapeutic management. Similarly, the presence of drug-resistant TB remains a major concern, often resulting from incomplete treatment, poor compliance, or irrational drug use.

A key limitation of the present study is its relatively small sample size (n = 119), which may limit the generalizability of the findings to the broader population. Larger, multicentric studies are recommended to validate these observations and provide more comprehensive insights.

Overall, the study highlights the complex interplay of educational, occupational, and clinical factors in TB epidemiology. Understanding these determinants is essential for designing targeted and effective public health interventions aimed at reducing disease burden and improving patient outcomes.

CONCLUSION:

The present study demonstrates that Tuberculosis is a multifactorial disease influenced by interplay of socio-demographic, economic, and clinical factors. The findings indicate that TB affects individuals across different educational levels, highlighting that awareness alone is insufficient without adequate preventive and control measures. Occupational vulnerability, particularly among daily wage workers, remains a significant contributor to disease risk due to unfavorable living and working conditions.

The study also underscores the critical impact of co-morbidities and drug resistance in complicating TB management and treatment outcomes. These factors necessitate integrated healthcare strategies that address both primary disease management and associated conditions. While current treatment programs appear effective in controlling disease progression, continued emphasis on adherence, early diagnosis, and monitoring is essential.

In conclusion, effective TB control requires a comprehensive approach that combines medical management with socio-economic interventions. Strengthening health education, improving access to healthcare, implementing occupational safety measures, and addressing co-morbid conditions are crucial for reducing TB burden. The findings provide practical insights for enhancing TB control strategies and support the need for further large-scale studies to validate and expand upon these results.

CONFLICTS OF INTERESTS:

All authors have declared no conflict of interest.

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