



Factors Affecting the Risk of Pulmonary Tuberculosis Among Patients with Type 2 Diabetes Mellitus

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Abstract

Tuberculosis is an infectious disease that ranks among the top ten causes of death worldwide. The high incidence and mortality rates of TB are associated with diabetes mellitus, an underlying condition that increases susceptibility to TB infection. This study aims to identify factors affecting the risk of tuberculosis in patients with type 2 diabetes mellitus. This unmatched case-control study was conducted at ten community health centers in

Medan. The sample size consisted of 64 cases and 64 controls, selected using purposive sampling. Data collection was completed using questionnaires. The collected data were analyzed using logistic regression analysis. Study results suggested that factors significantly affecting the risk of tuberculosis in patients with diabetes mellitus were adherence to diabetes mellitus treatment (OR: 3.194 (1.511-6.751); $p=0.002$), smoking (OR: 7.857 (3.551-17.384); $p < 0.001$), overweight (BMI >25 kg/m²) (OR: 0.269 (0.118-0.613); $p=0.002$), and the use of masks (OR: 0.427 (0.208-0.878); $p=0.021$). Smoking is the strongest predictor of tuberculosis in patients with type 2 diabetes mellitus. Community health centers should integrate smoking cessation campaigns into tuberculosis prevention programs, provide nutritional interventions for malnourished diabetes patients, assess and improve adherence to diabetes treatment, and promote mask usage among diabetes patients who have direct contact with tuberculosis patients.

Keywords: Pulmonary tuberculosis, Risks, Smoking, Type 2 diabetes mellitus

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Introduction

Pulmonary tuberculosis (TB) is an infectious disease that ranks among the top ten causes of death globally (WHO, 2024b). In 2023, an estimated 10.8 million TB cases were reported worldwide, up from 10.6 million cases in 2022 (WHO, 2024a). The increase in TB cases was also reported in various countries around the world, including Indonesia, with an estimated incidence of 969,000 cases and 144,000 deaths in 2022 (Kemenkes RI, 2023) and an increase to 1,090,000 cases in 2023 with an estimated 125,000 deaths (Kemenkes RI, 2024). The rising prevalence of diabetes mellitus (DM) is an underlying condition contributing to TB incidence and mortality. This is due to the higher susceptibility of diabetes patients to tuberculosis, with a two to four times higher risk compared to non-diabetic individuals (Ngo et al., 2021). In 2020, it is estimated that 370,000 new TB cases were caused by diabetes. Additionally, it is estimated that over 15% of people with TB worldwide also have diabetes, compared to 9.3% in the general adult population (20–79 years old). This is equivalent to 1.5 million people with TB and diabetes who require coordinated care and monitoring to optimize the management of both conditions (WHO, 2025). In Indonesia, the prevalence of diabetes mellitus among TB patients varies but is quite high, ranging from 5.4% to 44% (Mihardja et al., 2016).

Diabetes mellitus weakens the immune response, thereby inhibiting the elimination of various types of pathogens, including *Mycobacterium tuberculosis*, from entering the body. Consequently, identification and control of risk factors are essential to prevent tuberculosis infection in patients with type 2 diabetes mellitus. Patients with diabetes and tuberculosis also face a higher risk of mortality and relapse post-treatment, necessitating concurrent treatment to enhance the effectiveness of care (Thong et al., 2025). In countries with high prevalence rates, such as Indonesia, tuberculosis screening among diabetes patients is crucial for early detection of tuberculosis cases (Maryuni, 2019).

Previous studies have shown that the incidence of TB in patients with type 2 diabetes is associated with various factors such as sociodemographic factors (age, gender, and economic status), behavioral and lifestyle factors (diet and physical activity), and clinical factors (Aditya Nugraha et al., 2021). Maryuni (2019) found in her study that clinical factors such as treatment adherence and duration of diabetes are associated with TB incidence because they increase susceptibility to TB infection. Another study by Suwirda et al. (2025) explained that smoking habits, including duration and dosage, affect the risk of TB in patients with type 2 diabetes mellitus. Lower immunity is also suspected to be associated with nutritional status in patients with type 2 diabetes mellitus. Underweight diabetes patients are reported to be at higher risk of TB infection compared to those with normal nutritional status (Choi et al., 2021).



Data shows that the burden of TB and diabetes mellitus is also high in Medan, a city with the highest number of TB and DM cases in North Sumatra Province, with 15,722 TB cases and 43,825 DM cases in 2023 (Dinkes Provinsi Sumatera Utara, 2023). Findings from a preliminary survey conducted at the Padang Bulan Selayang II Community Health Center in Medan, which has the highest number of TB-DM patients (32 cases), indicate that most of these patients do not regularly undergo health check-ups, had uncontrolled blood sugar levels (random blood sugar >200 mg/dl and HbA1c >7%), were underweight (body mass index <18.5 kg/m²), and lived in densely populated areas with poor hygiene. Additionally, smoking habits were also found among TB-DM patients, particularly among adult men. Given the high incidence of TB-DM in Medan and based on the findings of a preliminary survey, we are interested in identifying the factors affecting the risk of TB infection in people with diabetes mellitus in Medan in order to provide a scientific basis for the prevention of TB among diabetes patients.

Methods

This study used a quantitative method with an unmatched case-control design conducted in Medan City from November 2024 to April 2025. The sample size was determined using Statcalc Epi Info version 7.2.6.0, resulting in 64 respondents in each of the case and control groups. Sampling was conducted at six community health centers with the highest number of TB-DM cases and four community health centers with the lowest number of TB-DM cases in Medan and was divided proportionally among each community health center to obtain a representative sample. Samples were selected using purposive sampling, with the following inclusion criteria for cases: (1) patients with type 2 diabetes mellitus with positive pulmonary TB test results based on clinical, radiological, and/or microbiological tests (rapid molecular tests, acid-fast bacilli tests, or sputum culture) that were fully recorded in medical records; (2) aged at least 18 years; and (3) residing in the working area of the community health center where the study was conducted, while the exclusion criteria were (1) patients with diabetes who have completed TB treatment and have been discharged as cured and (2) respondents with severe illness or poor general health. Meanwhile, the inclusion criteria for controls are (1) being aged at least 18 years, (2) having complete medical records, (3) residing in the work area of the community health center where the study was conducted, and (4) having received DM treatment for at least one month, with the following exclusion criteria for controls: (1) respondents with severe illness or poor general health and (2) respondents diagnosed with TB.

The dependent variable in this study was TB-DM status, which was determined based on medical records and categorized into non-TB DM (control) and TB-DM (case), while the independent variables were DM treatment adherence, smoking habits, body mass index (BMI),



mask usage, and multivitamin consumption, as determined through interviews using questionnaires. Diabetes mellitus treatment adherence was measured using the Morisky Medication Adherence Scale 8-Item (MMAS 8-Item) questionnaire, which is valid and reliable. The collected data were analyzed using logistic regression with a 95% confidence level or statistically significant if $p < 0.05$.

Results

The results of the study based on data from 64 case samples and 64 control samples are explained as follows.

Table 1. Respondent characteristics

Characteristics	Cases		Controls	
	n = 64	% (=100)	n = 64	% (=100)
Age				
<45 years	16	25.0	7	10.9
≥45 years	48	75.0	57	89.1
Gender				
Female	17	26.6	43	67.2
Male	47	73.4	21	32.8
Education				
Elementary school	13	20.3	13	20.3
Junior high school	1	1.6	3	4.7
Senior high school	48	75.0	47	73.4
University	2	3.1	1	1.6

The information in Table 1 shows that most respondents in the case group (75%) and control group (89.1%) were aged 45 years and above. Most respondents in the case group were male (73.4%), while the control group was dominated by female respondents (67.2%). Furthermore, the majority of respondents in the case group (75%) and control group (73.4%) had a college education.

Table 2. Results of Simple Logistic Regression Analysis

Variable	Cases		Control		OR (95% CI)	p
	n=64	%	n=64	%		
DM treatment adherence						
Non-adherent	48	75.0	31	48.4	3.194 (1.511-6.751)	0.002*
Adherent	16	25.0	33	51.6		
Smoking habits						
Smoking	44	68.8	14	21.9	7.857 (3.551-17.384)	<0.001*



Non-smoking	20	31.3	50	78.1		
Body mass index						
Overweight (BMI>25 kg/m ²)	11	17.2	30	46.9	0.269 (0.118-0.613)	0.002*
Underweight (IMT <18.5 kg/m ²)	8	12.5	1	1.6	5.867 (0.699-49.211)	0.103
Normal	45	70.3	33	51.6		
Masks usage						
No	31	48.4	44	68.8		
Yes	33	51.6	20	31.3	0.427 (0.208-0.878)	0.021*
Multivitamin consumption						
No	51	79.7	41	64.1		
Yes	13	20.3	23	35.9	2.201 (0.994-4.872)	0.052

*p<0.05

Table 2 shows that the factors significantly affecting the risk of tuberculosis in type 2 diabetes mellitus patients in Medan are adherence to diabetes treatment (p=0.002), smoking (p<0.001), being overweight (p=0.002), and mask usage (p=0.021). The findings indicate that type 2 diabetes patients who are non-adherent with treatment are 3.194 times (95% CI: 1.511–6.751) more likely to develop tuberculosis compared to those who are adherent with treatment. Type 2 diabetes patients who smoke also have a 7.857 (95% CI: 3.551-17.384) times higher risk of developing tuberculosis compared to those who do not smoke. Conversely, type 2 diabetes patients classified as overweight have a 0.269 (95% CI: 0.118–0.613) times lower risk of developing tuberculosis compared to those with a normal body mass index. Type 2 diabetes patients who did not wear masks when going out had a lower risk of 0.427 times (0.208–0.878) of developing tuberculosis compared to those who wore masks.

Table 3. Results of Multivariate Logistic Regression Analysis

	Variable	B	p	OR	95% CI	
					Lower	Upper
Step 1 ^a	Smoking	2.061	<0.001	7.857	3.551	17.384
	Constant	−0.916	0.001	0.400		
Step 2 ^b	Smoking	2.107	<0.001	8.222	3.517	19.216
	Overweight	−1.156	0.014	0.315	0.124	0.795
	Underweight	2.235	0.048	9.351	1.015	86.105
	Constant	−0.714	0.028	0.490		



Based on the results of the multivariate logistic regression analysis in Table 3, it is known that smoking is the strongest predictor of pulmonary tuberculosis in patients with type 2 diabetes mellitus ($p < 0.001$). Patients with type 2 diabetes who smoke have a risk up to 7.857 times (95% CI: 3.551–17.384) higher of developing tuberculosis infection compared to those who do not smoke.

Discussion

Research findings indicate that adherence to diabetes treatment significantly affects the risk of pulmonary tuberculosis in people with diabetes. This is consistent with a study by Fibriana et al. (2020), which suggests that there is a significant association between adherence to diabetes treatment and tuberculosis infection in diabetes patients. Rumende (2018) also found that non-adherence to antidiabetic medication is one of the risk factors for tuberculosis among diabetes patients and is associated with a higher risk of developing MDR-TB (multi-drug resistant tuberculosis). The study explains that adherence to antidiabetic medication can also influence tuberculosis outcomes in diabetes patients. Poor adherence to antidiabetic medication leads to uncontrolled blood sugar levels, which are associated with a weakened immune system, thereby increasing susceptibility to various infections, including tuberculosis. If medication adherence is not improved, this can worsen the health status of diabetes patients, making TB transmission possible if there is direct contact with a TB patient.

Smoking was also found to be a major predictor of tuberculosis in patients with type 2 diabetes, with smokers having up to 7.8 times greater risk of tuberculosis infection than non-smokers. Wagnew et al. (2018) also showed in their study that smoking was significantly associated with TB incidence in patients with type 2 diabetes. Another study by Feldman et al. (2024) also highlighted that both active and passive smoking are independent risk factors for TB infection, reactivation of TB, development of primary TB, and TB-related mortality. Smoking is one of the strongest predictors of tuberculosis in diabetes patients due to its direct effects on the immune system and respiratory system. Chemical substances in cigarette smoke, such as nicotine and carbon monoxide, have been shown to reduce alveolar macrophage activity, disrupt secretion clearance on the tracheobronchial surface, and suppress cellular immune function, which plays a crucial role in controlling *Mycobacterium tuberculosis* infection (Patra et al., 2014).

Based on the results of this study, it is also known that diabetes patients who are classified as overweight have a significantly lower risk of developing tuberculosis compared to those with a normal body mass index. Conversely, diabetes patients who are underweight have a higher risk of developing tuberculosis compared to those with a normal body mass index, although this is not significant. This is consistent with the study by Choi et al. (2021), who found



that compared to diabetes patients with normal weight, underweight patients showed an increased risk of TB incidence, while overweight patients showed a lower risk of TB. In the study by Lonnroth et al. (2010), it was also explained that each one-unit increase in BMI is associated with a 13.8% reduction in TB risk, meaning that the higher a person's BMI, the lower their risk of developing TB, and vice versa. A low BMI reflects poor energy reserves and nutritional status (malnutrition), which is associated with impaired cellular immune function, such as macrophage dysfunction and cytokine production, as well as reduced ability to form granulomas that can control latent TB infection. Conversely, while a high BMI is not an ideal metabolic condition, it provides energy reserves and support for certain immune functions that can inhibit the activation of latent TB into active TB (Cho et al., 2022).

The use of masks was also observed to affect pulmonary tuberculosis in patients with diabetes mellitus (DM), but conversely, diabetes patients who did not wear masks while outside had a lower risk of developing tuberculosis. This finding may be attributed to higher mask-wearing awareness among diabetes patients with tuberculosis (cases) compared to those without tuberculosis (controls), thereby empirically reducing the risk of tuberculosis. This is inconsistent with the findings of Suwirda et al. (2025), who recommended mask use for diabetes patients in contact with TB patients to reduce the risk of transmission. The World Health Organization (WHO) also recommends mask use by at-risk or vulnerable populations and in high-risk settings to prevent TB transmission (WHO, 2022).

Other research findings also suggest that there is no significant association between multivitamin consumption and tuberculosis in patients with type 2 diabetes mellitus. The study results indicate that the majority of respondents in both the case group (79.7%) and the control group (64.1%) did not consume multivitamins, suggesting no difference in multivitamin consumption between TB-DM patients and non-TB-DM patients. Therefore, multivitamin consumption does not affect the risk of tuberculosis in diabetes patients. Previous studies have found that individuals with vitamin D deficiency have a higher risk of developing active TB than those with normal vitamin D levels (Zhao et al., 2017). TB and TB-DM patients have also been reported to have lower serum vitamin D levels compared to healthy controls, suggesting that vitamin D supplementation during TB treatment may enhance the response to TB treatment. However, these findings are inconsistent across studies, potentially due to differences in patient characteristics, TB categories, or the presence of other comorbidities (Wahiduddin et al., 2024). As a result, vitamin D supplementation in TB or TB-DM patients is not yet widely recommended. Micronutrients such as zinc, vitamins A, D, E, and C, and iron have also been associated with improved immune responses in TB patients, particularly among those with



malnutrition, suggesting that multivitamin and mineral supplementation may be beneficial for improving clinical treatment outcomes (Patel et al., 2024).

Conclusion and Recommendation

Adherence to diabetes treatment, smoking, being overweight (BMI >25 kg/m²), and mask use are significant factors affecting the risk of tuberculosis in patients with type 2 diabetes. Smoking is the strongest predictor of tuberculosis in patients with type 2 diabetes. Community health centers should integrate smoking cessation campaigns into diabetes control programs for TB prevention. Screening should also be conducted routinely to assess medication adherence and nutritional status in diabetes patients, enabling immediate improvements and nutritional interventions to reduce the risk of tuberculosis in type 2 diabetes patients. Healthcare workers at community health centers should also educate diabetes patients to wear masks when in contact with tuberculosis patients to reduce the risk of transmission. Further research is recommended to identify other factors that have not yet been studied by controlling for glycemic control, immunological status, or socioeconomic factors.



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