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Frequency of Pulmonary Tuberculosis in Type 2 Diabetes on Insulin Therapy Presenting to MMC Mardan

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ABSTRACT

Background: Pulmonary tuberculosis continues to be a risky comorbidity among patients with type 2 diabetes mellitus, particularly those on long-term insulin therapy. Establishing the prevalence and risk factors of pulmonary tuberculosis in such individuals permits early prevention and detection, mostly in high-prevalence contexts. **Objective:** To determine the frequency of pulmonary tuberculosis in patients with type 2 diabetes on insulin therapy presenting to MMC Mardan. **Study Design:** Descriptive cross-sectional study. **Duration and Place of Study:** This study was conducted from January 2025 to May 2025, in the Department of Pulmonology, MTI-Mardan Medical Complex, Mardan. **Methodology:** A total of 113 patients aged 30–70 years with a diagnosis of T2DM on insulin therapy for at least 12 months were enrolled. Participants with at least two cardinal symptoms of tuberculosis underwent chest radiography followed by GeneXpert MTB/RIF assay for diagnostic confirmation. **Results:** The mean age was 49.23±11.61 years and the mean diabetes duration was 9.78±6.25 years. Overall frequency of pulmonary tuberculosis was 11.5% (n=13). Statistically significant associations were observed between PTB and rural residency ($p<0.001$), as well as smoking status ($p<0.001$). **Conclusion:** In our study, we concluded that pulmonary tuberculosis still poses a considerable risk among insulin-dependent type 2 diabetic individuals on insulin, particularly among rural residents and smokers.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder involving insulin resistance and relative insulin deficiency, resulting in chronic hyperglycemia.[1] It is typically linked to obesity, physical inactivity, and genetic predisposition.[2] With the passage of time, hyperglycemia, if prolonged, leads to complications in the microvasculature as well as the macrovasculature, considerably enhancing the risk of mortality and morbidity.[3] T2DM, even now, remains a fast-growing global burden, especially in middle- and low-income nations, creating key problems for global health.[4] Glycemic control, in fact, remains the key in the prevention of complications and the betterment of the patient's outcome.[5]

Type 2 diabetic patients are significantly susceptible to various infections, such as respiratory infections.[6] Hyperglycemia suppresses the activity of neutrophils, impairs cytokine signaling, and impinges on the overall immunity, consequently increasing the risk, as well as the severity, of infection.[7] Among the respiratory infections, tuberculosis (TB) has emerged as a notable comorbidity, significantly in high-prevalence contexts of the two diseases.[8] Diagnosis of diabetes in the context of TB has characteristic presentations, a history of late diagnosis, as well as unsatisfactory treatment outcomes.[9] Chronic inflammation, as well as the process of oxidative stress, in diabetic patients may even amplify injury in the lungs during the infection.[10]

Insulin therapy is generally prescribed in individuals with type 2 diabetes that are not achieving glycemic goals with oral glucose-reducing medication in monotherapy, or in long-standing disease, comorbidity, or with the development of acute illness.[11] It presents an effective and flexible tool for the achievement of strict glycemic control.[12] Insulin lowers blood glucose levels, in addition to lowering the inflammatory and immunosuppressive effects of hyperglycemia.[13] Insulin therapy requires attentive monitoring in order to avoid hypoglycemia, as well as dosing in accordance with nutritional intake and exercise.[14]

Pulmonary tuberculosis in an insulin-treated patient with type 2 diabetes mellitus presents a special clinical challenge. Poor glucose control despite insulin treatment remains frequent, compromising the host's defensive immunity, with reactivation of latent TB or new infection being the result.[15] Diabetes mellitus patients with TB risk broader pulmonary disease in the form of cavitary lesions,

among others, and late conversion of sputum.[16] Insulin therapy, despite being crucial in the glucose control battle, may not totally reverse the associated immunologic derangements.[17] Therefore, multi-management strategies embracing strict glucose control, early diagnosis of TB, and collaboration between the pulmonology service and the endocrinology service are essential in improving the outcome of the otherwise compromised group.[18]

A study conducted by Ullah H et al. reported a 12% prevalence of pulmonary tuberculosis among patients with type 2 diabetes.[19]

It was essential to conduct a study on pulmonary tuberculosis in individuals with type 2 diabetes on insulin treatment, especially in Mardan, because of the high prevalence of diabetes mellitus as well as tuberculosis in the area. There are limited local data regarding the impact of being treated for diabetes with respect to the severity of the disease, response to treatment, and outcome in diabetic patients treated for TB. Determining the association between the two diseases in the local population will be useful in devising appropriate clinical strategies, enhancing early diagnosis, and drafting better management guidelines. It can also contribute to assisting in the planning of public health interventions and the distribution of resources in the area.

MATERIAL AND METHODS

This descriptive cross-sectional analysis was carried out from January to May 2025, in the Department of Pulmonology at MTI-Mardan Medical Complex, Mardan. A total of 113 participants were enrolled. The sample size was determined using WHO sample size software, based on a 95% confidence level, 6% margin of error, and an expected prevalence of pulmonary tuberculosis in diabetic patients of 12%.[19]

Patients aged between 30 and 70 years, of either gender, who had documented type 2 diabetes and had been on insulin therapy for the past 12 months were considered eligible. Type 2 diabetes was defined either by a fasting blood glucose value equal to or exceeding 126 mg/dL, a random blood glucose ≥200 mg/dL, or a prior history of anti-diabetic medication. Only those individuals presenting with at least two of the following symptoms—persistent cough, fever, or night sweats—were included. Patients were excluded if they had a history of malignancy, immunocompromised conditions such as HIV or immunosuppressive therapy, liver cirrhosis, chronic kidney disease, pregnancy or lactation, gastrointestinal surgeries like gastrectomy or jejunal bypass, or had received organ transplants.

Once ethical clearance was granted and informed consent obtained, demographic and clinical details such as age, gender, body mass index, educational attainment, employment status, smoking history, residential locality, socioeconomic background, and duration of diabetes were recorded. Chest radiographs were conducted as part of the hospital's diagnostic routine to assess for pulmonary abnormalities. In individuals with radiological findings consistent with dense, homogeneous lung consolidations, sputum specimens were collected for molecular analysis using the GeneXpert MTB/RIF assay. The test was considered positive if *Mycobacterium tuberculosis* was detected with a cycle threshold (Ct) value of 16 or less, signifying a high bacillary load. All findings were recorded on a predesigned data collection form.

Data were statistically analyzed using SPSS version 26. Continuous variables were reported as means with standard deviation or as medians with interquartile ranges, depending on the distribution assessed via the Shapiro-Wilk test. Categorical variables were summarized as frequencies and percentages. Subgroup analyses were performed by stratifying the outcome variable—pulmonary tuberculosis—against demographic and clinical parameters. Statistical associations were assessed using the chi-square test or Fisher's exact test, with a p-value of ≤0.05 considered significant.

RESULTS

In this study patients had a mean age of 49.23±11.61 years, mean BMI of 26.74±3.65 kg/m^2, and mean diabetes duration of 9.78±6.25 years, with males comprising 61.9% (n=70) and females 38.1% (n=43) of the cohort. Socioeconomically, 46.9% (n=53) belonged to low-income groups, 44.2% (n=50) to middle-income, and 8.8% (n=10) to high-income brackets, while 57.5% (n=65) resided in rural areas compared to 42.5% (n=48) in urban areas, and 18.6% (n=21) were smokers versus 81.4% (n=92) non-smokers (Table 1).

Table 1

Patient Demographics

Demographics		Mean ± SD
Age (years)		49.23±11.61
BMI (Kg/m^2)		26.74±3.65
Duration of Diabetes (years)		9.78±6.25
Gender	Male n (%)	70 (61.9%)
	Female n (%)	43 (38.1%)
Socioeconomic Status	Low n (%)	53 (46.9%)
	Middle n (%)	50 (44.2%)
	High n (%)	10 (8.8%)
Residential Status	Rural n (%)	65 (57.5%)
	Urban n (%)	48 (42.5%)
Smoking	Yes n (%)	21 (18.6%)
	No n (%)	92 (81.4%)

The overall frequency of pulmonary tuberculosis was 11.50% (n=13) among the study participants (Table 2).

Table 2

Frequency of Pulmonary Tuberculosis in Type 2 Diabetes on Insulin Therapy (n=113)

Pulmonary Tuberculosis	Frequency	% age
Yes	13	11.50%
No	100	88.50%

Detailed demographic stratification analysis revealed several important patterns in tuberculosis distribution across different patient characteristics. Age-based analysis showed that among 60 patients aged ≤50 years, 6 (10.0%) developed pulmonary tuberculosis while 54 (90.0%) remained tuberculosis-free, compared to 53 patients aged >50 years where 7 (13.2%) had tuberculosis and 46 (86.8%) did not, yielding a non-significant difference (p=0.594) (Table-III). Gender distribution demonstrated that among 70 male patients, 10 (14.3%) had pulmonary tuberculosis and 60 (85.7%) were tuberculosis-negative,

while among 43 female patients, only 3 (7.0%) had tuberculosis and 40 (93.0%) remained unaffected, with this difference being statistically non-significant (p=0.364) using Fischer's exact test (Table-III). Socioeconomic stratification revealed a gradient pattern where low-income patients (n=53) had the highest tuberculosis prevalence at 9 cases (17.0%) versus 44 (83.0%) without tuberculosis, middle-income patients (n=50) showed 4 cases (8.0%) versus 46 (92.0%) without tuberculosis, and remarkably, none of the 10 high-income patients (0.0%) developed tuberculosis, all remaining tuberculosis-free (100.0%), though this trend did not reach statistical significance (p=0.209) using Fischer's exact test (Table-III). Diabetes duration analysis comparing patients with ≤10 years duration (n=58) versus >10 years duration (n=55) showed tuberculosis rates of 7 cases (12.1%) versus 51 (87.9%) tuberculosis-free in the shorter duration group, and 6 cases (10.9%) versus 49 (89.1%) tuberculosis-free in the longer duration group, with no significant association (p=0.847) (Table-III). However, two demographic factors demonstrated highly significant associations with pulmonary tuberculosis development. Residential status analysis revealed a stark contrast where all 13 tuberculosis cases (20.0%) occurred exclusively among the 65 rural residents, with 52 (80.0%) rural patients remaining tuberculosis-free, while remarkably, none of the 48 urban residents (0.0%) developed tuberculosis, all remaining tuberculosis-negative (100.0%), creating a highly significant association (p<0.001) using Fischer's exact test (Table-III). Similarly, smoking status showed the strongest association, with 8 of 21 smokers (38.1%) developing pulmonary tuberculosis compared to only 13 (61.9%) remaining tuberculosis-free, while among 92 non-smokers, merely 5 (5.4%) developed tuberculosis and 87 (94.6%) remained unaffected, demonstrating a highly significant relationship (p<0.001) using Fischer's exact test (Table 3).

Table 3

Association of Pulmonary Tuberculosis with Demographic Factors

Demographic Factors		Pulmonary Tuberculosis		p-value
		Yes n(%)	No n(%)	
Age (years)	≤50	6 (10.0%)	54 (90.0%)	0.594
	>50	7 (13.2%)	46 (86.8%)	
Gender	Male	10 (14.3%)	60 (85.7%)	0.364*
	Female	3 (7.0%)	40 (93.0%)	
Socioeconomic Status	Low	9 (17.0%)	44 (83.0%)	0.209*
	Middle	4 (8.0%)	46 (92.0%)	
	High	0 (0.0%)	10 (100.0%)	
Residential Status	Rural	13 (20.0%)	52 (80.0%)	<0.001*
	Urban	0 (0.0%)	48 (100.0%)	
Duration of Diabetes	≤10	7 (12.1%)	51 (87.9%)	0.847
	>10	6 (10.9%)	49 (89.1%)	
Smoking	Yes	8 (38.1%)	13 (61.9%)	<0.001*
	No	5 (5.4%)	87 (94.6%)	

*Fischer Exact Test

DISCUSSION

Recent studies found an 11.5% prevalence of pulmonary tuberculosis among insulin-treated patients with type 2 diabetes, much greater than in the general population. Our finding follows the well-established fact that diabetes mellitus places a condition of immunocompromise that significantly widens susceptibility to infection by tuberculosis in general, and to the emergence of active disease from pre-existing latent infection in specific. The observations that the patients in the study are insulin dependent serve to indicate that they likely possess a more advanced diabetes of potential deeper immune deficiency, since the therapeutic indication of insulin demands that the function of pancreatic beta cells must be appreciably compromised, making the regulation of blood glucose by oral agents impracticable.

Most striking of the observations was the lone appearance of tuberculosis infection among the population of the rurals without any detection of tuberculosis in the urbans, creating a highly significant association. It can be attributed largely to various interconnected factors like easy access of the health facilities with the consequence of late presentation, diagnosis, and treatment of diabetes and tuberculosis, lower nutritive status due to food insecurity, living conditions highly conducive to the propagation of tuberculosis, occupational exposure to dusts and environmental irritants that are harmful to the respiratory system, awareness about preventive health care, etc. The population of the rurals are also highly susceptible to hidden malnutrition and other comorbidities associated with it that tend to destroy the inherent immunity.

Robust association of smoking with tuberculosis development, with 38.1% tuberculosis in smokers compared with 5.4% in non-smokers, reflects the well-established respiratory and immunologic adverse consequences of smoking. Smoking damages the respiratory epithelium and clearance function of the cilia, impairs the function of the alveolar macrophage, suppresses the local immunity in the lungs, and leads to chronic inflammatory change favoring growth of mycobacteria as well as dissemination. Diabetes-induced immunosuppression plus smoking-induced respiratory injury has a synergetic effect that appreciably increases tuberculosis risk.

Our study results concurred with some of the key observations of the literature available, yet revealed some remarkable demographic characteristics characteristic of our population. The prevalence of 11.50% of pulmonary tuberculosis among insulin-treated patients with type 2 diabetes falls within the range of that reported by other studies, although less than in some of the high-prevalence regions. It corresponds quite well to the global literature, given the fact that Mustafa et al. [20] had recorded a 38% prevalence among diabetic pulmonary tuberculosis patients, while the present work explored the reverse relation - the prevalence of TB among diabetic patients.

The lack of significant association between age and tuberculosis development in our cohort (10.0% in ≤50 years vs 13.2% in >50 years, p=0.594) contrasts with findings from Chang et al. [21] who demonstrated a clear age-related increase in latent TB infection prevalence among diabetics (11.6% <50 years vs 25.8% ≥50 years, OR 2.97). This discrepancy may be attributed to the different populations studied - our focus on insulin-dependent diabetics versus their broader ambulatory diabetic population, and the distinction between active versus

latent TB infection. Additionally, Jeon & Murray [22] found that each 10-year age increment decreased TB risk by 0.6-fold, which partially supports our non-significant age findings, though their meta-analysis encompassed broader populations.

Gender distribution in our study showed higher tuberculosis rates in males (14.3%) compared to females (7.0%), though not statistically significant (p=0.364). This pattern is consistent with the male predominance observed in most studies in the literature, including Chiang et al. [23] (74% male), Shi et al. [24] (76% male), and Fu et al. [25] (56% male), reflecting the well-established epidemiological pattern of higher TB susceptibility in males across diverse populations.

The striking socioeconomic gradient observed in our study, where tuberculosis prevalence decreased from 17.0% in low-income to 8.0% in middle-income to 0.0% in high-income patients, echoes the findings of Mustafa et al. [20] who reported that 85% of diabetic-TB patients were of poor socioeconomic status. Although our trend did not reach statistical significance (p=0.209), possibly due to the small high-income group (n=10), it reinforces the critical role of socioeconomic determinants in TB-diabetes comorbidity, likely mediated through factors such as nutritional status, healthcare access, and living conditions.

Our finding that diabetes duration showed no significant association with TB development (12.1% in ≤10 years vs 10.9% in >10 years duration, p=0.847) differs from expectations that longer diabetes duration might increase TB susceptibility through prolonged immune compromise. This result suggests that the current glycemic control status and treatment regimen may be more important than disease duration per se, which aligns with Chiang et al. [23] who demonstrated that poor glycemic control significantly amplified radiographic severity while tight control attenuated diabetes-associated changes. Fu et al. [25] similarly found that glycemic control parameters (HbA1c or FBG) did not predict TB incidence when accounting for medication effects, supporting our duration-independent findings.

The most striking finding in our study was the exclusive occurrence of all 13 tuberculosis cases among rural residents (20.0% prevalence) with zero cases among urban dwellers (p<0.001). This dramatic rural-urban disparity has not been as clearly documented in the reviewed literature but likely reflects multiple interconnected factors including healthcare accessibility, nutritional status, environmental exposures, and population density differences that facilitate TB transmission in rural settings.

Similarly, our finding of significantly higher TB rates among smokers (38.1% vs 5.4% in non-smokers, p<0.001) strongly corroborates existing evidence. Shi et al. [24] identified smoking as an independent risk factor with an odds ratio of 12.25 (95% CI 2.53-59.37), while multiple studies in the literature noted substantial proportions of smokers among their cohorts (45% in Chiang et al.[23] The consistency of this association across different populations underscores smoking as a critical modifiable risk factor in the diabetes-TB syndemic, likely operating through impaired pulmonary immunity and structural lung damage that facilitates TB infection and progression.

These findings in combination suggest that although insulin-requiring diabetic patients continue to be at risk of pulmonary tuberculosis, the risk is not equally balanced within all demographic groups. The coincidence of socioeconomic disadvantage, rurality, and smoking status appears to determine a highly risky population group that should be the focus of special screening and prevention activities. The absence of tuberculosis among non-smoker, urban, high social class patients suggests that active control of diabetes within the context of protective social conditions can efficiently suppress the risk of TB even among insulin-requiring patients theoretically corresponding by that circumstance to more severe diabetes with greater immunodeficiency.

A number of limitations of the present study must be kept in perspective. The single-center study may not allow generalizability of results to other health care facilities or geographical locales with different tuberculosis epidemiology and health infrastructure. The small population of 113 patients, although sufficient to demonstrate the associations we observed, might have been too small to demonstrate more modest distinctions, especially in subgroup analyses like the stratification by socio-economic status where the highest-income group added up to only 10 patients. By virtue of being a cross-sectional study, the temporal associations as well as the causes of demographic factors in the development of tuberculosis are excluded. Also, the present study did not adjust for possibly crucial confounding variables like status of glycemic control, length of history of insulin therapy, history of diabetic complications, nutritional status, or history of specific exposure to tuberculosis, which may explain the associations that we observed.

CONCLUSION

In our study, we concluded that pulmonary tuberculosis still poses a considerable risk among insulin-dependent type 2 diabetic individuals, and that rural living status and smoking status are the most important risk factors instead of typical demographic factors. Our result underscores the importance of targeted screening strategies focusing on high-risk group, especially rural diabetic smokers, while exhibiting the positive protective impact of living in the city and non-smoker status. Our findings indicate that tuberculosis prevention among diabetic individuals requires multi-faceted intervention focusing on glycemic control as well as social determinants of health in order to significantly eliminate disease burden among this susceptible group.

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