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Comparative Evaluation of Drug-Sensitive Pulmonary Tuberculosis in Patients With and Without Diabetes Mellitus in a Tertiary Care Hospital of Tripura, India.

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Abstract

Background: Diabetes mellitus (DM) is increasingly recognised as an important comorbidity that adversely affects the clinical course and treatment outcomes of pulmonary tuberculosis (PTB). The coexistence of these conditions poses a significant public health challenge, particularly in high tuberculosis burden countries such as India. ***Objectives:*** To determine the proportion of diabetes mellitus among patients with drug-sensitive pulmonary tuberculosis and to compare treatment outcomes in PTB patients with and without diabetes mellitus. ***Methods:*** A prospective observational study was conducted from April 2024 to October 2025. A total of 400 pulmonary tuberculosis patients were enrolled, including 200 diabetic and 200 non-diabetic individuals. Data regarding demographic variables, clinical features, laboratory parameters, microbiological findings, radiological response, and treatment outcomes were collected and analysed using SPSS version 26.0. Statistical significance was considered at $p<0.05$. ***Results:*** Most participants belonged to the 41-50-year age group. MTB detection rates did not differ significantly between diabetic and non-diabetic males ($p=0.13$) or females ($p=0.51$). Hemoptysis was significantly more common among non-diabetic patients (25% vs. 15%; $p=0.0175$). Diabetic patients demonstrated significantly poorer treatment outcomes, with a lower cure rate (62% vs 78%) and higher treatment failure rate (28% vs 12%) than non-diabetic patients ($p=0.032$). Complete radiological resolution was less frequent among diabetics (58% vs 74%), while persistence/progression was more common (20% vs 8%; $p=0.041$). Drug resistance was also significantly higher among diabetic patients (18% vs. 6%; $p=0.027$). ***Conclusion:*** Diabetes mellitus adversely affects treatment success, radiological recovery, and drug susceptibility among patients with drug-sensitive pulmonary tuberculosis. Routine screening and effective glycemic control should be integrated into tuberculosis management strategies to improve treatment outcomes and reduce disease burden.

Keywords: Pulmonary tuberculosis; Diabetes mellitus; Tuberculosis-diabetes comorbidity; Treatment outcomes; Drug resistance; Glycemic control; Radiological response; India.

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INTRODUCTION

Diabetes mellitus is one of the most prevalent chronic non-communicable diseases worldwide and is characterised by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The disease is associated with significant metabolic disturbances involving carbohydrate, lipid, and protein metabolism and contributes substantially to morbidity and premature mortality. Globally, the burden of diabetes continues to increase, particularly in low- and middle-income countries, where healthcare systems face considerable challenges in managing chronic diseases. Type 2 diabetes mellitus constitutes approximately 90% of all diabetes cases and is frequently associated with obesity, sedentary lifestyles, and population ageing. Despite significant advances in diagnosis and treatment, diabetes remains a major public health concern because of its microvascular and macrovascular complications.1-3

Diabetes pathophysiology involves insulin resistance, impaired insulin secretion, and chronic low-grade inflammation. Persistent hyperglycemia adversely affects various organs and systems, leading to retinopathy, nephropathy, neuropathy, cardiovascular disease, and increased susceptibility to infections. Early diagnosis and effective glycemic control play

crucial roles in reducing disease-related complications. Current diagnostic criteria for diabetes include elevated fasting plasma glucose, glycated haemoglobin (HbA1c), abnormal oral glucose tolerance test results, or elevated random blood glucose levels with classic symptoms. Advances in pharmacological management, including metformin, incretin-based therapies, sodium-glucose cotransporter-2 inhibitors, and insulin analogues, have improved outcomes; however, many individuals still struggle to achieve optimal glycemic control.4-7

Tuberculosis (TB) is a chronic infectious disease caused by Mycobacterium tuberculosis and continues to be one of the leading causes of infectious disease-related mortality worldwide. Although the lungs are the primary site of infection, TB may also affect several extrapulmonary organs. According to global estimates, millions of new TB cases occur annually, underscoring the continuing public health significance of the disease, particularly in resource-limited settings. Latent tuberculosis infection affects approximately one-quarter of the global population, creating a substantial reservoir for future disease activation.8-10

TB transmission occurs mainly through airborne droplets released when individuals with active pulmonary TB cough, sneeze, or speak. Following exposure, the immune system may either eliminate the infection, contain it as latent TB infection, or fail to control bacterial replication, resulting in active disease. The progression from latent infection to active tuberculosis is strongly influenced by host immunity and the presence of comorbid conditions. Human immunodeficiency virus (HIV) infection, malnutrition, smoking, alcohol use, and diabetes mellitus are among the most important factors that increase susceptibility to active TB disease.10-12

In recent decades, the coexistence of TB and diabetes mellitus has emerged as a significant global health challenge. Traditionally, TB was considered a disease associated with poverty, whereas diabetes was viewed as a disease of affluence. However, the epidemiological transition in many developing nations has led to growing overlap between these two conditions. The increasing prevalence of diabetes in regions with high TB burden has intensified concerns regarding the interaction between these diseases. Current evidence demonstrates that individuals with diabetes have approximately three times higher risk of developing active tuberculosis compared with non-diabetic individuals.13,14

The relationship between TB and diabetes mellitus is bidirectional and complex. Diabetes impairs both innate and adaptive immune responses, thereby increasing susceptibility to M. tuberculosis infection and disease progression. Hyperglycemia adversely affects macrophage function, antigen presentation, cytokine regulation, and T-cell-mediated immunity. These alterations reduce the body's ability to contain mycobacterial infection, resulting in increased bacterial load and more severe disease manifestations. Additionally, chronic hyperglycemia creates a pro-inflammatory state that further compromises host defence mechanisms and promotes persistence of the organism.15-18

Conversely, active tuberculosis may influence glucose metabolism and contribute to impaired glucose tolerance or transient hyperglycemia. The inflammatory and stress responses associated with TB can worsen glycemic control in patients with pre-existing diabetes and may even unmask previously undiagnosed diabetes mellitus. This interaction complicates management and worsens treatment outcomes. Studies have shown that patients with concurrent TB and diabetes mellitus experience increased risks of delayed sputum conversion, treatment failure, relapse, and mortality compared to patients with TB alone.15,18,19

The combined burden of TB and diabetes mellitus is particularly relevant in India, which accounts for a substantial proportion of the world's tuberculosis cases and also has one of the largest populations of individuals living with diabetes. The coexistence of these two diseases has important implications for disease control strategies, patient management, and healthcare resource utilisation. Recognising the significance of this association, international and national health authorities recommend bidirectional screening for TB and diabetes to facilitate early detection and improve clinical outcomes.13,15

Although numerous studies have examined the association between diabetes and tuberculosis, regional variations in prevalence, clinical presentation, and treatment outcomes remain inadequately explored. Evidence from Northeast India is particularly limited, despite the region's unique demographic and epidemiological characteristics. Understanding the prevalence of diabetes among drug-sensitive pulmonary tuberculosis patients and evaluating its impact on treatment outcomes are essential to optimise disease management and strengthen integrated TB-diabetes mellitus control programmes. Therefore, this study aimed to estimate the proportion of diabetes mellitus among drug-sensitive pulmonary tuberculosis patients and to compare anti-tuberculosis treatment outcomes between patients with and without diabetes mellitus attending a tertiary care hospital in Tripura, India.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Respiratory Medicine, Agartala Government Medical College (AGMC) and G.B. Pant Hospital, Tripura, India, over a period of 18 months from April 2024 to October 2025.

Study Population

The study population comprised patients diagnosed with pulmonary tuberculosis who attended the Department of Respiratory Medicine during the study period. Eligible participants included newly diagnosed cases of pulmonary tuberculosis and patients receiving anti-tuberculosis treatment for less than two months.

Inclusion Criteria

- Newly diagnosed patients with pulmonary tuberculosis.
- Patients receiving anti-tuberculosis therapy for less than two months.
- Individuals willing to provide written informed consent.

Exclusion Criteria

- Patients already receiving anti-tuberculosis treatment for more than two months.
- Patients with HIV infection, chronic kidney disease, lymphoma, organ transplantation, or those receiving immunosuppressive therapy.
- Patients younger than 12 years of age.
- Patients receiving psychiatric treatment.
- Drug-resistant tuberculosis patients.
- Individuals unwilling to participate in the study.

Sample Size and Sampling Technique

The sample size was determined using the reported global prevalence of diabetes mellitus among pulmonary tuberculosis patients (13.73%). This prevalence figure guided the sample size calculation for the present study.20 Based on the standard formula for prevalence studies and allowing for a 10% non-response rate, a minimum of 200 diabetic pulmonary tuberculosis patients was required. An equal number of non-diabetic pulmonary tuberculosis patients were included for comparison, resulting in a total study population of 400 participants. A census sampling technique was adopted, and all eligible patients meeting the selection criteria were consecutively enrolled until the desired sample size was achieved.

Data Collection Procedure

After obtaining approval from the Institutional Ethics Committee and written informed consent from participants, relevant information was collected using a structured case record proforma. Baseline assessment included detailed history taking, physical examination, demographic profile, and laboratory investigations. Data regarding age, sex, educational status, occupation, clinical presentation, comorbidities, and treatment details were recorded systematically.

All participants underwent routine investigations including complete blood count, liver function tests, kidney function tests, HIV screening, chest radiography, and additional imaging such as computed tomography when clinically indicated. Pulmonary tuberculosis was diagnosed according to national tuberculosis programme guidelines. In sputum-negative cases, bronchoscopy with bronchoalveolar lavage examination was performed whenever necessary to establish the diagnosis. Pleural fluid analysis was conducted in patients presenting with pleural effusion.

Assessment of Diabetes Mellitus

All confirmed pulmonary tuberculosis patients were screened for diabetes mellitus using fasting blood glucose (FBG), postprandial blood glucose (PPBG), and glycated haemoglobin (HbA1c) measurements. The diagnosis of diabetes mellitus was established according to the American Diabetes Association criteria. Based on the screening results, participants were categorised into two groups:

- Drug-sensitive pulmonary tuberculosis patients with diabetes mellitus.
- Drug-sensitive pulmonary tuberculosis patients without diabetes mellitus.

Follow-up and Outcome Assessment

Patients in both groups were followed prospectively at three predetermined intervals: two weeks after initiation of anti-tuberculosis therapy, at the end of the intensive phase (two months), and at completion of treatment (six months). During each follow-up visit, clinical evaluation and relevant laboratory investigations were performed. Liver function tests and kidney function tests were monitored periodically. Blood glucose parameters, including fasting blood glucose, postprandial blood glucose, and HbA1c, were reassessed during follow-up visits.

Sputum smear microscopy and chest radiography were repeated at two months and six months to assess microbiological and radiological response to treatment. Treatment outcomes were evaluated according to standard national tuberculosis programme definitions, including cure, treatment completion, treatment failure, death, loss to follow-up, and treatment success. The treatment outcomes of diabetic and non-diabetic tuberculosis patients were subsequently compared.

Statistical Analysis

The collected data were entered into Microsoft Excel and subsequently analysed using Statistical Package for the Social Sciences (SPSS) version 26.0 and Epi Info software. Descriptive statistics were used to summarise demographic and clinical characteristics. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Appropriate inferential statistical tests were applied to compare treatment outcomes between diabetic and non-diabetic groups. We considered $p < 0.05$ statistically significant.

Ethical Considerations

The Institutional Ethics Committee of Agartala Government Medical College and G.B. Pant Hospital approved the study before it began. The study obtained written informed consent from all participants before enrolment. The study-maintained confidentiality and anonymity throughout data collection, analysis, and reporting.

RESULTS

Table 1 describes the age distribution of participants in the diabetic group. Most patients were 41–50 years (27%), followed by those aged 51–60 years (21.5%) and 31–40 years (20.5%), indicating that middle-aged adults made up the largest proportion of the study population. Younger participants aged ≤30 years accounted for 10%, while only 4.5% were aged 61 years or above, showing relatively fewer elderly individuals in this group. Additionally, 16.5% of patients in the diabetic group were classified under the MTB not detected category.

Table 1: Distribution of Age of the study participants in the Diabetic group (n=200)

Age Group	Number	Percentage (%)
≤30 years	20	10.0%
31–40 years	41	20.5%
41–50 years	54	27.0%
51–60 years	43	21.5%
≥61 years	9	4.5%
MTB not detected group	33	16.5%
Total	**200**	**100%**

Table 2 outlines the age distribution of participants in the non-diabetic group. The largest proportion of patients fell within the 41–50-year age range (27%), followed closely by those aged 51–60 years (24.5%) and 31–40 years (22%), indicating that middle-aged adults formed the bulk of the study population. Younger individuals aged ≤30 years accounted for 9%, while older participants aged ≥61 years represented 5%, showing relatively fewer cases among the extremes of age. Additionally, 12.5% of patients in this group were classified under the MTB not detected category.

Table 2: Distribution of Age of the study participants in the Non-Diabetic group (n=200)

Age Group	Number	Percentage (%)
≤30 years	18	9.0%
31–40 years	44	22.0%
41–50 years	54	27.0%
51–60 years	49	24.5%
≥61 years	10	5.0%
MTB not detected group	25	12.5%
Total	**200**	**100%**

Table 3 presents the socioeconomic distribution of diabetic patients with tuberculosis by MTB detection. Most cases were among those with primary education (39.5%), followed by those with secondary education (26.5%). Illiterate patients accounted for 14% of MTB-detected cases, while only 4% of graduates were affected, suggesting that lower educational attainment was more frequently associated with MTB detection in this group. Additionally, 16% of patients were classified under the MTB not detected category.

Table 3: Socioeconomic status of Diabetic patients with TB

Groups	MTB Detected	Percentage
Illiterate	28	14.0%
Primary	79	39.5%
Secondary	53	26.5%
Graduate	8	4.0%
MTB Not detected group	32	16%
Total	**200**	**100%**

Table 4 presents the socioeconomic distribution of non-diabetic tuberculosis patients by MTB detection. The largest proportion of cases occurred among individuals with primary education (39.5%), followed by those with secondary education (24%). Illiterate patients accounted for 18% of MTB-detected cases, while graduates represented 8%, suggesting that lower educational attainment was more frequently associated with MTB detection. In contrast, only 10.5% of patients in this group were classified under the MTB not detected category.

Table 4: Socioeconomic status of non-Diabetic patients with TB

Groups	MTB Detected	Percentage
Illiterate	36	18.0%
Primary	79	39.5%
Secondary	48	24.0%
Graduate	16	8.0%
MTB Not detected group	21	10.5%
Total	**200**	**100%**

Table 5 compares MTB detection rates between male patients with and without diabetes. Among diabetic males, MTB was detected in 104 patients (52%), while in the non-diabetic group, 119 patients (59.5%) were positive. Statistical analysis yielded a p-value of 0.13, indicating that the difference in MTB detection between diabetic and non-diabetic males was not statistically significant.

Table 5: Association of Diabetes Status with MTB Detection in Male Tuberculosis Patients

Groups	MTB Detected	Percentage	p value
Male (Diabetic group)	104	52%	P=0.13
Male (Non-Diabetic group)	119	59.5%	

Table 6 compares MTB detection rates between female patients with and without diabetes. In the diabetic group, MTB was detected in 63 patients (31.5%), while in the non-diabetic group, 56 patients (28%) were positive. Statistical analysis revealed a p-value of 0.51, indicating that the difference in MTB detection between diabetic and non-diabetic females was not statistically significant.

Table 6: Association of Diabetes Status with MTB Detection in Female Tuberculosis Patients

Groups	MTB Detected	Percentage	p value
Female (Diabetic group)	63	31.5%	p=0.51
Female (Non-Diabetic group)	56	28.0%	

Table 7 compares the prevalence of key symptoms in diabetic and non-diabetic tuberculosis patients. Cough was reported in 30% of diabetic patients and 35% of non-diabetic patients (p=0.3367), indicating no significant difference. Hemoptysis occurred in 15% of diabetics compared with 25% of non-diabetics, and this difference was statistically significant (p=0.0175), suggesting that hemoptysis was more common among non-diabetic patients. Dyspnea was observed in 22% of diabetics and 20% of non-diabetics, with a p-value of 0.7127, showing no significant variation. Similarly, chest pain was reported in 15% of diabetics and 12% of non-diabetics, with a p-value of 0.4644, also not significant.

Table 7: Comparison of Symptom Distribution Between Diabetic and Non-Diabetic Tuberculosis Patients

Symptoms	Diabetic TB Group n (%)	Non-Diabetic TB Group n (%)	p value	Interpretation
Cough	60 (30%)	70 (35%)	0.3367	Not Significant
Hemoptysis	30 (15%)	50 (25%)	**0.0175**	Significant
Dyspnea	44 (22%)	40 (20%)	0.7127	Not Significant
Chest pain	30 (15%)	24 (12%)	0.4644	Not Significant

Table 8 presents the descriptive statistics of the study population, highlighting both continuous and categorical variables. The participants had a mean age of 41.8 years, with elevated glycemic indices reflected in mean fasting blood sugar of 152 mg/dl, post-prandial blood sugar of 285 mg/dl, and HbA1c of 9.2%, indicating poor glycemic control among diabetics. Males constituted 62% of the group, while females accounted for 38%. Educational attainment varied: 40% had secondary education, 22% primary, 20% graduate, and 18% were illiterate. Occupational distribution showed housewives (28%) and farmers (22%) as major groups, followed by drivers (15%) and others (35%). Treatment outcomes revealed that 68% of patients were cured, 22% experienced treatment failure, and 10% were lost to follow-up. Radiological assessment demonstrated complete resolution in 64% of cases, while partial resolution and persistence were each observed in 18%. Drug resistance was detected in 12% of patients, whereas 88% remained sensitive. Overall, 55% of the study population were diabetic, compared to 45% non-diabetic, ensuring a balanced representation for comparative analysis.

Table 8: Descriptive Statistics of Study Population (Mean ± SD and Percentages)

Variable	Mean ± SD / n (%)
Age (yrs)	41.8 ± 12.4
FBS (mg/dl)	152 ± 18.6
PPBS (mg/dl)	285 ± 32.1
HbA1c (%)	9.2 ± 1.8
Sex (Male)	62%
Sex (Female)	38%
Education (Illiterate)	18%
Education (Primary)	22%
Education (Secondary)	40%
Education (Graduate)	20%
Occupation (Housewife)	28%
Occupation (Farmer)	22%
Occupation (Driver)	15%
Occupation (Others)	35%
Treatment Outcome (Cured)	68%
Treatment Outcome (Failed)	22%
Treatment Outcome (Lost)	10%
Radiological Complete Resolution	64%
Radiological Partial Resolution	18%
Radiological Persistence	18%
Drug Resistance (Yes)	12%
Drug Resistance (No)	88%
Diabetes Status (Yes)	55%
Diabetes Status (No)	45%

Table 9 illustrates the association between diabetes status and treatment outcomes among tuberculosis patients. The mean age of diabetic patients was slightly higher (41.8 years) than that of non-diabetic patients (39.5 years). Treatment success differed notably between the two groups: 62% of diabetic patients achieved cure, whereas 78% of non-diabetic patients were cured. Conversely, treatment failure was more frequent in the diabetic group (28%) compared to the non-diabetic group (12%). Loss to follow-up was similar in both groups (10%). ANOVA revealed a significant difference between the groups ($p=0.032$), indicating that diabetes status was significantly associated with treatment outcomes in tuberculosis patients.

Table 9: Association of Diabetes Status with Treatment Outcome in Tuberculosis Patients

Diabetes Status	Mean Age (yrs)	Cured (%)	Treatment Failed (%)	Lost to Follow-up (%)	ANOVA p-value
Diabetic	41.8	62%	28%	10%	0.032
Non-Diabetic	39.5	78%	12%	10%	—

Table 10 highlights the relationship between diabetes status and radiological progression in tuberculosis patients. Diabetic individuals had a higher mean HbA1c level (9.8%) compared to non-diabetic patients (7.2%), reflecting poorer glycemic control. Radiological outcomes differed significantly between the two groups: complete resolution was achieved in 58% of diabetic patients, whereas 74% of non-diabetic patients showed complete resolution. Partial resolution was slightly more common in diabetics (22%) compared to non-diabetics (18%). Persistence or progression of radiological findings was markedly higher among diabetics (20%) than non-diabetics (8%). Statistical analysis using

ANOVA demonstrated a significant association between diabetes status and radiological progression, with a p-value of 0.041, indicating that poor glycemic control in diabetic patients adversely influenced radiological recovery.

Table 10: Association of Diabetes Status with Radiological change in Tuberculosis Patients

Diabetes Status	Mean HbA1c (%)	% Complete Resolution	% Partial Resolution	% Persistence/Progression	ANOVA p-value
Diabetic	9.8	58%	22%	20%	
Non-Diabetic	7.2	74%	18%	8%	**0.041**

Table 11 demonstrates the association between diabetes status and drug resistance in tuberculosis patients. Diabetic individuals had a higher mean fasting blood sugar level (162 mg/dl) compared to non-diabetic patients (132 mg/dl), reflecting poorer glycemic control. Drug resistance was observed in 18% of diabetic patients, whereas only 6% of non-diabetic patients exhibited resistance. Conversely, drug sensitivity was more common among non-diabetics (94%) compared to diabetics (82%). ANOVA revealed a significant difference between the two groups (p=0.027), indicating that diabetes status was significantly associated with increased drug resistance in tuberculosis patients.

Table 11: Association of Diabetes Status with Drug Resistance in Tuberculosis Patients

Diabetes Status	Mean FBS (mg/dl)	% Resistant	% Sensitive	ANOVA p-value
Diabetic	162	18%	82%	
Non-Diabetic	132	6%	94%	**0.027**

DISCUSSION

The present study compared the clinical profile and treatment outcomes of drug-sensitive PTB patients with and without DM in a tertiary care hospital in Tripura. The findings demonstrate that diabetes significantly influences treatment response, radiological recovery, and drug resistance among tuberculosis patients.

Most participants in both diabetic and non-diabetic groups were middle-aged, particularly in the 41-50 year age category. Viswanathan et al. and Stevenson et al. reported similar findings, noting that TB and DM coexist most often among middle-aged adults because of cumulative metabolic abnormalities and declining immune competence.21,22 Likewise, Giridharan et al. and Jali et al. identified middle-aged adults as the principal age group affected by tuberculosis in India.23,24 These findings indicate that the convergence of diabetes and tuberculosis is increasingly affecting economically productive age groups, emphasising the need for targeted screening and early intervention.

Educational status analysis revealed that a large proportion of patients in both groups belonged to lower educational categories, with primary education representing the largest subgroup. Previous studies by Bhargava et al. and Balakrishnan et al. reported that poor literacy and socioeconomic disadvantage increase susceptibility to tuberculosis and adversely affect healthcare-seeking behaviour and treatment adherence.25,26 Similar findings among non-diabetic tuberculosis patients have been documented by Rajeswari et al. and Dhanaraj et al., who highlighted the important role of poverty, inadequate living conditions, and limited education in sustaining TB transmission.27,28. These findings therefore reinforce the contribution of socioeconomic determinants to the burden of tuberculosis, regardless of diabetic status.

The comparison of MTB detection between diabetic and non-diabetic patients showed no statistically significant differences between males and females. Although MTB detection rates varied slightly between groups, diabetes status alone was not significantly associated with bacteriological confirmation. Workneh et al. reported similar observations and suggested that the association between diabetes and tuberculosis may vary across populations and demographic settings.29 Previous studies have also indicated that gender-specific differences in TB-DM interaction are often inconsistent and may be influenced by socioeconomic and biological factors.30 These findings suggest that while diabetes increases susceptibility to TB, its direct relationship with MTB detection remains complex.

Assessment of symptom profiles demonstrated that cough remained the most common presenting symptom in both groups. Dyspnoea and chest pain occurred with similar frequency, whereas hemoptysis was significantly more common among non-diabetic patients. Previous studies by Viswanathan et al. and Bibi et al. similarly reported variations in clinical presentation between diabetic and non-diabetic TB patients.21,31 Barot et al. also documented that diabetic patients frequently present with less typical respiratory manifestations compared to non-diabetics.32 These observations may be explained by altered immune responses and differences in disease progression among diabetic individuals, which can modify the clinical presentation of pulmonary tuberculosis.

The descriptive characteristics of the study population revealed a predominance of males and middle-aged adults. Poor glycaemic control among diabetic patients was evident from elevated fasting blood glucose, postprandial blood glucose, and HbA1c levels. Socioeconomic and occupational factors were also prominent, with many patients belonging to lower educational and occupational groups. Lönnroth et al. reported similar observations and emphasised the importance of social determinants in tuberculosis epidemiology.33 Moreover, Baker et al. demonstrated that diabetes adversely affects tuberculosis outcomes, particularly among individuals with inadequate glycaemic control.34

A major finding of the present study was the significant difference in treatment outcomes between diabetic and non-diabetic tuberculosis patients. Diabetic patients showed lower cure rates and substantially higher treatment failure rates compared with non-diabetic patients. This finding is consistent with reports by Baker et al., who identified diabetes as an important predictor of poor TB treatment outcomes.34 Furthermore, Dooley and Chaisson highlighted that hyperglycaemia impairs host immune mechanisms, delays sputum conversion, and increases the likelihood of treatment failure.35 The present results therefore support the growing evidence that diabetes negatively influences treatment success among tuberculosis patients.

Radiological response to anti-tuberculosis therapy was also significantly poorer among diabetic patients. Complete radiological resolution was less frequent, while lesion persistence or progression was more common in the diabetic group. Higher HbA1c values among diabetic patients further indicate that poor glycaemic control may contribute to delayed healing of pulmonary lesions. Similar findings were reported by Chiang et al., who observed slower radiological improvement among diabetic TB patients.36 Restrepo et al. additionally noted that uncontrolled diabetes was associated with persistent pulmonary abnormalities and delayed recovery.37 These findings emphasise the importance of maintaining optimal glycaemic control during tuberculosis treatment.

Another important observation was the significantly higher prevalence of drug resistance among diabetic patients compared with non-diabetic patients. Elevated fasting blood glucose levels were associated with a greater likelihood of resistance to anti-tuberculosis drugs. Ruslami et al. reported similar conclusions, identifying slower microbiological response among diabetic TB patients.38 Mi et al. also reported increased odds of drug resistance among patients with coexisting diabetes and tuberculosis.39 Poor glycaemic control may facilitate prolonged bacterial persistence, thereby increasing the risk of resistance development and unfavourable treatment outcomes.

Study Limitations

1. The study population may not be sufficiently representative of all regional and socioeconomic variations in tuberculosis-diabetes comorbidity.
2. The observational study design limits the ability to establish a causal relationship between diabetes and tuberculosis outcomes.
3. Variations in glycemic control throughout the course of tuberculosis treatment were not assessed longitudinally.
4. Interpretation of radiological findings may have been influenced by observer-related variability.
5. Detailed molecular characterisation and resistance pattern analysis of drug-resistant isolates were not performed.
6. Important socioeconomic determinants such as income, nutritional status, and healthcare accessibility were not comprehensively evaluated.
7. The sample size may have been insufficient to detect subtle gender-specific differences in the interaction between diabetes mellitus and tuberculosis.

CONCLUSION

This study demonstrated that diabetes mellitus significantly adversely affects the clinical course and treatment outcomes of drug-sensitive pulmonary tuberculosis. Although microbiological detection rates were comparable between diabetic and non-diabetic patients, individuals with diabetes experienced lower cure rates, poorer radiological recovery, higher treatment failure rates, and greater drug resistance. Poor glycemic control appeared to contribute substantially to unfavourable treatment responses and delayed disease resolution. The findings underscore the importance of integrating diabetes screening, optimal glycemic management, and tuberculosis care to improve treatment outcomes. Strengthening bidirectional screening, patient education, and coordinated management strategies may help reduce the burden of TB-DM comorbidity and enhance overall tuberculosis control in high-burden settings.

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