RESEARCH PAPER

Exploring the Association Between Diabetes Mellitus and Tuberculosis in a TB-Positive Population: An Observational Study

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Received: 28th Feb, 2026; Revised: 6th March 2026; Accepted: 7th April, 2026; Available Online: 20th April, 2026

ABSTRACT

Background: In low- and middle-income countries, tuberculosis (TB) remains a significant public health issue. Recent evidence highlights the increased risk of developing comorbid conditions such as diabetes mellitus (DM) in patients with active TB, which can complicate treatment outcomes and lead to patient morbidity. Therefore, understanding the sociodemographic characteristics of TB patients and their relationship with diabetes is essential for targeted prevention and management strategies. This observational study aims to investigate the association between DM and TB in a TB-positive cohort.

Methods: The study was conducted among individuals diagnosed with active TB. Data were collected from medical records, to assess the presence of comorbidities, particularly DM and other relevant sociodemographic and clinical variables. Statistical analysis was used to characterize the study population, and inferential analysis was performed to identify significant associations between DM and TB incidence.

Result: Among 346 TB-positive patients (67% male), 30.06% were diabetic, with higher prevalence observed in males, employed individuals, and those reporting alcohol or smoking habits. Diabetes was also strongly associated with comorbid conditions ($p < 0.001$). Correlation analysis revealed older patients had longer diabetes duration and higher comorbidity rates. Logistic regression identified lifestyle factors and comorbidity as significant predictors of TB–DM convergence.

Conclusion: The study underscores the substantial burden of diabetes mellitus among tuberculosis-positive patients, notably among males and employed individuals. These findings highlight the necessity of integrated screening and management strategies for both conditions, in order to improve health conditions and mitigate dual disease burden, especially in high-risk TB populations.

Keywords: *Tuberculosis, Diabetes Mellitus, Comorbidity, Sociodemographic Factors, Lifestyle Risk Factors, TB–DM Association.*
How to cite this article: Pandey SK, Bharti AK, Sen A, Mangal S, Ray M, Indu R. Exploring the Association Between Diabetes Mellitus and Tuberculosis in a TB-Positive Population: An Observational Study. Int J Drug Deliv Technol. 2026;16(62s): 1716-1722. DOI: 10.25258/ijddt.16.62s.172
Source of support: Nil.
Conflict of interest: None

INTRODUCTION

In low- and middle-income countries, tuberculosis (TB) and diabetes mellitus (DM) represent two significant global health challenges. In 2023, the World Health Organization (WHO) reported around 10.8 million TB cases and around 1.25 million deaths worldwide, underscoring its ongoing impact.(1) Meanwhile, the International Diabetes Federation estimated 537 million adults had diabetes in 2021, with projections reaching 643 million by 2030.(2)

Growing research emphasizes a bidirectional relationship between these diseases. Individually, both conditions contribute significantly to the global health burden. In recent years, growing attention has been directed toward the interaction between TB and diabetes, particularly because of the epidemiological overlap in countries heavily affected by both conditions. In low- and middle-income countries (LMICs), the coexistence of tuberculosis (TB) and diabetes is emerging as a significant public health challenge where both diseases are prevalent. Countries such as India, China, Indonesia, and the Philippines are facing simultaneous epidemics of tuberculosis and diabetes, fueled by urbanization, shifts in lifestyle, and aging populations.(3) In these contexts, the co-occurrence of TB and diabetes is increasingly being identified as a syndemic, where the interaction between the two diseases leads to more severe health outcomes.

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Epidemiological studies show that there is an increased risk of developing active TB in diabetic individuals as compared to non- diabetic individuals.(4) A meta-analysis reported that diabetes was linked to an approximately 2 to 4-fold increased risk of developing TB.(5)

Individuals with diabetes are more susceptible to tuberculosis (TB) primarily due to the immunosuppressive effects of chronic hyperglycemia.(5) Elevated blood sugar levels impair the function of macrophages, reduce neutrophil activity, and weaken T cell-mediated immune responses—critical components in the body's defense against *Mycobacterium tuberculosis*.(6) Diabetes not only increases TB risk but also worsens treatment outcomes. Research shows that TB patients with diabetes face higher rates of treatment failure, relapse, delayed sputum conversion, and greater mortality. A study in Pune, India, found significantly higher early death rates in TB patients with diabetes compared to those without diabetes.(7)

Health policy increasingly emphasizes the need for integrated TB and diabetes care, including bidirectional screening. The WHO has issued policy briefs, particularly targeting Asian countries, highlighting the dual burden of TB-DM comorbidity and urging health systems to coordinate efforts in prevention, screening, diagnosis, and treatment of both diseases.(8)

Despite this well-known link, diabetes screening among TB patients is still limited, especially in regions with a high burden of both diseases. Research has shown a significant number of TB patients have undiagnosed diabetes—for instance, nearly 25.3% of TB patients in India were found to have diabetes, many of whom were unaware of their condition (Rawat et al., 2021).(9-10) This underscores the urgent need to incorporate diabetes screening into TB programs to enhance patient outcomes and reduce the strain on healthcare systems.

Cross-sectional studies are essential for understanding the epidemiology of TB-DM comorbidity, as they help identify its prevalence and associated risk factors, offering important insights to guide clinical practice and inform public health policies, especially in resource-constrained settings. This observational study aims to examine the relationship between diabetes mellitus and tuberculosis within a TB-positive population. It seeks to estimate the prevalence of diabetes among TB patients, identify demographic and clinical factors associated with the comorbidity. Furthermore, the study will investigate differences in clinical presentation and outcomes between TB patients with and without diabetes.

METHODOLOGY

Type of Study
This study was designed as an observational study to assess the sociodemographic characteristics, diabetic status, lifestyle habits, and comorbidities among tuberculosis (TB)- positive patients, as well as the associations between these factors.

Study Duration
The study was conducted over a period of six months.

Study Site
The research was carried out at **Rajendra Institute of Medical Sciences,** located in Ranchi, Jharkhand, which serves a diverse population from urban, suburban, and rural areas.

Inclusion Criteria
- Records of patients of all age groups who tested positive for tuberculosis during the study period.
- Both male and female patients.

Exclusion Criteria
- Records of patients who tested negative for tuberculosis.
- Patients with incomplete or missing sociodemographic or clinical data records.

Data Collection

The following data were collected from the medical records of 346 TB-positive patients:
- Sociodemographic variables including age, gender, residence (urban, suburban, rural), and employment status.
- Medical history, including diabetes status, family history of tuberculosis, and presence of other comorbidities such as cardiovascular diseases, hypertension, and chronic pulmonary diseases.
- Lifestyle habits, including alcohol consumption and smoking status.
- Duration of diabetes for diabetic patients.

The American Diabetic Association (ADA) criteria was employed to screen for diabetic patients.

Data for this observational study were retrieved from hospital medical records after obtaining written permission from the hospital authority. Institutional Ethics Committee (IEC) clearance was waived, as the study involved no direct patient interaction. Patient identity and confidentiality were strictly maintained throughout the study in accordance with ethical standards.

DATA ANALYSIS AND INTERPRETATION
Collected data were entered into a statistical software package for analysis. Descriptive statistics, such as means, standard deviations, frequencies, and percentages, were calculated for continuous and categorical variables. Associations between categorical variables (e.g., gender and diabetes status, residence and diabetes status) were evaluated using Chi-square tests of independence. A p-value < 0.05 was considered statistically significant. For continuous variables, Pearson correlation analysis was performed to assess the relationship between age and duration of diabetes mellitus among diabetic TB patients. The strength and direction of correlation were interpreted based on the Pearson correlation coefficient (r). Binomial

logistic regression analysis was employed to identify the sociodemographic predictors for the risk of convergence of TB and DM.

RESULTS

Data were collected from the medical records of 346 TB-positive patients.

Sociodemographic characteristics

The age of the study participants ranged from 2 to 80 years, with a mean age of approximately 38.09 years (± 0.86), indicating a wide age distribution among the TB-positive cohort. The average age of the overall study population varied across subgroups. Female participants had a mean age of 33.71 years, while the average age for male participants was higher at 40.24 years. Among diabetic patients, the mean age was notably higher at 49.41 years, indicating that diabetes was more common in the older segment of the TB-positive population.

Table 1 illustrates the sociodemographic features of the study population. The study included a total of 346 TB-positive patients. Among them, 67.05% (n = 232) were male and 32.95% (n = 114) were female, indicating a predominance of male participants. In terms of residence, 51.45% (n = 178) were from rural areas, followed by 25.14% (n = 87) from sub-urban, and 23.41% (n = 81) from urban settings.

Regarding employment status, 52.89% (n = 183) of the participants were employed while 47.11% (n = 163) were unemployed. Among the unemployed population include the females who were mostly home makers and also children who were students. A positive family history of TB was reported by 33.53% (n = 116) of the participants, while 66.47% (n = 230) did not report any such history.

Out of the total study population, 30.06% (n = 104) were diabetic, and the remaining 69.94% (n = 242) were non-diabetic. Assessment of lifestyle habits showed that 7.51% (n = 26) consumed alcohol only, 23.99% (n = 83) smoked, 26.01% (n = 90) reported both alcohol and smoking habits, while 42.49% (n = 147) reported no such habits. Additionally, 34.97% (n = 121) had other comorbid conditions, whereas 65.03% (n = 225) did not report any comorbidity. The comorbid conditions include cardiovascular diseases, hypertension, chronic pulmonary diseases, etc.

Table 1: Sociodemographic characteristics of the study population

Characteristics	Frequency	Percentage
Gender		
Male	232	67.05
Female	114	32.95
Residence		
Rural	178	51.45
Sub urban	87	25.14
Urban	81	23.41
Employment status		
Employed	183	52.89
Unemployed	163	47.11
Family history of TB		
Yes	116	33.53
No	230	66.47
Diabetes status		
Diabetic	104	30.06
Non-diabetic	242	69.94
Lifestyle habits		
Alcohol	26	7.51
Smoking	83	23.99
Alcohol, Smoking	90	26.01
NA	147	42.49
Comorbidity status		
Present	121	34.97
Absent	225	65.03

Association between sociodemographic features and diabetic status

Table 2 illustrates the association between sociodemographic features and diabetic status of the study population. As evident from Table 2, among the male

participants, 35.34% (n = 82) were diabetic and 64.66% (n = 150) were non-diabetic. In the female group, 19.30% (n = 22) were diabetic, while 80.70% (n = 92) were non-diabetic. A Chi-square test of independence was conducted to examine the relationship between gender and the presence of diabetes among TB patients. The association was found to be statistically significant, $\chi^2(1, N = 346) = 9.362$, $p = 0.003$. This indicates that diabetes status varies significantly by gender, with a higher proportion of diabetes observed among male patients compared to females.

Table 2: Association between sociodemographic features and diabetic status

Socio-demographic features	Diabetes status		Chi-square (χ^2)	P value
	Diabetic	Non-diabetic		
Gender				
Male	82	150	9.362	0.003**
Female	22	92		
Residence				
Urban	21	60	1.108	0.575
Sub urban	29	58		
Rural	54	124		
Employment status				
Employed	71	112	14.115	0.000**
Unemployed	33	130		
Lifestyle habits				
Alcohol consumption/smoking	81	118	25.25	0.000**
No habits	23	124		
Comorbidity status				
Present	64	57	46.15	0.000**
Absent	40	185		

** indicates significance at $p<0.01$

Among the urban residents, 25.93% (n = 21) were diabetic and 74.07% (n = 60) were non-diabetic. In the sub-urban group, 33.33% (n = 29) were diabetic while 66.67% (n = 58) were non-diabetic. Among rural participants, 30.34% (n = 54) were diabetic and 69.66% (n = 124) were non-diabetic (Table 2). A Chi-square test of independence was conducted to examine the relationship between place of residence and diabetes status among TB patients. The association was found to be statistically non-significant, $\chi^2(2, N = 346) = 1.108$, $p = 0.575$. This suggests that diabetes incidence among TB patients does not vary significantly by urban, suburban, or rural residence.

As suggested by Table 2, 38.80% (n = 71) of the employed participants were diabetic and 61.20% (n = 112) were non-diabetic. In contrast, among the unemployed group, 20.25% (n = 33) were diabetic, while 79.75% (n = 130) were non-diabetic. A Chi-square test of independence was performed to examine the association between employment status and diabetes status among TB patients. The result showed a highly significant association, $\chi^2(1, N = 346) = 14.115$, $p < 0.001$. The findings indicate that diabetes prevalence was significantly higher among employed individuals compared to the unemployed. This may reflect occupational or lifestyle-related risk factors that merit further investigation.

Among participants with lifestyle habits such as alcohol consumption and/or smoking, 40.70% (n = 81) were diabetic and 59.30% (n = 118) were non-diabetic (Table 2). In contrast, among those with no such habits, only 15.65% (n = 23) were diabetic, while 84.35% (n = 124) were non-diabetic. A Chi-square test of independence was conducted to assess the association between lifestyle habits (alcohol or smoking) and diabetes status among TB patients. The result showed a highly significant relationship ($p < 0.001$). A notably higher proportion of individuals who consumed alcohol or smoked were diabetic compared to those who had no such habits. This suggests that unhealthy lifestyle practices are strongly associated with increased diabetes incidence in this population.

Among participants with comorbid conditions, 52.89% (n = 64) were diabetic and 47.11% (n = 57) were non-diabetic. In contrast, among those without comorbidities, only 17.78% (n = 40) were diabetic, while 82.22% (n = 185) were non-diabetic. A Chi-square test of independence was performed to examine the relationship between comorbidity status and diabetes mellitus among TB patients. The association was found to be highly significant, $\chi^2(1, N = 346) = 46.150$, $p < 0.001$. A substantially higher proportion of patients with comorbidities were diabetic compared to those without, suggesting that the presence of comorbid conditions is strongly associated with diabetes in this study population.

Correlation analysis between age and duration of DM and comorbidity status

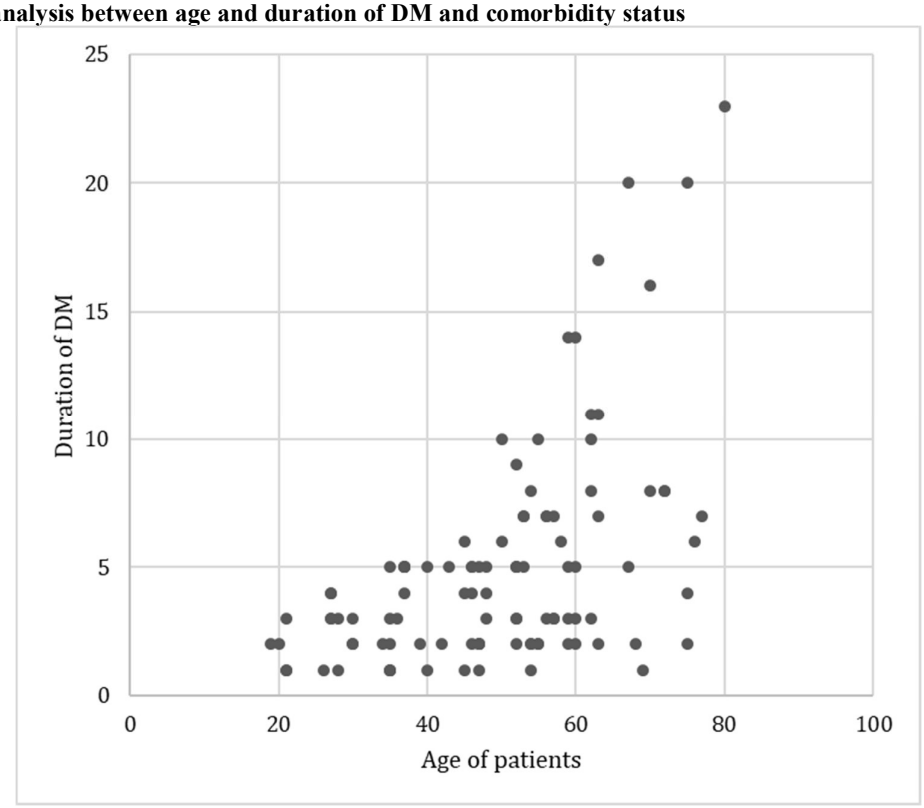

Figure 1: Correlation of age of patients with duration of DM

A Pearson correlation analysis was conducted to evaluate the relationship between the age of TB patients with diabetes mellitus (DM) and the duration of their diabetes. The analysis revealed a moderate positive correlation, with a Pearson correlation coefficient (r) of 0.519. This association was found to be statistically significant with a p-value < 0.001. The result indicates that as the age of diabetic TB patients increases, the duration of their diabetes tends to increase as well (Figure 1). Correlation analysis of the age of the patient with the comorbidity status revealed that comorbid conditions were more evident among the elderly patients as compared to the young patients ($p<0.001$, $r= 0.301$).

Logistic regression analysis of TB and DM patients with sociodemographic features

The binomial logistic regression analysis concluded that lifestyle and comorbidity were significant sociodemographic predictors for the risk of convergence of TB and DM. The details are provided in Table 3.

Table 3: Logistic regression analysis of TB and DM patients with sociodemographic features

Variables	B	SE	Wald	p-value	OR	95% CI
Gender	0.080	0.470	0.029	0.865	1.083	0.431~2.723
Employment	-0.218	0.371	0.346	0.556	0.804	0.388~1.664
Lifestyle	-1.153	0.390	8.766	0.003**	0.316	0.147~0.677
Comorbidity	1.616	0.267	36.515	0.000**	5.030	2.979~8.495

** indicates significance at $p<0.01$

DISCUSSION

Tuberculosis (TB) and diabetes mellitus (DM) are significant global health challenges that often coexist, complicating disease management. Research has emphasized the increased risk of TB in diabetic cohorts.(11,12) Therefore, it is essential to comprehend the sociodemographic factors and the interplay between TB and DM in order to ensure improved patient care and reduce morbidity. The present study aims to evaluate the sociodemographic profile of TB-positive patients and elucidate the association between diabetes mellitus and TB.

The demographic analysis reveals that the TB burden in this study was more pronounced among males, aligning with national and global trends that indicate higher TB prevalence in men.(1,13-14) The higher male representation could be attributed to occupational exposure, delayed healthcare seeking by males, or sociocultural norms that affect healthcare accessibility for women. The rural predominance of TB patients in the present study was also in line with the findings of a study

conducted in Karnataka, India, where the prevalence was 88%.(15) Nutrition deficiency, lack of proper healthcare infrastructure, and inadequate living conditions could be the contributing factors, thereby emphasizing the need for strengthening TB detection and treatment services in rural areas.(16)

The finding that 30.06% of TB patients also had diabetes is alarming. This aligns with the reported 29% prevalence of diabetes among TB patients in Puducherry, which is notably higher than that seen in the general population.(17) This finding supports the growing evidence on the TB-diabetes syndemic, necessitating the need for routine screening. This co-morbidity is clinically significant, as diabetes can impair immune response, delay TB diagnosis, and complicate treatment.(12) Furthermore, more than half of the participants (57.51%) reported harmful lifestyle habits such as smoking and/or alcohol consumption—both of which are known risk factors for TB reactivation and poor treatment outcomes.(18) The high prevalence of comorbidities (34.97%) further highlights the need for an integrated approach to TB care, including screening and management of non-communicable diseases (NCDs) and behavioral risk factors.

The significant association between employment status and diabetes among TB patients suggests that employed individuals are more likely to be diabetic. This trend may be influenced by occupational stress, sedentary work environments, irregular eating habits, or limited time for physical activity—all of which are known contributors to the development of diabetes. Additionally, employed individuals may have better access to healthcare, leading to higher rates of diagnosis. These findings emphasize the need for workplace-based health promotion programs and routine screening for non-communicable diseases like diabetes, particularly among working populations with TB. The significant association between lifestyle habits and diabetes among TB patients highlights the impact of modifiable risk factors on comorbidity. These findings underscore the importance of integrating behavioural counselling and lifestyle modification programs into TB care to reduce the burden of diabetes in this vulnerable population.

The strong association between diabetes and comorbidities such as cardiovascular diseases, hypertension, and chronic pulmonary disorders highlights the complex interplay of infectious and non-communicable diseases in TB patients. Older individuals, with longer diabetes duration, are at increased risk due to weakened immunity and complications that may impair TB management. These findings emphasize the need for integrated care models addressing both communicable and chronic conditions, with early screening and proactive management of diabetes and comorbidities. Incorporating routine checks into TB programs can improve outcomes, reduce complications, and optimize healthcare resource utilization in vulnerable populations.

CONCLUSION

This study highlights a significant burden of diabetes mellitus among tuberculosis-positive patients, particularly among males and employed individuals. While family history of TB and place of residence did not show a significant association with diabetes status, lifestyle factors such as alcohol consumption and smoking, as well as the presence of other comorbidities, were strongly linked to higher diabetes prevalence in this population. The moderate positive correlation between age and duration of diabetes emphasizes the chronic nature of diabetes among older TB patients. These findings underscore the importance of integrated screening and management strategies for diabetes in TB control programs to improve patient outcomes.

CONFLICT OF INTEREST

All authors have no Conflict of Interest.

FUNDING

None provided.

ETHICAL APPROVAL

The present study was conducted using retrospective data obtained from existing medical records, with prior permission from the concerned hospital authorities. No direct patient contact or intervention was involved at any stage. All data were anonymized before analysis, and strict confidentiality of patient information was maintained throughout the study. As the research utilized secondary data without identifying details, and posed minimal risk to participants, the requirement for formal ethical approval was waived by the institution.

Author Contributions

Sudipto Mangal: Conceptualization, methodology design, data acquisition, data curation, formal analysis, drafting of the manuscript, and critical revision of the final version. **Sudhanshu Kumar Pandey:** Data acquisition, statistical support, preparation of tables/figures, and contribution to manuscript editing. **Abhay Kumar Bharti:** Field investigation, coordination with study participants, data verification, and support in drafting the methodology section. **Anindita Sen:** Supervision during study planning, review of scientific content, and assistance in refining the discussion and conclusion. **Moumita Ray:** Guidance in epidemiological interpretation, substantial revision of the manuscript, and quality enhancement of the final draft. **Rania Indu*** (Corresponding Author): Overall project administration, supervision, study design oversight, interpretation of findings, critical review, and final approval of the manuscript for submission.

AVAILABILITY OF DATA & MATERIAL

Data were collected, analyzed and presented in the result section.

ARTIFICIAL INTELLIGENCE INVOLVEMENT

No material has been partially or totally produced with the help of artificial intelligence software or tools.

ACKNOWLEDGMENTS

The authors would like to acknowledge JIS University and Jharkhand Rai University for giving the platform to carry on this survey-based research work.

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