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Sociodemographic, clinical, and environmental determinants of tuberculosis and diabetes mellitus comorbidity: A case-control study

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Abstract

Background: Tuberculosis-Diabetes Mellitus comorbidity poses a major challenge in controlling communicable and non-communicable diseases simultaneously. TB-DM comorbidity represents a significant health concern, as both conditions can mutually influence one another, necessitating focused attention in clinical management, prevention, and treatment strategies. Therefore, it is essential to investigate how sociodemographic, clinical, and environmental factors contribute to the prevalence and severity
Purpose: To explore how sociodemographic, clinical, and environmental factors contribute to the prevalence and severity of tuberculosis-diabetes mellitus comorbidity.
Method: A quantitative research with a case control matching study research design. This study used secondary data from the tuberculosis information system of the West Sumatra Provincial Health Office. Samples were taken as many as 830 people with a ratio of cases (Tuberculosis-Diabetes Mellitus) and controls (Tuberculosis) 1:1. Data collected were comorbidity status of tuberculosis-diabetes mellitus and tuberculosis, sociodemographic, clinical and environmental data. Data were analyzed by univariate, bivariate, multivariate.
Results: Univariately, there were 830 cases of tuberculosis-diabetes mellitus comorbidity and 830 cases of tuberculosis. Age ≥ 45 (81.45%), employment (62.53%), urban residential area (47.21%), health facility referral (12.77%), type of pulmonary tuberculosis (98.3%), history of tuberculosis relapse (10.72%). There was an association between age, occupation, type of tuberculosis, and history of tuberculosis treatment with tuberculosis-diabetes mellitus comorbidity ($p<0.05$). There was no association between residential area and referral status with the incidence of DR-TB comorbidity ($p>0.05$). The most dominant risk factor for tuberculosis-diabetes mellitus comorbidity was age with p-value=0.0001 with OR=11.031 (95% CI 8.0143-15.185).
Conclusion: Age tends to be the risk probability for tuberculosis-diabetes mellitus comorbidity compared to tuberculosis. It is recommended that routine screening for diabetes mellitus be carried out in tuberculosis patients, especially in the age group ≥ 45 years because this group has the highest risk of experiencing tuberculosis-diabetes mellitus comorbidity.

Keywords: Age; Comorbidities; Diabetes Mellitus; Tuberculosis.

INTRODUCTION

Tuberculosis-Diabetes mellitus (TB-DM) comorbidity is a serious public health problem worldwide (Kakisingi, Kabamba, Muteba, Tamunbango, Tanon, Situakibanza, & Mwamba, 2023). TB-DM patients refer to individuals who are concurrently infected with Mycobacterium tuberculosis and suffer from diabetes mellitus. Patients with this comorbidity often exhibit more extensive pulmonary cavities on chest X-rays, smear-positive or culture-positive pulmonary TB, a higher

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bacterial load, an increased risk of TB relapse, multidrug-resistant TB, and elevated mortality rates(Kibirige, Andia-Biraro, Olum, Adakun, Zawedde-Muyanja, Sekaggya-Wiltshire, & Kimuli, 2024). TB disease is an infectious disease caused by Mycobacterium tuberculosis germs that often attack the lungs. These bacteria are rod-shaped and acid-resistant, often known as acid-resistant bacilli (Dabhi, Thangakunam, Gupta, James, Thomas, Naik, & Christopher, 2020; Mantovani, Ningsih, & Tambunan, 2022). TB can be spread through the air when people with TB cough, sneeze, or spit (World Health Organization, 2021). TB is a major cause of health problems and one of the leading causes of death worldwide (Ibrahim, 2017). Approximately 10.6 million people worldwide are currently living with active TB, comprising 5.8 million men, 3.5 million women, and 1.3 million children. About 25% of the world's population is infected with TB and 5% to 10% of them develop active TB (Shiferaw, Sinishaw, Amare, Alem, Asefa, & Klinkenberg, 2021; World Health Organization, 2020).

Diabetes mellitus has now become a serious threat to global health (Sary & Maulida, 2019). DM is a chronic disease that occurs when the pancreas does not produce enough insulin, or when the body cannot effectively use the insulin it produces (Lubis & Kanzanabilla, 2021). Data from the International Diabetes Federation (IDF) shows that the global prevalence of DM is 10.5% or 536.6 million sufferers in 2021 and is expected to continue to increase to 12.2% or 783.2 million people living with DM worldwide in 2045 (Sun, Saeedi, Karuranga, Pinkepank, Ogurtsova, Duncan, & Magliano, 2022). This makes DM the seventh leading cause of death in the world, reaching 6.7 million people in 2021, meaning that there is a death from DM every 5 seconds (Salsabila, & Sjaaf, 2022). DM is known as a "silent killer" disease because it can affect all organs of the body causing various complications (Hasnita, Rasyidah, & Astuti, 2020; Joseph, & Vadasseril, 2022).DM is a risk factor for all types of infection and severity of infectious diseases including TB (Kim, Ha, Kim, & Choi, 2019; Obels, Ninsiima, Critchley, & Huangfu, 2022). The global burden of DM-TB is high with a prevalence of 16% globally, 17% in Asia, 7% in Africa, 24% in North America, 23% in Oceania, 11% in South America, and 6% in Europe (Lutfiana, van Boven, Zubair, Pena, & Alffenaar, 2019).The prevalence of DM is nearly 15% in TB patients, and the prevalence of comorbidity of DM and pulmonary TB is significantly higher in countries with a high TB burden (Li, Zhao, Jiang, Zhang, Zhang, Shen, & Chen, 2024). This comorbidity not only increases mortality by up to 40% but also prolongs treatment duration and the risk of drug resistance (Obels et al., 2022).

Patients with diabetes have a higher risk of pleural empyema which can lead to TB (Zwicky, Rouiller, Candinas, Kocher, & Beldi, 2022). The incidence of empyema in diabetic patients compared to non-diabetic patients is 15.8: 8.1 per 100,000 population (Wen, Wei, Han, He, & Wang, 2019). Diabetics who have uncontrolled blood sugar levels (≥ 200 Mg/dl) are more at risk for bacterial growth and development (Anita, & Sari, 2022). Recent research suggests DM increases the risk of active TB by 2-3 times due to decreased cellular immunity, while TB infection can worsen glycemic control through chronic inflammatory mechanisms (Baker, Harries, Jeon, Hart, Kapur, Lönnroth, & Murray, 2011). TB patients with DM are almost four times more likely to experience recurrence of TB after cure, almost twice as likely to develop MDR, and twice as likely to die during TB treatment, compared to TB patients without DM (Baker et al., 2011; Tegegne, Mengesha, Teferra, Awoke, & Habtewold, 2018). Diabetes mellitus is a very dominant disease as a comorbidity of pulmonary TB (Anita, et al., 2022). Research shows that countries with an increased prevalence of DM will experience an increased prevalence of TB. From several studies in Asia, the prevalence of DM with TB co-infection ranges from 5-50%, with the incidence rate in DM patients increasing 1.8-9.5 times compared to the general population (Amelia, Fujiati, Lindarto, Yunir, & Kusnanto, 2024). The prevalence of TB- DM is also still high, which is around 110 per 100,000 people (Ministry of Health of the Republic of Indonesia, 2018).

Tuberculosis (TB) ranks as the second most prevalent disease in West Sumatra, with a reported 11,790 cases. In 2021, the province's Case Detection Rate (CDR) for TB was significantly lower than the national average, standing at 35.8%. Meanwhile, the number of individuals diagnosed with diabetes mellitus (DM) reached 48,206, with Padang City

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recording the highest number of cases. The rise in TB cases in West Sumatra has paralleled the increase in DM prevalence (Central Bureau of Statistics of West Sumatra Province, 2022; Anisha & Vionanda, 2023).

Findings from a preliminary survey indicate a steady increase in TB cases in West Sumatra over the past three years. According to reports from the West Sumatra Provincial Health Office (2022–2024), the number of TB cases successively reached 13,360, 14,287, and 14,931, with 12,166 new TB cases recorded in 2024. Similarly, TB-DM comorbidity cases have shown an upward trend during the same period—905 cases in 2022, 1,092 in 2023, and 1,105 in 2024—representing a 7.4% incidence rate in 2024. Among 624 TB-related deaths, 64 patients had comorbid diabetes. However, several TB patients have not yet undergone DM screening, suggesting a potential for further increases in TB-DM comorbidity in the province.

The burden of TB is further exacerbated by viral infections, the emergence of multidrug-resistant (MDR) and extensively drug-resistant (XDR) TB strains, and coexisting chronic conditions such as diabetes mellitus, all of which contribute to higher morbidity, mortality, and recurrence rates (Al-Bari, Peake, & Eid, 2024). A research conducted in India reported a 23.7% prevalence of diabetes among TB patients, with 2.8% previously diagnosed and 97.8% newly detected cases (Hullalli, Gudadinni, & Motappa, 2024). The prevalence of diabetes among TB patients ranged from 4.5% to 13.4% in urban populations (Beraldo, Andrade, Pinto, Silva-Sobrinho, R. A., Saita, Monroe, & Villa, 2021). Correspondingly, a study by Juang Li (2024) in China involving 322 pulmonary TB patients revealed that 54 (16.8%) had comorbid diabetes (Li et al., 2024). Overall, TB-DM comorbidity is influenced by a combination of sociodemographic, clinical, behavioral and lifestyle, and environmental determinants (Baker et al., 2011; Beraldo et al., 2021; Li et al., 2024; Niazi & Kalra, 2012; Tegegne et al., 2018).

TB-DM comorbidity represents a significant health concern, as both conditions can mutually influence one another, necessitating focused attention in clinical management, prevention, and treatment strategies. Therefore, it is essential to investigate how sociodemographic, clinical, and environmental factors contribute to the prevalence and severity of TB-DM comorbidity in West Sumatra Province. Currently, there is limited information regarding the impact of these factors on TB-DM comorbidity within this region. A review of existing literature indicates that few studies have specifically examined the relationship between sociodemographic, clinical, and environmental determinants and TB-DM comorbidity, particularly in the context of West Sumatra Province..

RESEARCH METHOD

A quantitative research approach using a case–control matching design. As an observational and epidemiological study, it aimed to identify the relationship between specific risk factors and the occurrence of a particular disease. Data collection was conducted between March and May 2025, utilizing the SI-TB 03 database (2024) from the West Sumatra Provincial Health Office. The research was carried out across West Sumatra Province, which consists of 12 districts and 7 cities.

The population of this study included all patients diagnosed with tuberculosis–diabetes mellitus (TB-DM) comorbidity in West Sumatra Province, as recorded in the SI-TB 03 dataset for 2024. Both the case and control groups were derived from this population. According to the provincial SI-TB 03 register, there were 1,157 individuals identified with TB-DM comorbidity. The sampling technique adopted was total sampling, meaning all eligible individuals were included as research subjects, provided they met the inclusion criteria. Consequently, the final sample comprised 830 participants in the case group and 830 participants in the control group.

For the case group, total sampling was applied, encompassing all TB-DM patients in the 2024 SI-TB 03 database who met the inclusion criteria. The control group consisted of TB patients without diabetes, selected through matching based on gender and district/city corresponding to those in the case group. After matching, simple random sampling was conducted within each subgroup sharing similar characteristics.

Inclusion criteria for the case group covered patients diagnosed with TB-DM according to the 2024 SI-TB data of the West Sumatra Provincial Health Office, and patients with complete data consistent with the study variables and operational definitions. While the exclusion criteria were patients not

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diagnosed with diabetes mellitus in the 2024 SI-TB 03 data, incomplete variable data, individuals residing outside West Sumatra Province, and TB-DM patients co-infected with HIV.

Inclusion Criteria for the control group included TB patients confirmed to be free from diabetes mellitus based on 2024 SI-TB data, and patients with complete data according to the research variables and operational definitions.

While for the exclusion criteria were incomplete variable data, residence outside West Sumatra Province, and TB patients co-infected with HIV.

This study utilized secondary data derived from two sources: the SI-TB 03 tuberculosis information system (2024) of the West Sumatra Provincial Health Office and the Central Bureau of Statistics of West Sumatra Province. Secondary data refer to information not obtained directly from research subjects but from existing records or databases.

Data processing was conducted using Epi Info version 7, while statistical analyses included univariate analysis, bivariate analysis using the McNemar test, and multivariate analysis employing conditional logistic regression.

This research has been declared to have passed the ethical review by the Research Ethics Commission Team of the Faculty of Public Health, Andalas University with the number: B/65/UN16.12.D/PP/2025.

RESEARCH RESULTS

Table 1. Characteristics of the Respondents (N=1,660)

Variables	Group		*p-value*	OR 95% CI
	Case (n=830)	Control (n=830)		
Age (Mean±SD)(Year)	(51.73±9.999)	(40.94±12.06)		
≥ 45	676/81.45	235/28.31	0.0001	11.500 (8.39-15.76)
< 45	154/18.55	595/71.69		
Gender (n/%)				
Male	495/59.64	495/59.64		
Female	335/40.46	335/40.46		
Occupation (n/%)				1.559
Employed	519/62.53	467/56.27	0.0001	(1.201-2.022)
Unemployed	311/37.47	363/43.73		
Residential Area (n/%)				1.218
Urban	396/47.21	384/46.27	0.277	(0.852-1.740)
Rural	434/52.29	446/53.73		
Referral Status (n/%)				1.246
Health Facility Referral	106/12.77	90/10.84	0.185	(0.899-1.727)
Self-attended	724/87.23	740/89.16		
Type of Tuberculosis (n/%)				6.615
Pulmonary Tuberculosis	815/98.19	742/89.40	0.0001	(3.692-11.853)
Extrapulmonary Tuberculosis	15/1.81	88/10.60		
TB Treatment History (n/%)				2.857
Relapse	89/10.72	37/4.46	0.0001	(1.857-4.393)
New	741/89.28	793/95.54		

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Table 1 presents the demographic characteristics of the study participants, comprising 1,660 individuals—830 respondents each in the case and control groups. The mean age of participants in the case group was 51.73 years (SD ±9.999), compared to 40.94 years (SD ±12.06) in the control group. A majority of respondents in the case group (81.45%) were aged ≥45 years, whereas only 28.31% of the control group fell within this age category.

In terms of gender distribution, 59.64% of respondents in both groups were male. Regarding employment status, 62.53% of individuals in the case group were employed, compared to 56.27% in the control group. Analysis of residential area indicated that 52.29% of respondents with TB-DM and 53.73% of those in the control group resided in rural areas.

For referral status, 87.23% of case group respondents and 89.16% of control respondents reported coming to health facilities independently. Based on tuberculosis type, 98.19% of TB-DM patients had pulmonary tuberculosis, while 89.40% of control respondents presented the same type. Concerning treatment history, 89.28% of the case group and 95.54% of the control group were classified as new cases.

Statistical analysis revealed several significant associations. The age variable demonstrated a p-value of 0.0001 ($p < 0.05$) with a matched odds ratio (OR) of 11.500 (95% CI: 8.39–15.76), indicating a strong association between age and the occurrence of TB-DM comorbidity. The employment variable also showed a significant relationship ($p = 0.0001$; matched-OR = 1.5591, 95% CI: 1.201–2.022), suggesting that occupational status is related to the likelihood of TB-DM comorbidity.

In contrast, residential area was not significantly associated with TB-DM comorbidity ($p = 0.277$; matched-OR = 1.2182, 95% CI: 0.852–1.740), nor was referral status ($p = 0.185$; matched-OR = 1.2462, 95% CI: 0.899–1.727). However, tuberculosis type exhibited a significant association with comorbidity ($p = 0.0001$; matched-OR = 6.615, 95% CI: 3.692–11.853). Similarly, treatment history was significantly related to the incidence of TB-DM comorbidity ($p = 0.0001$; matched-OR = 2.857, 95% CI: 1.857–4.393).

Overall, these findings indicate that age, employment status, tuberculosis type, and treatment history are significantly associated with the incidence of TB-DM comorbidity, whereas residential area and referral status show no statistically significant relationship.

Table 2. Multivariate Analysis Model

Variables	β	p-value	Matched OR	95% CI	
				Lower	Upper
Age	2,400	0,0001	11,031	8,014	15,185
Type of TB	1,588	0,0001	4,895	2,327	10,296

Based on Table 2, the age variable emerged as the most dominant factor associated with the incidence of TB-DM comorbidity, showing a p-value of 0.0001 ($p < 0.05$) and the highest matched odds ratio (OR) of 11.031. This finding indicates that individuals aged ≥45 years have an 11.031-fold higher risk of developing TB-DM comorbidity compared to those aged <45 years.

In addition, the type of tuberculosis was also identified as a significant factor influencing TB-DM comorbidity, with a p-value of 0.0001 ($p < 0.05$) and a matched OR of 4.895. The selected model was determined to be the most suitable, as indicated by the Final -2 Log Likelihood value of 694.1339, demonstrating its robustness in explaining the observed associations.

DISCUSSION

The results of this study indicated that the majority of respondents were male (59.64%), which aligns with findings from a study conducted in Kediri, where 64% of TB-DM cases occurred among men (Abbas, 2022). This higher prevalence among males may be influenced not only by biological factors but also by behavioral factors, such as a higher prevalence of smoking, which can reduce respiratory resistance and increase metabolic complications among TB patients with diabetes (Wati, Ariyanto, & Prasetyowati, 2024).

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Conversely, a study conducted in Padang City (2020) reported a slightly different pattern, with TB-DM cases being more common among women (57%) than men (43%) (Fatimah, 2022). Differences in hormonal and immunological profiles between men and women may partially explain these variations. Estrogen, for instance, has been shown to possess immunoprotective properties, which may influence susceptibility to infectious and chronic diseases (Sarvasti, 2020).

Age was found to be a significant factor associated with TB-DM comorbidity, with the condition being more prevalent among individuals aged ≥45 years; 61% of TB-DM patients were in this age group(Yague-Santiago, del Pilar Ramírez-Díaz, Velázquez-Ramírez, Zenteno-Cuevas, & Luna-Hernández, 2022). Physiologically, advancing age leads to declines in immune function and pancreatic β-cell activity, resulting in reduced insulin secretion and increased susceptibility to infections (Setiyorini & Wulandari, 2018; Pradinda, Russilawati, & Ilhami, 2022). Older adults tend to experience immunosuppression, which elevates their risk for both TB and DM (Anyanwu, Ajumobi, Afolabi, Usman, & Kehinde, 2022). This supports the view that TB-DM comorbidity reflects age-related immune decline, contributing to vulnerability to both conditions (Kibirige et al., 2024).

Occupational factors also appear to play a role in the development of TB-DM comorbidity. Physically demanding jobs, as well as overcrowded or unsanitary work environments, can increase exposure to TB infection. Additionally, occupational stress and insufficient rest may disrupt glycemic control in diabetic individuals. Studies in Mexico have shown that physical activity levels and occupational strain influence both glycemic control and TB susceptibility (Wake, 2020; Yague-Santiago et al., 2022). A higher percentage of those who worked were found in the TB-DM comorbidity (80.4%) compared to the TB control group (70.7%) (Praveen, Kambar, Sajna, & Areekal, 2024). Employment status also reflects socioeconomic determinants that affect access to healthcare, nutrition, and lifestyle behaviors (World Health Organization, 2003; Nugraha, Gotera, & Yustin, 2021; Kibirige et al., 2024). Interestingly, those who were unemployed were found to have 2.1 times greater risk of TB-DM comorbidity than those who were employed (Nugrahaeni, Kusumasari, Budiana, & Mauliku, 2025).

Regarding residential area, most TB-DM patients in this study resided in rural areas, although the difference compared to urban areas was minimal. These findings suggest that urban residence is not a significant risk factor for TB-DM comorbidity in West Sumatra Province. While residential location may not directly influence disease incidence, socioeconomic status and healthcare accessibility remain important contextual factors (Rohman, 2018; Hartono et al., 2020). Differences in lifestyle and health-seeking behaviors between rural and urban populations may contribute to these patterns. In China, rapid urbanization and the adoption of Westernized lifestyles have been linked to a higher prevalence of non-communicable diseases such as diabetes (Muntner, Gu, Wildman, Chen, Qan, Whelton, & He, 2005).

The study also found that referral status did not significantly affect TB-DM incidence. Most patients accessed primary healthcare services independently, without formal referrals, due to ease of access and proximity (Nasution, Kurniansyah, & Priyanti, 2021). Strengthening primary healthcare capacity can reduce unnecessary hospital referrals, ensuring timely diagnosis and treatment at the community level (Harma, Yuniarti, & Nurvitasari, 2024). However, studies from China show that migrant TB patients with DM experience longer healthcare delays due to lack of insurance and poor adherence to referral protocols. Similarly, TB patients diagnosed at higher-level hospitals often experience longer diagnostic and referral delays, highlighting systemic challenges in timely case management (Xiao, Huang, Li, Zhou, Wei, Chen, & Zou, 2021).

Although referral status was not found to be a major risk factor in this study, it is often observed that patients referred from other healthcare facilities tend to have more severe or complex conditions, which require advanced care. Such patients are more likely to undergo comprehensive examinations that can lead to earlier detection of TB-DM comorbidity. Since diabetes is associated with higher risks of heart failure, mortality, and TB relapse (Baker et al., 2011), it is recommended that all TB patients undergo blood glucose screening to facilitate early detection of comorbid DM.

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Metabolic complications from DM can impair TB treatment outcomes and increase the risk of relapse or reinfection. Chronic hyperglycemia weakens T-cell and macrophage function, reducing host defense and compromising TB therapy effectiveness. Additionally, high-carbohydrate diets (e.g., rendang rice) and obesity may exacerbate hyperglycemia, elevating the risk of recurrence. Conversely, active TB infection can induce insulin resistance via inflammatory mediators such as IL-6 and TNF-α, creating a bidirectional relationship where DM worsens TB outcomes (Yorke, Atiase, Akpalu, Sarfo-Kantanka, Boima, & Dey, 2017). Some studies have shown no significant association between TB treatment history and TB-DM comorbidity (Yague-Santiago et al., 2022); however, patients with TB-DM tend to exhibit higher bacterial loads and delayed sputum conversion, contributing to treatment failure and relapse (Lee, Fu, Lai, Chiang, Chan, & Lin, 2016).

Among all variables analyzed, age emerged as the most dominant factor influencing TB-DM comorbidity in West Sumatra, with a p-value of 0.0001 ($p < 0.05$) and the highest matched odds ratio (OR) of 11.031. This finding suggests that individuals aged ≥45 years are approximately 11 times more likely to develop TB-DM comorbidity compared to younger individuals. This supports prior evidence that aging-related immune decline and pancreatic dysfunction increase vulnerability to both TB and DM (Workneh, Bjune, & Yimer, 2017; Abbas, 2022). Furthermore, uncontrolled hyperglycemia impairs monocyte–macrophage activity, further predisposing older adults to infection and complicating TB treatment outcomes.

CONCLUSION

The findings reveal that age ≥ 45 years is the most significant risk factor, as individuals in this age group are 11.031 times more likely to experience TB-DM comorbidity compared to younger individuals. Employment status was also found to be associated with a higher vulnerability to TB-DM, with working individuals showing greater risk. In contrast, residential area and referral status demonstrated no significant association with the occurrence of TB-DM comorbidity.

RECOMMENDATION

The study recommends strengthening data recording and reporting systems to ensure the accuracy of case documentation. Health workers at all healthcare levels are encouraged to perform dual screening in TB services to facilitate early detection of DM and minimize treatment delays. Moreover, public awareness and targeted screening programs for individuals aged ≥ 45 years should be enhanced to effectively manage and reduce the incidence of TB-DM comorbidities.

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