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RISK FACTORS OF TYPE 2 DIABETES MELLITUS IN PULMONARY TUBERCULOSIS PATIENTS

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ABSTRACT

Background: Diabetes mellitus (DM) and tuberculosis (TB) are major global health concerns with a bidirectional relationship that exacerbates clinical outcomes. Indonesia faces a high prevalence of both diseases; however, specific risk factors contributing to the incidence of Type 2 DM (T2DM) among pulmonary TB patients remain underexplored, particularly in North Sumatra. This study aims to identify risk factors associated with T2DMin patients with pulmonary TB.

Method: A retrospective case-control study was conducted involving 80 participants, comprising 40 pulmonary TB patients with T2DM and 40 without DM. Data were obtained from electronic medical records and analyzed using Chi-square tests, Fisher's Exact Test, and multivariate logistic regression.

Result Educational level (OR = 5.001; p = 0.027), occupational status (OR = 3.500; p = 0.038), and nutritional status based on body mass index (OR = 3.498; p = 0.017) were significantly associated with the incidence of T2DM in pulmonary TB patients.

Result: No significant associations were found for age, gender, radiographic findings, or smoking habits. Higher educational level, employment in the private sector, and having a normal to overweight BMI are key risk factors for T2DM among pulmonary TB patients.

Keywords: T2DM, pulmonary tuberculosis, risk factors, comorbidity.

ABSTRAK

***Latar Belakang**: Diabetes mellitus (DM) dan tuberkulosis (TB) adalah masalah kesehatan global utama dengan hubungan dua arah yang memperburuk hasil klinis. Indonesia menghadapi prevalensi tinggi kedua penyakit tersebut; namun, faktor risiko spesifik yang berkontribusi terhadap kejadian DM Tipe 2 (DMT2) pada pasien TB paru masih kurang dieksplorasi, terutama di Sumatera Utara. Penelitian ini bertujuan untuk mengidentifikasi faktor risiko yang terkait dengan pasien T2DMin dengan TB paru.*

***Metode:** Studi kasus-kontrol retrospektif dilakukan dengan melibatkan 80 peserta, yang terdiri dari 40 pasien TB paru dengan DMT2 dan 40 tanpa DM. Data diperoleh dari rekam medis elektronik dan dianalisis menggunakan tes Chi-square, Fisher's Exact Test, dan regresi logistik multivariat.*

***Hasil** Tingkat pendidikan (OR = 5,001; p = 0,027), status pekerjaan (OR = 3,500; p = 0,038), dan status gizi berdasarkan indeks massa tubuh (OR = 3,498; p = 0,017) secara signifikan terkait dengan kejadian T2DM pada pasien TB paru.*

***Hasil:** Tidak ada hubungan signifikan yang ditemukan untuk usia, jenis kelamin, temuan radiografi, atau kebiasaan merokok. Tingkat pendidikan yang lebih tinggi, pekerjaan di sektor swasta, dan memiliki BMI normal hingga kelebihan berat badan adalah faktor risiko utama DMT2 di antara pasien TB paru.*

***Kata kunci:** DMT2, TBC paru, faktor risiko, komorbiditas.*

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1. Introduction

Individuals with diabetes mellitus (DM) are at a higher risk of developing active tuberculosis (TB) compared to the general population. According to a study by Noubiap et al., individuals with DM are two to four times more likely to develop active TB than those without DM [1]. In countries with a high prevalence of DM, the contribution of DM to TB incidence may account for up to 25% of cases [2]. In Indonesia, it is estimated that approximately 11% to 13% of TB patients also have DM, a proportion expected to rise in parallel with the increasing national prevalence of diabetes [3]. In 2021, Indonesia reported over 969.000 TB cases and approximately 19.5 million adults living with DM [3,4]. Based on these figures, it is estimated that around 106,590 to 125,970 TB patients were also living with DM, representing approximately 11% to 13% of the national TB burden. This indicates that Indonesia bears one of the highest dual burdens of TB and DM globally, underscoring the urgency of integrated screening and treatment strategies [3,4]. This comorbidity poses significant challenges for disease control, particularly regarding early detection, sustained treatment, and preventing complications.

Type 2 diabetes mellitus (T2DM) has been identified as a major risk factor for TB, primarily due to its adverse impact on immune function. Chronic hyperglycemia impairs key immune mechanisms, including macrophage activity, cytokine signaling, and T-cell responses, thereby increasing susceptibility to Mycobacterium tuberculosis infection [5]. Conversely, TB infection can induce systemic inflammation and metabolic stress, which may lead to temporary hyperglycemia or reveal undiagnosed T2DM. Anti-TB drugs such as isoniazid and rifampicin have also been associated with

hyperglycemic effects by altering glucose metabolism and hepatic insulin sensitivity. In addition to biological mechanisms, overlapping risk factors such as malnutrition, smoking, low socioeconomic status, and overcrowded living conditions contribute to the bidirectional interaction between the two diseases. This dual burden significantly worsens clinical outcomes, including delayed sputum conversion, higher relapse rates, and increased mortality among TB patients with concurrent T2DM, underscoring the importance of early diagnosis and integrated management strategies [6].

Despite the growing recognition of TB-DM comorbidity, evidence on specific risk factors associated with the onset of DM among pulmonary TB patients in Indonesia, particularly in North Sumatra, remains scarce. Identifying these factors is critical for informing targeted screening and developing effective interventions. This study aims to investigate the risk factors linked to the incidence of T2DM in pulmonary TB patients at Prof. Dr. Chairuddin P. Lubis Hospital, to enhance clinical practice and contribute to public health policy efforts in mitigating the dual burden of TB and DM.

2. Methods

2.1. Study Design

A retrospective case-control observational study was conducted to identify risk factors associated with T2DM in patients diagnosed with TB. The study was conducted at the Infection Outpatient Clinic, Department of Pulmonology and Respiratory Medicine, Prof. Dr. Chairuddin P. Lubis Hospital, from April 2024 to January 2025. A total of 80 subjects were recruited and divided equally into two groups (1:1 ratio): 40 pulmonary TB patients with T2DM (case group) and 40 pulmonary TB patients without T2DM (control group). Subjects were selected purposively based on predefined inclusion and exclusion criteria.

2.2. Inclusion and Exclusion Criteria

Eligible participants were adult patients (≥18 years), of either sex, with complete electronic medical records and a confirmed diagnosis of pulmonary TB, with or without coexisting T2DM. Patients diagnosed with DM but without pulmonary TB, or those with incomplete medical records, were excluded from the study.

2.3. Data Collection

Secondary data were collected from the hospital's electronic medical record system. Variables collected included sociodemographic data (age, sex, occupation, education level), clinical parameters (body mass index, smoking history), and radiological and laboratory findings. All data were compiled and organized in digital format for analysis.

2.4. Ethical Considerations

Ethical approval was granted by the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara (Approval Number: 1316/KEPK/USU/2024). All procedures adhered to ethical standards for medical research, ensuring patient confidentiality and compliance with the principles of informed consent and data protection.

2.5. Data Analysis

Descriptive statistics were used to summarize the distribution and characteristics of the study variables. Bivariate analyses, using the Chi-square test or Fisher's Exact Test as appropriate, were performed to evaluate associations between independent variables (e.g., age, sex, occupation, nutritional status, smoking history) and the incidence of T2DM in TB patients. Multivariate logistic regression analysis was conducted to determine the most significant predictors of T2DM among pulmonary TB patients.

3. Results

A total of 80 patients diagnosed with pulmonary tuberculosis (TB) who met the inclusion criteria were included in the study. Table 1 presents the demographic and clinical characteristics of the study population, including sex, age, educational attainment, occupational status, nutritional status based on body mass index (BMI), chest radiographic findings, smoking habits, and comorbid diabetes mellitus (DM) status.

Table 1. Demographic and Clinical Characteristics of Pulmonary TB Patients

Demographic Characteristics	**n = 80, (%)**
Gender,	
Man	56 (70)
Woman	24 (30)
Age,	
≥ 45 years	61 (76.2)
< 45 years	19 (23.8)
Education,	
High School and College	65 (72)
Elementary and Middle School	15 (18)
Occupation,	
Private employees	22 (23.5)
Others	58 (66.5)
Nutritional Status,	
Underweight	30 (37.5)
Normoweight	34 (42.5)
Overweight	16 (20)
Thorax Photo,	
Infiltrate	45 (56.3)
Pleural effusion	15 (18.8)
Bronchiectasis	15 (18.8)
Cavity	1 (1.3%)
Infiltrates and cavities	1 (1.3)
Infiltration and fibrosis	1 (1.3)
Cavities and bronchiectasis	1 (1.3)
Cavities and abscesses	1 (1.3)
Smoking Habits,	
Yes	54 (60.3)
No	26 (29.7)
DM Status,	
With DM	40 (50)
Without DM	40 (50)

Most TB patients were male (70%) with a mean age of 53.8 years. Most had completed at least high school (72%), and 23.5% were employed in the private sector. Based on BMI, normoweight status

was most common (42.5%). Infiltrates were the most frequent radiological finding (56.3%), and a substantial proportion of patients (60.3%) reported smoking.

Table 2. Bivariate Analysis of Risk Factors for T2DM in Pulmonary TB Patients

Demographic Characteristics	**Pulmonary TB**		**p**	**OR**
	DM (n,%)	**Non DM (n,%)**		**(95% CI)**
Gender,				
Man	31 (77.5)	25 (62.5)	0.143[a]	(2,067)
Woman	9 (22.5)	15 (37.5)		(0.776-5.507)
Age (year)				
≥ 45	33 (82.5)	28 (70)	0.189[a]	(2,020)
< 45	7 (17.5)	12 (30)		(0.7-5.829)
Education,				
High School and College	37 (92.5)	28 (70)	0.010[a]	(5,286)
Elementary and Middle School	3 (7.5)	12 (30)		(1,361-20,534)
Occupation,				
Private employees	16 (40)	6 (15)	0.012[a]	(3,778)
Others	24 (60)	34 (85)		(1,291-11,057)
BMI, kg/m2				
≥ Normoweight	31 (77.5)	19 (47.5)	0.006[a]	(3,807)
Underweight	9 (22.5)	21 (52.5)		(1,447-10,017)
Photo Thorax,				
Infiltrate	25 (62.5)	20 (50)	0.358[c]	-
Pleural effusion	5 (12.5)	10 (25)		
Bronchiectasis	9 (22.5)	6 (15)		
Cavity	0	1 (2.5)		
Infiltrates and cavities	0	1 (2.5)		
Infiltration and fibrosis	0	1 (2.5)		
Cavities and bronchiectasis	0	1 (2.5)		
Cavities and abscesses	0	1 (2.5)		
Smoking Habits,				
Yes	29 (72.5)	25 (62.5)	0.422[a]	(1,582)
No	11 (27.5)	15 (37.5)		(0.615-4.066)

[a]*Chi Square*, [b]T Independent, [c]Kruskal Wallis.

Significant associations were observed between DM incidence and education level (p = 0.010; OR = 5.286; 95% CI: 1.361–20.534), occupational status (p = 0.012; OR = 3.778; 95% CI: 1.291–11.057), and BMI (p = 0.006; OR = 3.807; 95% CI: 1.447–10.017). Other variables, such as gender (p = 0.143), age (p = 0.189), radiological features (p = 0.358), and smoking habits (p = 0.422), did not demonstrate statistically significant associations with DM among TB patients. These findings indicate that higher educational attainment, employment in the private sector, and normoweight or overweight BMI were significantly associated with an increased risk of T2DM in TB patients.

Table 3. Multivariate Logistic Regression Analysis of Factors Associated with DM in Pulmonary TB Patients

Variables	B	P	OR	95% CI for OR	
				Lower	Upper
Education	1.610	0.027	5.001	1.206	20.733
Occupation	1.253	0.038	3.500	1.074	11.408
BMI	1.252	0.017	3.498	1.248	9.806
Constant	-2.449	0.002	0.086		

The multivariate model identified education, occupation, and nutritional status as independent predictors of DM in pulmonary TB patients. Among these, educational level emerged as the most dominant risk factor (OR = 5.001), followed by occupation (OR = 3.500) and BMI (OR = 3.498). These results suggest that patients with higher education, employment as private sector workers, and normal or elevated BMI are at greater risk for developing T2DM alongside pulmonary TB.

The findings of this study identify several significant determinants associated with the development of type 2 diabetes mellitus (DM) among patients diagnosed with pulmonary tuberculosis (TB) at Prof. Dr. Chairuddin P. Lubis Hospital. Multivariate analysis revealed that educational attainment, employment status, and nutritional status were significantly correlated with DM incidence in TB patients, while other variables such as age, sex, chest radiograph findings, and smoking history did not demonstrate significant associations.

4. Discussion

Age was not significantly associated with the development of DM among TB patients (p = 0.157). This result contrasts with previous studies, such as that by Tenaye et al. (2019), which found a higher DM risk in TB patients over 41 years of age [7], and the study by Jing Li et al. (2024), which reported a 1.04-fold increase in DM risk for each additional year of age [8]. The lack of association in the present study may be attributed to sample distribution imbalances or population-specific characteristics that influenced the statistical outcomes [9,10].

Gender was similarly not associated with the incidence of DM in TB patients, aligning with the findings by Rau and Huldjannah (2021) [11]. This suggests that the interaction between TB and DM is not significantly influenced by sex. However, other studies, including Viswanathan et al. (2022), have reported higher DM prevalence in males, often attributed to lifestyle factors such as smoking and dietary habits [12–14].

Education level emerged as a significant predictor of DM incidence, with an odds ratio (OR) of 5.001, indicating that patients with a high school or higher education had a fivefold increased risk compared to those with lower educational attainment. This result may reflect lifestyle factors commonly associated with higher education levels, such as sedentary behavior and consumption of high-calorie diets. However, contrasting findings were reported by Patrick et al. (2021), who observed no significant correlation between education and DM among TB patients [15], suggesting that contextual lifestyle and behavioral variables may influence these outcomes [16,17].

Occupational status was another significant factor, with individuals employed in the private sector showing a 3.5-fold higher risk of DM (OR = 3.5). This is consistent with the results of Tiwari et al. (2020), who found that sedentary occupations and occupational stress are associated with elevated DM risk [18]. Although other studies, such as that by Jing Li et al. (2024), did not observe this

association [8], it is plausible that occupational stress and physical inactivity contribute to insulin resistance through hormonal and metabolic pathways involving cortisol dysregulation [19,20].

Body mass index (BMI) was also a significant determinant of DM in TB patients. These findings align with the literature indicating that overweight and obesity, particularly central obesity, are important risk factors for insulin resistance and impaired glucose tolerance [21,22]. Accumulation of visceral adiposity is known to disrupt insulin signaling and increase systemic inflammation, thereby exacerbating metabolic dysfunction. Therefore, targeted interventions to manage body weight may be critical in reducing DM risk in TB patients [23].

In contrast, chest radiographic findings did not exhibit a significant association with DM incidence ($p = 0.686$), consistent with the study by Husein and Majdawati (2014) [24]. Although imaging remains essential for TB diagnosis, the data suggest that metabolic and behavioral risk factors exert greater influence on DM development in this patient population [25].

Smoking history was also not significantly associated with DM among TB patients in this study. While previous studies, such as that by Rau and Huldjannah (2021), found significant associations [11], the present findings may be due to the lack of stratification by smoking intensity or duration. Nonetheless, smoking remains a known contributor to metabolic dysfunction and impaired pancreatic beta-cell function [19,21,24]. Future research should account for dose-response relationships in smoking exposure to more accurately assess its role in DM risk.

This study's strength lies in its ability to identify independent risk factors for T2DM in TB patients through multivariate analysis of real-world clinical data. The inclusion of comprehensive variables such as education, occupation, and nutritional status provides valuable insights for targeted interventions. The study also adheres to ethical standards and utilizes clinical data, enhancing its relevance to practice. However, the case-control design without matching introduces potential selection bias, and its retrospective nature limits the ability to measure disease incidence directly. Moreover, the findings may not be generalizable beyond the population at Prof. Dr. Chairuddin P. Lubis Hospital, as regional differences could affect external validity.

5. Conclusion

This study concludes that educational attainment, occupational status, and body mass index (BMI) are independent and significant risk factors for the development of type 2 diabetes mellitus in patients with pulmonary tuberculosis. While no significant associations were observed with gender, age, chest radiographic findings, or smoking history, higher education levels, private sector employment, and elevated BMI were strongly associated with DM incidence. Among these, educational level emerged as the most dominant predictive factor. These findings underscore the need for integrated screening and intervention strategies targeting modifiable risk factors, particularly in TB patients with higher socioeconomic profiles.

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Conflict of Interest Statement

The author declares that there is no conflict of interest in this research.

Author Contributions

NPH conceptualized the study, designed the research methodology, and led the initial data collection and analysis process. NPH, LK, and NNS contributed to statistical analysis, data interpretation, and writing the initial draft of the manuscript. SS and GNY performed the literature review and provided critical revision and intellectual contributions to the manuscript. All authors read and approved the final manuscript for publication.

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