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Prevalence and predictors of tuberculosis among patients with diabetes mellitus: A cross-sectional hospital-based study.

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Abstract

Background
Diabetes mellitus (DM) is increasingly recognized as a significant risk factor for tuberculosis (TB), particularly in developing countries where both conditions are highly prevalent. The coexistence of these diseases complicates clinical outcomes and challenges TB control efforts. This study aimed to determine the prevalence of TB among diabetic patients and to identify the major predictors associated with its occurrence.

Methods
A hospital-based cross-sectional study was conducted over 18 months (April 2024–September 2025). A total of 100 adult patients with type 2 diabetes mellitus were enrolled. Detailed demographic, clinical, and laboratory data were recorded. Tuberculosis was diagnosed based on clinical findings, radiological evidence, sputum smear microscopy, GeneXpert assay, and histopathological confirmation when necessary. Statistical analysis included descriptive statistics and chi-square tests to identify significant predictors.

Results
The overall prevalence of TB among diabetic patients was 14%, with pulmonary TB (11%) being more frequent than extrapulmonary TB (3%). The mean age of participants was 54.7 ± 10.8 years, and 58% were male. Univariate analysis revealed that age ≥ 60 years (p=0.02), duration of diabetes >10 years (p=0.002), poor glycemic control (HbA1c ≥8%, p=0.02), low BMI (<18.5 kg/m², p=0.003), and HIV co-infection (p=0.02) were significant predictors of TB. Smoking and gender were not statistically significant.

Conclusion
The prevalence of TB among diabetic individuals remains considerably high, underscoring the bidirectional link between chronic hyperglycemia and infection risk.

Recommendations
Routine TB screening should be integrated into diabetes clinics, and strict glycemic control with nutritional support is essential to reduce TB risk. Interdisciplinary collaboration between TB and diabetes programs is strongly recommended. Early screening for TB should be prioritized among diabetics with prolonged disease duration, poor glycemic control, or low BMI.

Keywords: *Diabetes mellitus, Tuberculosis, Prevalence; Predictors; Glycemic control, Body Mass Index, HIV co-infection*
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Introduction

Tuberculosis (TB) continues to remain one of the most pressing global health concerns, particularly in low- and middle-income countries where communicable and non-communicable diseases coexist. According to the World Health Organization (WHO) Global Tuberculosis Report 2024, an estimated 10.6 million people developed TB worldwide, with India accounting for nearly 27% of the global burden [1]. In recent years, diabetes mellitus (DM) has emerged as a major contributor to the resurgence of TB in endemic regions [2].

Diabetes is characterized by chronic hyperglycemia and impaired immune responses, including defective macrophage activation, reduced cytokine secretion, and compromised T-cell–mediated immunity, all of which facilitate *Mycobacterium tuberculosis* infection and reactivation from latency [3]. Moreover, sustained hyperglycemia adversely affects TB treatment outcomes by delaying sputum conversion, increasing relapse rates, and elevating mortality [4].

The bidirectional relationship between TB and DM represents a serious public-health challenge. Tuberculosis itself can worsen glucose metabolism through stress-induced hyperglycemia and pancreatic dysfunction, while diabetes increases the likelihood of developing active TB nearly threefold [2, 5]. This synergistic interaction threatens global TB-elimination efforts, prompting the WHO and the International Union Against Tuberculosis and Lung Disease (IUATLD) to emphasize integrated screening and joint management strategies for these conditions [2].

Several Indian studies have reported a wide variation in TB prevalence among diabetic patients, ranging from 8% to 15%, depending on regional, metabolic, and diagnostic factors [1, 3, 5]. However, there remains limited regional evidence identifying the specific predictors of TB among diabetics, such as disease duration, glycemic control, nutritional status, and HIV co-infection. Understanding these determinants is vital for developing targeted interventions and strengthening public-health strategies.

In this context, the present study was undertaken at Gandhi Medical College, Secunderabad, a tertiary-care teaching institution in South India, to estimate the prevalence and predictors of tuberculosis among patients with diabetes mellitus. By elucidating the demographic, clinical, and biochemical correlates of TB in this high-risk population, the study aims to inform integrated diabetes-TB screening protocols and support evidence-based disease-control initiatives in India.

Materials and methods

Study design and setting

This was a hospital-based cross-sectional observational study conducted in the Department of Respiratory Medicine, Gandhi Medical College and Hospital, Secunderabad, Telangana, a tertiary-care teaching institution that serves a large urban and semi-urban population. The study was carried out over 18 months from April 2024 to September 2025.

Study population

The study population included adult patients (aged ≥18 years) with a known diagnosis of type 2 diabetes mellitus (T2DM) attending the diabetes outpatient clinic or admitted to the medical wards during the study period.

Sample size and sampling technique

The sample size of 100 adults with type 2 diabetes mellitus was calculated using the standard formula for estimating a proportion in a cross-sectional study:
$n=Z2\times p(1-p)d2$
Assuming a 15% expected prevalence of tuberculosis among diabetics based on previous Indian studies, with a 95% confidence level (Z = 1.96) and a precision (d) of 7%, the calculated sample size was:
$n=(1.96)2\times 0.15\times 0.85(0.07)2\approx 99.6$
Thus, the required minimum sample size was 100, which was adopted for the study. Consecutive sampling was used until this number was achieved.

Inclusion criteria

- Patients aged ≥18 years diagnosed with type 2 diabetes mellitus according to the American Diabetes Association (ADA 2023) criteria.
- Willingness to participate and provide written informed consent.

Exclusion criteria

- Patients with type 1 diabetes mellitus or gestational diabetes.

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- Individuals with chronic renal failure, malignancy, or other severe systemic illnesses are likely to confound TB diagnosis.
- Patients already on anti-tubercular therapy at the time of recruitment.

Data collection procedure

After obtaining informed consent, participants were interviewed using a structured case record form that included demographic data (age, gender, residence, socioeconomic status), duration of diabetes, and lifestyle habits such as smoking and alcohol use. Clinical examination findings were recorded, including body mass index (BMI) and signs suggestive of tuberculosis.

laboratory and diagnostic evaluation

All participants underwent fasting blood glucose and HbA1c estimation to assess glycemic control. Patients with clinical suspicion of tuberculosis were further evaluated using:
Chest X-ray (PA view)
Sputum smear microscopy for acid-fast bacilli (AFB)
GeneXpert MTB/RIF assay
Erythrocyte sedimentation rate (ESR)
Mantoux test
Ultrasound or CT imaging for extrapulmonary lesions, when indicated
Histopathological confirmation, where applicable
TB diagnosis was confirmed when either microbiological or radiological evidence supported active infection as per Revised National Tuberculosis Control Programme (RNTCP) guidelines.

Operational definitions

Poor glycemic control: HbA1c $\geq$ 8%
Low BMI: <18.5 kg/m²
Pulmonary TB: Infection involving the lung parenchyma confirmed radiologically or microbiologically.
Extrapulmonary TB: TB affecting organs other than the lungs confirmed by imaging or histopathology.

Statistical analysis

Data were entered in Microsoft Excel and analyzed using IBM SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Associations between categorical variables were evaluated using the Chi-square test (χ^2) or Fisher's exact test, as appropriate. A *p-value <0.05* was considered statistically significant.

Ethical considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of Gandhi Medical College, Secunderabad. Written informed consent was obtained from all participants before inclusion, and confidentiality of patient data was strictly maintained throughout the study in accordance with the Declaration of Helsinki.

Results

Participant flow

During the study period, 118 adults with known type 2 diabetes mellitus were screened for eligibility. Of these, 12 individuals were excluded because they had conditions that could confound tuberculosis diagnosis (chronic renal failure – 5; malignancy – 3; already on anti-tubercular therapy – 4). Six additional patients declined consent. A total of 100 eligible participants were therefore included and underwent complete clinical and diagnostic evaluation. No enrolled patient was lost to follow-up within the study visit, and all 100 participants were included in the final analysis.

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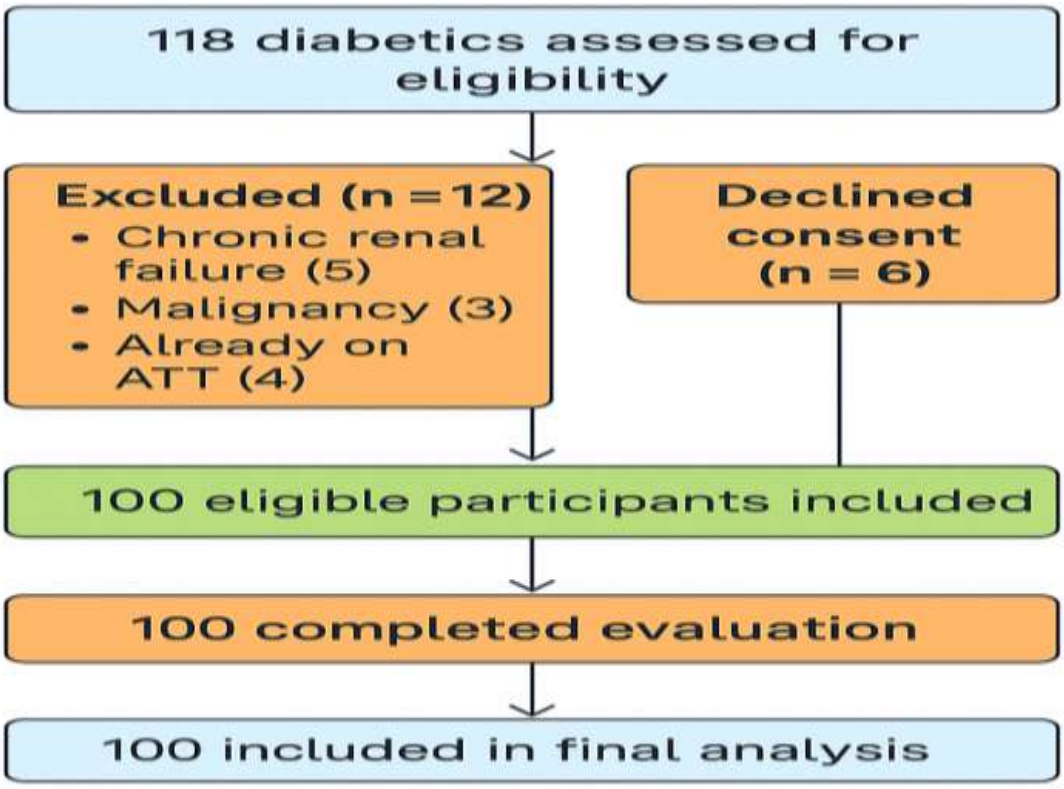

Figure 1: Participant flow diagram

A total of 100 patients with diabetes mellitus were enrolled during the 18-month study period at Gandhi Medical College. The mean age of participants was 54.7 ± 10.8 years, with a slight male predominance (58%).

Demographic profile

As shown in Table 1, the majority of patients (52%) were in the 40–59-year age group, followed by 30% aged ≥ 60 years. Urban residents constituted two-thirds (67%) of the cohort. More than half belonged to the middle socioeconomic class (53%), and 44% had diabetes for 5–10 years.

Table 1. Demographic characteristics of the study population (n = 100)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	<40	18	18.0
	40–59	52	52.0
	≥60	30	30.0
Sex	Male	58	58.0
	Female	42	42.0
Residence	Urban	67	67.0
	Rural	33	33.0
Socioeconomic Status	Upper	14	14.0
	Middle	53	53.0
	Lower	33	33.0

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Duration of Diabetes (years)	<5	38	38.0
	5–10	44	44.0
	>10	18	18.0

Clinical and laboratory characteristics

The mean duration of diabetes was 7.3 ± 4.5 years, with an average fasting blood glucose of 162 ± 38 mg/dL and a mean HbA1c of 8.4 ± 1.6 % (Table 2). A history of smoking and alcohol use was noted in 28% and 21% of patients, respectively. Underweight (BMI < 18.5 kg/m²) was observed in 12%, while 9% had a previous history of tuberculosis. HIV co-infection was detected in 3% of cases.

Table 2. Clinical and laboratory profile of diabetic patients

Parameter	**Mean ± SD / n (%)**
Mean Duration of Diabetes (years)	7.3 ± 4.5
Mean Fasting Blood Glucose (mg/dL)	162 ± 38
Mean HbA1c (%)	8.4 ± 1.6
History of Smoking	28 (28.0)
History of Alcohol Use	21 (21.0)
BMI < 18.5 kg/m²	12 (12.0)
Previous TB history	9 (9.0)
HIV Co-infection	3 (3.0)

Prevalence of tuberculosis among diabetic patients

The overall prevalence of tuberculosis (TB) among the diabetic population was 14%, with pulmonary TB (11%) being more common than extrapulmonary forms (3%) (Table 3). Newly diagnosed TB accounted for 9%, while 5% represented recurrent disease.

Table 3. Prevalence of tuberculosis among diabetic patients

TB Status	**No. of Patients**	**Percentage (%)**
Total TB cases	**14**	**14.0**
Pulmonary TB	11	11.0
Extrapulmonary TB	3	3.0
Newly Diagnosed	9	9.0
Recurrent TB	5	5.0

Predictors of tuberculosis

Univariate analysis revealed that age ≥ 60 years, duration of diabetes > 10 years, poor glycemic control (HbA1c ≥ 8%), low BMI (< 18.5 kg/m²), and HIV co-infection were significantly associated with the occurrence of TB (Table 4). Smoking and sex did not show statistical significance.

Table 4. Predictors of tuberculosis among diabetic patients (Univariate Analysis)

Predictor Variable	**TB Present (n=14)**	**TB Absent (n=86)**	**χ^2 / t-Value**	**p-Value**	**Significance**
Age ≥ 60 years	8 (57.1%)	22 (25.6%)	5.12	0.02	Significant
Male sex	10 (71.4%)	48 (55.8%)	1.14	0.28	NS
Duration of DM >10 years	7 (50.0%)	11 (12.8%)	9.86	0.002	Significant
Poor Glycemic	11 (78.6%)	38 (44.2%)	5.37	0.02	Significant

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Control (HbA1c ≥8%)					
Smoking	6 (42.9%)	22 (25.6%)	1.84	0.17	NS
BMI <18.5 kg/m²	5 (35.7%)	7 (8.1%)	8.71	0.003	Significant
HIV Co-infection	2 (14.3%)	1 (1.2%)	5.14	0.02	Significant

Discussion

The present hospital-based cross-sectional study conducted at Gandhi Medical College, Secunderabad, assessed the prevalence and determinants of tuberculosis (TB) among individuals with type 2 diabetes mellitus (T2DM). A 14% prevalence of TB was recorded, with pulmonary disease forming the major share. This pattern strengthens the understanding that diabetes substantially increases TB susceptibility, especially in countries like India where both conditions remain highly endemic [6,7].

Comparison with global and regional studies

The prevalence reported in this cohort is comparable to figures described from Ethiopia (13.7%) and Nigeria (15.2%), indicating a consistent epidemiological pattern across diverse regions [9,10]. Evidence from multiple studies shows that chronic hyperglycemia disrupts innate and adaptive immune pathways, allowing easier acquisition and reactivation of Mycobacterium tuberculosis infection [7,11]. Comparable proportions have also been documented in Southeast Asian populations, where diabetes has emerged as a key non-communicable driver of TB morbidity [8].

Age and duration of diabetes

Older age (≥60 years) and a longer duration of diabetes (>10 years) emerged as significant predictors of TB. Gradual immune senescence, combined with long-standing metabolic stress, weakens host defence and raises vulnerability to active infection. Findings from Ethiopia support this association, showing a direct link between prolonged diabetes duration and increased TB incidence [10].

Effect of glycemic control

Poor glycemic control (HbA1c ≥8%) showed a strong association with TB. This observation aligns with the meta-analysis that demonstrated the negative influence of uncontrolled diabetes on TB treatment outcomes, sputum conversion, relapse risk, and mortality [12]. Hyperglycemia promotes oxidative stress, impairs macrophage function, and disturbs granuloma integrity mechanisms central to containing M. tuberculosis infection [6,7]. Maintaining adequate glycemic control is therefore essential for lowering reactivation risk.

Nutritional and immunological factors

A higher proportion of TB occurred among underweight individuals (BMI <18.5 kg/m²), highlighting the impact of poor nutritional status on immune weakening. Reduced cytokine production and impaired macrophage activation contribute to this vulnerability. Similar patterns have been documented in both Ethiopian and Nigerian studies [9,10]. HIV co-infection also increased TB susceptibility, consistent with previous reports describing the combined immunosuppressive burden of HIV and diabetes [8].

Lifestyle and behavioral correlates

Although smoking and alcohol use were relatively common, their association with TB did not reach statistical significance. Global evidence still identifies smoking as an independent risk factor for TB through airway injury and diminished mucosal immunity [8,9]. The absence of significance here is likely due to small subgroup sizes and socioeconomic confounders.

Clinical and public-health implications

The interrelationship between TB and diabetes demands coordinated clinical and programmatic strategies. The dual burden creates biological and epidemiological challenges that complicate disease control [7]. Integrated screening for TB in diabetes clinics and diabetes assessment in TB services is essential. Early radiological and molecular screening,

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particularly using GeneXpert, can help in detecting cases earlier and reducing community spread. Strengthening collaboration between NTEP and NPCDCS is important for bidirectional screening, improved data sharing, and integrated care. Limited integration has already been linked to delayed diagnosis and higher drug resistance among diabetic TB cases [6].

Pathophysiological insights

Recent mechanistic work provides further clarity on the relationship between TB and metabolic dysfunction. Evidence shows that TB infection can trigger insulin resistance and metabolic derangements, potentially creating a cycle that sustains both conditions [11]. Early metabolic screening among TB patients may therefore help identify previously unrecognized diabetes.

Generalizability

The findings of this hospital-based cross-sectional study from Gandhi Medical College, Secunderabad, reflect patterns that are highly relevant to similar tertiary-care and urban healthcare settings in India, where tuberculosis and diabetes coexist as dual epidemics. Although the study sample was modest (n=100), the demographic and clinical spectrum of participants closely mirrors that of the general diabetic population attending government hospitals in South India. However, caution is warranted in extrapolating results to community or rural populations, where variations in nutritional status, healthcare access, and TB exposure may differ. Multicentric studies across diverse geographic and socioeconomic strata are therefore required to enhance external validity and substantiate the predictors identified in this cohort.

Conclusion

The present study highlights a substantial 14% prevalence of tuberculosis among patients with type 2 diabetes mellitus at Gandhi Medical College, Secunderabad, with pulmonary TB being predominant. Significant predictors included older age, longer diabetes duration, poor glycemic control, low BMI, and HIV co-infection, emphasizing the complex interplay between metabolic and infectious diseases. These findings reinforce the need for routine TB screening in diabetic clinics, particularly among high-risk groups, alongside strict glycemic management and nutritional optimization. Integration of diabetes and TB control programs with bidirectional screening can markedly reduce morbidity, improve treatment outcomes, and support national TB elimination efforts through early detection and holistic care.

Limitations

The study was limited by its single-center cross-sectional design and modest sample size (n=100), which may restrict causal inference and external validity. Potential confounders such as socioeconomic factors, nutritional status variations, and medication adherence were not extensively analyzed, warranting larger multicentric longitudinal studies for broader applicability.

Recommendations

Routine bidirectional screening for tuberculosis in all patients with diabetes mellitus should be implemented at primary and tertiary care levels. Individuals with poor glycemic control, long-standing diabetes, or low BMI warrant heightened surveillance. Integration of TB detection within diabetic clinics and vice versa should be institutionalized under NTEP–NPCDCS collaboration. Strengthening glycemic monitoring, ensuring nutritional counseling, and educating patients about early respiratory symptoms can aid in timely diagnosis. Additionally, periodic training of healthcare providers and community awareness initiatives are essential to reduce diagnostic delays, enhance treatment adherence, and ultimately curtail the dual burden of diabetes-associated tuberculosis in India.

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Abbreviations

TB – Tuberculosis
DM – Diabetes Mellitus
T2DM – Type 2 Diabetes Mellitus

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WHO – World Health Organization
ADA – American Diabetes Association
BMI – Body Mass Index
HbA1c – Glycated Hemoglobin
AFB – Acid-Fast Bacilli
RNTCP – Revised National Tuberculosis Control Programme
NTEP – National Tuberculosis Elimination Programme
NPCDCS – National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke
ESR – Erythrocyte Sedimentation Rate
HIV – Human Immunodeficiency Virus
CT – Computed Tomography
PA – Posteroanterior

Source of funding

The study had no funding.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

VGK-Concept and design of the study, results interpretation, review of literature, and preparing the first draft of the manuscript. Statistical analysis and interpretation, revision of manuscript. **PS**-Concept and design of the study, results interpretation, review of literature, preparing the first draft of the manuscript, and revision of the manuscript.**RSC**-Review of literature and preparing the first draft of the manuscript. Statistical analysis and interpretation.

Data availability

Data is available on request.

Author biography

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