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RISK FACTORS FOR PULMONARY TUBERCULOSIS IN DIABETES MELLITUS PATIENTS

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ABSTRACT

Tuberculosis (TB) is a contagious infectious disease that causes major health problems globally. Indonesia is a country with a high burden of TB cases, with an incidence of 312 per 100,000 population. The number of suspected tuberculosis cases in Aceh in 2022 is 85,945 cases. Aceh Besar has the second highest number of tuberculosis cases, namely 3644 people. DM sufferers have uncontrolled glucose levels so they are at risk of developing TB. This research was conducted to analyze the risk factors for the incidence of tuberculosis in DM sufferers at the Aceh Besar. This research is a quantitative research approach case control study. The sample in this study was DM sufferers with a total sample of 104 people with a sample number of 52 people in each group. Sampling in research uses the technique of purposive sampling. Sample selection for the control group was carried out by selecting DM sufferers of the same gender as the case group. Data collection was carried out using questionnaires and data from examination results from community health centers. Data analysis used multiple logistic regression tests with a confidence level of 95%. The results of the study showed that factors associated with the incidence of pulmonary tuberculosis in diabetes mellitus sufferers in Aceh Besar were secondary education (OR=8.84; 95%CI=1.67–46.69), not working (OR=3.12; 95%CI=1.16–8.35), poor lifestyle (OR=4.97; 95%CI=1.68–14.71), underweight nutritional status (OR=4.38; 95%CI=1.14–16.77), smoking (OR=3.19; 95%CI=1.35–7,55), unhealthy house (OR=2.36; 95%CI=1.07 – 5.18), poor quality of health services (OR=0.03; 95%CI=0.01–0.09), family history of TB (OR=9.40; 95%CI=2.57–34.34) and contact directly with TB sufferers (OR=4.71; 95%CI=1.79–12.40). The most dominant factor associated with the incidence of tuberculosis in diabetes mellitus sufferers in Aceh Besar is smoking (OR=12.71; 95%CI=2.07–77.68). It is hoped that the public, especially DM sufferers, will stop smoking to engage in physical activity or consider seeking support or health consultation to help stop smoking. Additionally, it is hoped to not have direct contact with TB sufferers, to and use a mask when interacting with TB sufferers.

Keywords: DM sufferers; risk factors; tuberculosis

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INTRODUCTION

Tuberculosis (TB) is a contagious infectious disease that poses a significant global health issue. TB is caused by the acid-resistant bacterium Mycobacterium tuberculosis, which is transmitted through airborne droplets from individuals with active TB (WHO, 2020). Approximately 85% of TB cases occur in the lungs (pulmonary TB), although other organs can also be affected (extrapulmonary TB). Over the past two centuries, TB is estimated to have caused one billion deaths (Dheda et al., 2016).According to the World Health Organization (WHO) in the 2020 Global Tuberculosis Report, 87% of TB cases in 2019 were concentrated in 30 high TB burden countries. Geographically, Southeast Asia had the highest number of new TB cases, accounting for 44% of global incidence. Eight countries—India, Indonesia, China, the Philippines, Pakistan, Nigeria, Bangladesh, and South Africa—accounted for two-thirds of global TB cases (WHO, 2020).

Despite effective TB treatment regimens, the disease burden and mortality remain high. In 2019, there were 10 million active TB cases and 1.4 million deaths annually. Nearly half a million individuals experienced rifampicin-resistant TB (RR-TB), with 78% of these cases being multidrug-resistant TB (MDR-TB). About 90% of TB cases occur in adults, with adult men comprising the largest burden (56%), followed by women (32%) and children (12%). Among total cases, 8.2% were individuals living with HIV, making TB the leading cause of death among people with HIV (WHO, 2020).Nationally, Indonesia's TB case notification rate showed an increasing trend from 2010 to 2018 (566,623 cases). However, sharp declines were observed in 2019 (543,874 cases) and 2020 (351,936 cases) (Kemenkes RI, 2021). This decline is likely attributed to the impact of COVID-19 on TB healthcare services, such as fear of visiting healthcare facilities due to infection risks and stigma arising from similar symptoms between COVID-19 and TB (WHO, 2021). Delayed diagnoses increase vulnerability to TB and the risk of transmission before effective treatment begins (Lönnroth et al., 2009).

Indonesia is among the high TB burden countries, with an incidence rate of 312 per 100,000 population in 2020 (WHO, 2020). TB cases are higher among men, with the majority found in the 45-54 age group (17.3%), followed by the 25-34 (16.8%) and 15-24 (16.7%) age groups (Kemenkes, 2020). Data from the 2018 Basic Health Research (Riskesdas) indicated a prevalence of pulmonary TB diagnosed by doctors in Indonesia at 0.4%, with Aceh at 0.5% (Riskesdas, 2018).TB progression risk is influenced by exogenous, endogenous, and environmental factors (Dheda et al., 2016). The transition from latent TB to active TB occurs when an individual's immune system is compromised, such as with HIV/AIDS or other immune-deficient conditions (Bloom et al., 2017). Major risk factors contributing to the TB epidemic include HIV, diabetes mellitus (DM), tobacco smoking, alcohol use, malnutrition, indoor air pollution (Lönnroth et al., 2010), drug use (Silva et al., 2018), and immunosuppressive therapy (Ayelign et al., 2019).

On an individual level, the risk of TB is 20 times higher for people living with HIV. However, at the community level, the prevalence of diabetes mellitus (DM) contributes more to TB cases due to the larger number of individuals affected by DM (Getahun et al., 2010). Currently, more people are living with TB-DM than TB-HIV. To reduce TB incidence, targeting risk factors that facilitate disease progression is essential (Baker et al., 2011).According to the International Diabetes Federation, three out of four DM patients live in low- and middle-income countries where TB is endemic (WHO, 2020). The increasing number of DM cases poses challenges for TB care and control, especially in countries with high burdens of both diseases (Faurholt-Jepsen et al., 2011). Poor glycemic control and hyperglycemia are linked to TB risk and outcomes (van Crevel et al., 2017). Uncontrolled DM can exacerbate TB progression (Leegaard et al., 2011; Leung et al., 2008; Lee et al., 2016).DM is recognized as a significant comorbidity for TB development. Systematic reviews show that DM patients have an increased risk of latent TB (Lee et al., 2017; Foe-Essomba et al., 2021) and are two to three times more likely to develop active TB compared to non-DM individuals (Jeon & Murray, 2008; Al-Rifai et al., 2017; Hayashi & Chandramohan, 2018). Consequently, 15% of global TB cases are linked to DM (WHO, 2011).

The prevalence of DM among TB patients varies globally, ranging from 1.9% to 45%, while TB prevalence among DM patients is 0.38% to 14%, higher in Asia and Africa (Workneh et al., 2017). Effective management of TB-DM comorbidities requires bidirectional screening, i.e., screening TB patients for DM and vice versa (WHO, 2011; Pizzol et al., 2016). The WHO and Indonesia's national TB guidelines recommend such screenings.DM and TB

worsen each other's clinical outcomes, with DM linked to more severe TB presentations, higher treatment failure rates, relapses, and MDR-TB risk (Baker et al., 2011; Noubiap et al., 2019). TB patients with DM often present with cavitary lung lesions, higher bacillary loads, delayed sputum conversion, and increased mortality risk (Restrepo et al., 2007; Alisjahbana et al., 2007; Awad et al., 2019).Several risk factors contribute to DM-TB comorbidity, such as gender, older age, urban living, tobacco use, sedentary lifestyle, poor glycemic control, family history of DM, and household TB exposure (Workneh et al., 2017).Based on Aceh's 2021 health profile, the percentage of suspected TB patients receiving proper TB services was 35.64%, with 85,945 suspected TB cases. Aceh Utara had the highest number (4,292 cases), followed by Aceh Besar (3,644 cases). Data from the Aceh Besar Health Office showed 128 DM-TB patients in 2022 and 82 cases as of August 2023, indicating a potential increase in DM-TB cases.This study aims to analyze risk factors for tuberculosis incidence among DM patients in Aceh Besar primary healthcare centers.

METHOD

This study is an analytical research with a case-control approach to determine the relationship between risk factors and tuberculosis (TB) occurrence in patients with diabetes mellitus (DM). The research was conducted in 28 primary healthcare centers (Puskesmas) in Aceh Besar Regency in August 2023.The study population consisted of all DM patients aged over 15 years recorded in the 28 Puskesmas in Aceh Besar in 2022, totaling 8,752 individuals. The sample included DM patients from the Aceh Besar area. The case group comprised DM patients with TB, while the control group consisted of DM patients without TB. Sampling was conducted using a purposive sampling technique. Based on data from the Aceh Besar Health Office, there were 52 cases of DM-TB in Aceh Besar. With a 1:1 ratio, the total sample size was 104 participants. Selection for the control group ensured that DM patients matched the gender of those in the case group.The data used in this study included both primary and secondary data. Primary data were collected through questionnaires to gather information on respondents' characteristics, lifestyle, smoking behavior, quality of healthcare services, insurance ownership, DM self-management, duration of DM, family history of TB, family history of DM, and direct contact with TB patients. Additionally, primary data on physical home conditions were obtained through direct observation. Secondary data were sourced from medical records from the Puskesmas, including the names of DM-TB and DM patients, as well as their weight and height measurements.

The research instruments included a questionnaire modified from several studies. Healthcare service quality was measured using 22 statements adapted from Johan (2009). Lifestyle was assessed using 20 statements modified from Supriati (2020). DM self-management was measured using the Summary of Diabetes Self-Care Activities Questionnaire, which consists of 17 statements (Aris, 2020). Healthy housing conditions were evaluated using an instrument based on the technical guidelines for healthy housing assessment (Ministry of Health, 2002). Additionally, respondents' body weight and height were measured as part of the study.Data collection was carried out by distributing questionnaires to respondents based on data obtained from each Puskesmas in the Aceh Besar area. Data collection was supported by 28 enumerators, one from each Puskesmas. The enumerators were program officers for DM-TB. Before data collection, the enumerators were given a briefing to ensure accurate and consistent data gathering.Data analysis was performed using the STATA software. The analysis consisted of three stages: univariate analysis, bivariate analysis using logistic regression tests, and multivariate analysis using multiple logistic regression tests.

RESULT

Table 1.
Relationship between characteristic factors, health factors, health system factors and DM factors with the incidence of tuberculosis in diabetes mellitus patients

Variable	Tuberculosis control n (%)	Tuberculosis case n (%)	OR (95% CI)	p-value	COR (95% CI)[a]	p-value
Characteristic Factors						
Age			1,005 (0,96 – 1,04)	0,764	1,005 (0,96 – 1,04)	0,768
Education						
- Higher	10 (19,23)	2 (3,85)				
- Intermediate	13 (25,00)	23 (44,23)	8,84 (1,67 – 46,69)	0,010	8,10 (1,51 – 43,95)	0,014
- Base	29 (55,77)	27 (51,92)	4,65 (0,93 – 23,19)	0,061	3,82 (0,80 – 18,17)	0,092
Work						
- Work	45 (86,54)	35 (67,31)				
- Doesn't work	7 (13,46)	17 (32,69)	3,12 (1,16 – 8,35)	0,023	3,5 (1,15 – 10,6)	0,027
Income						
- ≥ Regional minimum wage	6 (11,54)	8 (15,38)	0,71 (0,23 – 2,23)	0,567	0,71 (0,22 – 2,25)	0,566
- < Regional minimum wage	46 (88,46)	44 (84,62)				
Marriage						
- Marry	37 (71,15)	40 (76,92)				
- Widow/Widower	13 (25,00)	11 (21,15)	0,78 (0,31 – 1,96)	0,601	0,81 (0,33 – 1,97)	0,655
- Single	2 (3,85)	1 (1,92)	0,46 (0,04 – 5,31)	0,536	0,50 (0,04 – 5,51)	0,571
Health Factors						
Lifestyle						
- Good	47 (90,38)	34 (65,38)				
- Not good	5 (9,62)	18 (34,62)	4,97 (1,68 – 14,71)	0,004	4,25 (1,43 – 12,63)	0,009
Nutritional status						
- Normal	49 (94,23)	41 (78,85)				
- Thin	3 (5,77)	11 (21,15)	4,38 (1,14 – 16,77)	0,031	3,66 (1,02 – 13,14)	0,046
Smoke						
- None	41 (78,85)	28 (53,85)				
- Any	11 (21,15)	24 (46,15)	3,19 (1,35 – 7,55)	0,008	5,33 (1,55 – 18,3)	0,008
Healthy Home						
- Healthy	32 (61,54)	21 (40,38)				
- Unwell	20 (38,46)	31 (59,62)	2,36 (1,07 – 5,18)	0,032	1,73 (0,91 – 3,27)	0,090
Health System Factors						
Quality of Service						
- Good	7 (13,46)	43 (82,69)				
- Not Good	45 (86,54)	9 (17,31)	0,03 (0,01 – 0,09)	0,000	0,02 (0,00 – 0,19)	0,000
Access						
- Easy	35 (67,31)	29 (55,77)				
- Difficult	17 (32,69)	23 (44,23)	1,63 (0,73 – 3,62)	0,228	1,75 (0,73 – 4,17)	0,207
JKN Insurance Ownership						
- Any	51 (98,08)	52 100,00)				
- None	1 (1,92)	0 (0,00)	1 (empty)		1 (empty)	
Diabetes Mellitus Factors						
Self Management DM						
- Good	8 (15,38	8 (15,38)				
- Not Good	44 (15,38)	44 (84,62)	1 (0,34 – 2,90)	1,000	1 (0,37 – 2,66)	1,000
Long time suffering from DM			0,99 (0,90 – 1,08)	0,925	0,99 (0,91 – 1,08)	0,927
DM History						

Variable	Tuberculosis control n (%)	Tuberculosis case n (%)	OR (95% CI)	p-value	COR (95% CI)[a]	p-value
- None	35 (67,31)	27 (51,92)				
- Any	17 (32,69)	25 (48,08)	1,90 (0,86 – 4,22)	0,112	1,8 (0,83 – 3,89	0,136
History of TB						
- None	49 (94,23)	33 (63,46)				
- Any	3 (5,77)	19 (36,54)	9,40 (2,57 – 34,34)	0,001	8,99 (2,08 – 38,7)	0,003
Direct Contact						
- Never	45 (86,54)	30 (57,69)				
- Ever	7 (13,46)	22 (42,31)	4,71 (1,79 – 12,40)	0,002	6 (1,76 – 20,36)	0,004

Description: Logistic regression analysis matched by gender

Based on Table 1, the characteristic factors associated with the occurrence of pulmonary tuberculosis in diabetes mellitus (DM) patients in Aceh Besar are secondary education (OR=8.84; 95% CI=1.67–46.69; p-value=0.010) and unemployment (OR=3.12; 95% CI=1.16–8.35; p-value=0.023).The health-related factors associated with tuberculosis in DM patients in Aceh Besar are poor lifestyle (OR=4.97; 95% CI=1.68–14.71; p-value=0.004), underweight nutritional status (OR=4.38; 95% CI=1.14–16.77; p-value=0.031), smoking (OR=3.19; 95% CI=1.35–7.55; p-value=0.008), and unhealthy housing conditions (OR=2.36; 95% CI=1.07–5.18; p-value=0.032).The healthcare system factors associated with pulmonary tuberculosis in DM patients in Aceh Besar include poor healthcare service quality (OR=0.03; 95% CI=0.01–0.09; p-value=0.000). The diabetes-related factors associated with tuberculosis in DM patients in Aceh Besar are a family history of TB (OR=9.40; 95% CI=2.57–34.34; p-value=0.001) and direct contact with TB patients (OR=4.71; 95% CI=1.79–12.40; p-value=0.002).

Tabel 2.

Characteristic factor associated with the occurrence of pulmonary tuberculosis in diabetes mellitus (DM) patients

Variable	Characteristic Factors		Health Factors		Health System Factors		Diabetes Mellitus Factors	
	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value
Secondary Education	7,04 (1,30 – 38,14)	0,024						
Basic Education	2,64 (0,52 – 13,26)	0,237						
Doesn't work	3,65 (1,11 – 11,94)	0,032						
Bad Lifestyle			9,29 (2,04 – 41,23)	0,004				
Underweight Nutritional Status			3,88 (0,82 – 18,37)	0,087				
Smoke			8,71 (2,01 – 37,62)	0,004				
Unhealthy Home			1,54 (0,62 – 3,86)	0,349				
Poor Service Quality					0,02 (0,00 – 0,18)	0,000		
Difficult Access					0,65 (0,14 – 2,82)	0,566		
There is DM History							1,40 (0,56 – 3,49)	0,458
There is a history of TB							4,38 (0,79 – 24,2)	0,090
Have you ever had direct contact?							2,69 (0,59 – 12,17)	0,196

Based on table 2, the most dominant characteristic factor associated with the occurrence of pulmonary tuberculosis in diabetes mellitus (DM) patients in Aceh Besar is secondary education (OR=7.04; 95% CI=1.30–38.14; p-value=0.024). The most dominant health-related factor is poor lifestyle (OR=9.29; 95% CI=2.04–42.23; p-value=0.004). The most dominant healthcare system factor is poor quality of healthcare services (OR=0.02; 95% CI=0.00–0.18; p-value=0.000). The most dominant diabetes-related factor is a family history of TB (OR=4.38; 95% CI=0.79–24.2; p-value=0.090).Based on Table 3, in Model 1, which examines the relationship between characteristic and health-related factors, the most dominant factor associated with pulmonary tuberculosis in DM patients in Aceh Besar is lifestyle (OR=7.29; 95% CI=1.91–27.81; p-value=0.004). In Model 2, combining Model 1 with healthcare access factors, the most dominant factor is smoking (OR=9.20; 95% CI=1.69–49.98; p-value=0.010). In Model 3, which integrates Model 2 with diabetes-related factors, the most dominant factor remains smoking (OR=12.71; 95% CI=2.07–77.68; p-value=0.006).

DISCUSSION

Relationship between Characteristic Factors and the Incidence of Tuberculosis in Diabetes Mellitus Patients

The study results indicate that characteristic factors associated with pulmonary tuberculosis in diabetes mellitus (DM) patients in Aceh Besar include secondary education and unemployment. The most dominant characteristic factor is secondary education, with an odds ratio of 7.04 (95% CI=1.30–38.14; p-value=0.024).Respondents with secondary education are 8.84 times more likely to develop pulmonary tuberculosis compared to those with higher education. After controlling for gender, respondents with secondary education remain 8.16 times more at risk of pulmonary tuberculosis than those with higher education. This finding aligns with the study by Lusiani (2019), which showed a significant association between education and pulmonary tuberculosis in type 2 DM patients, with an odds ratio of 5.8 (p=0.023; 95% CI=1.27–27.28)However, the findings contradict Sa'adah et al. (2022), which reported no association between education and pulmonary tuberculosis in DM patients, and Hapsari & Isfandiari (2017), which also found no relationship between education and tuberculosis risk in type 2 DM patients. According to Irawan (2020), education indirectly influences the risk of pulmonary tuberculosis in type 2 DM patients. Improved access to health information, both online and offline, at healthcare facilities allows type 2 DM patients to be more aware of preventing tuberculosis infection and other diseases.

The study also found that unemployed respondents are 3.12 times more likely to develop pulmonary tuberculosis than employed respondents. After controlling for gender, unemployed respondents remain 3.5 times more at risk (OR=3.5; 95% CI=1.15–10.6; p-value=0.027). This finding aligns with the research by Hapsari and Isfandiari (2017), which demonstrated an association between employment status and pulmonary tuberculosis, showing that unemployed DM patients are 3.297 times more likely to develop pulmonary tuberculosis than those who are employed. While employment may expose individuals to environments with tuberculosis infection risks, those who are unemployed or spend more time at home are more likely to have contact with TB patients or people in their surroundings with TB.The study also found no significant association between pulmonary tuberculosis and other demographic factors, such as age, income, and marital status. This is consistent with Lusiani (2019), who found no relationship between gender, age, and pulmonary tuberculosis in type 2 DM patients. Similarly, Sa'adah et al. (2022) and Nasruddin et al. (2017) reported no association between age, gender, and tuberculosis in DM patients.

Type 2 DM patients with an income below the regional minimum wage (UMK) are 13.214 times more likely to develop pulmonary tuberculosis compared to those with incomes above or equal to the UMK. Social and economic disparities between men and women contribute to this finding, as men are more exposed to tuberculosis bacteria due to outdoor activities and occupational demands (Harso et al., 2017). Furthermore, other studies show that tuberculosis is more prevalent in men than women, not only due to biological differences but also due to lifestyle risk factors such as smoking, occupational hazards, indoor air pollution from cooking, and industrial exposure (Abbas, 2022).As individuals age, pancreatic cell function and insulin secretion decline. Additionally, uncontrolled hyperglycemia predisposes individuals to infections due to impaired monocyte-macrophage function (Hidayah & Amal, 2019).

Relationship between Health Factors and Tuberculosis Incidence in Diabetes Mellitus Patients

The study results indicate that health factors associated with pulmonary tuberculosis (TB) in diabetes mellitus (DM) patients in Aceh Besar include poor lifestyle, underweight nutritional status, smoking, and unhealthy housing conditions. Among these, the most dominant health factor is a poor lifestyle, with an odds ratio (OR) of 9.29 (95% CI=2.04–42.23; p-value=0.004).Respondents with a poor lifestyle are 4.97 times more likely to develop pulmonary TB compared to those with a good lifestyle. This finding aligns with the study by Workneh et al. (2017), which identified lifestyle as a risk factor for TB in DM patients. DM patients with poor lifestyle habits, such as an unhealthy diet and lack of physical activity, are at a higher risk of TB. Conversely, better DM management, including improved blood sugar control, lowers the risk of TB.The study also found that DM patients with underweight nutritional status are at higher risk of developing pulmonary TB compared to those with normal nutritional status. This finding contradicts the study by Yosephine et al. (2021), which reported that DM patients with at-risk nutritional status (both underweight and overweight) had a protective effect against pulmonary TB, with an OR of 0.352. This discrepancy may be due to Yosephine et al.'s bivariate analysis combining underweight and overweight categories, resulting in an overall protective effect against TB in DM patients.

Furthermore, respondents who smoke are 3.19 times more likely to develop pulmonary TB compared to non-smokers. Smoking behavior emerged as the most dominant factor associated with TB in DM patients. This finding is consistent with Sasmita et al. (2019), which demonstrated a relationship between smoking and TB occurrence in DM patients. However, it differs from Nasruddin et al. (2017), which found no significant association between smoking history and pulmonary TB in DM patients.Smoking impairs the respiratory immune system, making individuals more susceptible to infection. It damages the mucociliary clearance mechanism due to toxins in cigarette smoke, harms phagocytic cells in the respiratory tract, and reduces the immune response to antigens, increasing susceptibility to pulmonary TB (Fauzia et al., 2016). Cigarettes contain over 4,800 chemical substances, including nicotine, tar, carbon monoxide, and lead (Rosyanti & Kusumaningtiar, 2020), which damage lung tissues and reduce lung capacity (Rohmayani, 2023). Consequently, smokers are more vulnerable to TB, as the disease primarily targets the lungs.The study also found that respondents living in unhealthy housing conditions are 2.36 times more likely to develop pulmonary TB compared to those in healthy housing. This finding aligns with Manalu et al. (2022), which identified physical housing conditions—such as overcrowding, inadequate ventilation, poor flooring, and insufficient lighting—as risk factors for pulmonary TB.

Unhealthy housing conditions have a negative impact on residents, as they facilitate the transmission of infectious diseases like pulmonary TB caused by Mycobacterium tuberculosis. This bacterium can survive for long periods in high-humidity environments, increasing the risk of transmission (Romadhan et al., 2019). DM patients, who are already more susceptible to infections due to compromised immunity, are at greater risk of contracting TB in poorly maintained physical home environments.

Relationship between Health System Factors and Tuberculosis Incidence in Diabetes Mellitus Patients

The study results indicate that the healthcare system factor associated with pulmonary tuberculosis (TB) in diabetes mellitus (DM) patients in Aceh Besar is poor healthcare service quality. Respondents who received poor-quality healthcare services were 0.03 times less likely to prevent the development of pulmonary TB compared to those who received good-quality healthcare services.According to the study, most DM-TB respondents stated that the healthcare services provided were good. Healthcare professionals have delivered adequate care for DM-TB patients in managing their condition. However, Irma (2018) noted that initial actions in healthcare services could contribute to delays in the diagnosis and treatment of TB. Symptoms such as a persistent cough lasting more than three weeks or coughing up blood are associated with faster diagnosis. These symptoms raise suspicion of TB, prompting timely diagnostic procedures and treatment. Conversely, nonspecific symptoms may lead to inappropriate interventions, such as the administration of regular cough medicine, without proper TB evaluation (Irma, 2018).The study also revealed that certain healthcare system factors were not significantly associated with pulmonary TB in DM patients in Aceh Besar. These factors include difficult access to healthcare services (OR=1.63; 95% CI=0.73–3.62; p-value=0.228) and the lack of national health insurance (JKN). This finding contrasts with Rohman & Hartono (2016), who demonstrated an association between distance from healthcare facilities and pulmonary TB. Several studies have highlighted that TB treatment failure is often due to factors such as low patient motivation, limited knowledge about TB, medication side effects, economic status, transportation challenges to healthcare facilities, and poor communication quality between TB patients and healthcare providers (Janan, 2019). Bernice (2023) further noted that long distances to healthcare facilities are associated with delayed sputum conversion.

Healthcare facilities are critical in supporting patient health, as behavioral changes in patients are often influenced by the quality of these facilities. Many individuals improve their health behaviors when they receive high-quality healthcare services that support their recovery. This relationship has been evidenced by changes in patient behavior. For example, TB patients are more likely to adhere to treatment if they receive the desired healthcare services and facilities, ultimately improving TB recovery rates.Additionally, patient recovery from TB is influenced by treatment adherence. It is crucial for patients to complete their therapy programs to achieve recovery promptly. Irregular treatment and incomplete medication combinations have been linked to the development of multidrug-resistant TB strains (Dewi & Fazri, 2023).

Relationship between Health System Factors and Tuberculosis Incidence in Diabetes Mellitus Patients

The study results show that family history of tuberculosis (TB) (OR=9.40; 95% CI=2.57–34.34; p-value=0.001) and direct contact with TB patients (OR=4.71; 95% CI=1.79–12.40; p-value=0.002) are diabetes-related factors associated with pulmonary tuberculosis in diabetes mellitus (DM) patients in Aceh Besar.Respondents with a family history of TB were 9.40 times more likely to develop tuberculosis compared to those without such a history.

According to Pralambang & Setiawan (2021), a family history of TB is a significant risk factor for tuberculosis. When one family member is infected with TB, other members are at higher risk due to frequent direct contact with the infected person, especially when living in the same household.
The study also found that respondents who had been in direct contact with TB patients were 4.71 times more likely to develop tuberculosis compared to those who had no contact. This finding aligns with research by Sa'adah et al. (2022), which established a relationship between contact history with TB patients and TB incidence among type 2 DM patients. According to Irawan (2020), type 2 DM patients with a history of contact with pulmonary TB patients are 10.43 times more likely to develop pulmonary TB than those without such contact. Similarly, Nasruddin et al. (2017) confirmed a significant influence of pulmonary TB contact history on TB incidence in type 2 DM patients.Contact history plays a critical role in tuberculosis, as Mycobacterium tuberculosis, the causative agent, is highly infectious. It is an aerobic bacterium that can survive for extended periods in dried sputum and is easily transmitted via droplet infections through coughing, sneezing, or speaking (Lusiani, 2019). Frequent contact with active TB patients increases the risk of transmission to healthy individuals.

The study also showed that certain DM-related factors were not associated with pulmonary TB in DM patients in Aceh Besar. These factors include poor DM self-management (OR=1.00; 95% CI=0.34–2.90; p-value=1.000), duration of DM (OR=0.99; 95% CI=0.90–1.08; p-value=0.925), and family history of DM (OR=1.90; 95% CI=0.86–4.22; p-value=0.112). These findings align with Lusiani (2019), who reported no significant relationship between DM treatment history, duration of DM, or TB contact history with pulmonary TB incidence in type 2 DM patients.This could be due to many patients being diagnosed with DM only after developing pulmonary TB or during glucose testing prompted by their TB diagnosis (Yosephine et al., 2021). The findings also align with Nasruddin et al. (2017), who found no correlation between DM duration and pulmonary TB incidence in DM patients.However, the study contradicts Lusiani (2019), who demonstrated a relationship between DM management practices and TB incidence in type 2 DM patients. Positive DM management can improve health behaviors and reduce TB risk among DM patients (Lusiani, 2019). Similar findings were reported by Sasmita et al. (2019) and Irawan (2020), who identified a relationship between family history of DM and TB incidence in DM patients.

The rising prevalence of DM contributes to an increased TB incidence due to weakened cellular immunity. DM patients exhibit reduced T lymphocyte and neutrophil counts, along with decreased T-helper 1 (Th1) lymphocytes and inflammatory mediators like TNF-α, IL-1β, and IL-6. A decline in Th1 lymphocytes makes DM patients more susceptible to TB, as these cells are crucial for controlling and inhibiting Mycobacterium tuberculosis growth. Furthermore, macrophage dysfunction in DM patients reduces reactive oxygen species production, chemotaxis, and phagocytic activity (Abbas, 2022).The heightened TB risk in DM patients may be linked to defects in immune cell function and host defense mechanisms. Although the underlying mechanisms remain unclear, hypotheses suggest that cytokines play a key role in human defense against TB. DM patients, particularly those with poor glycemic control, also exhibit reduced leukocyte bactericidal activity (Christie Y. Jeon & Megan B. Murray, 2008). According to Wang et al. (2009), the increased TB risk in DM patients is likely due to defects in alveolar macrophages or T lymphocytes, along with a higher prevalence of mature alveolar macrophages in active pulmonary TB patients.

Researchers believe that TB incidence in DM patients can be attributed to direct contact with TB patients. The weakened immune systems of DM patients make them more susceptible to

M. tuberculosis infection. Additionally, a family history of TB increases the risk of transmission, especially when family members live in unhealthy physical environments or spend extended periods at home due to unemployment, leading to more frequent direct contact with TB patients.

CONCLUSION

The factors associated with the incidence of pulmonary tuberculosis in diabetes mellitus (DM) patients in Aceh Besar include characteristics factors (medium education level and unemployment), health factors (unhealthy lifestyle, undernutrition, smoking, and unhealthy housing conditions), health system factors (poor quality of healthcare services), and diabetes-related factors (family history of TB and direct contact with TB patients). The most dominant factor associated with pulmonary tuberculosis in DM patients in Aceh Besar is smoking (OR=12.71; 95% CI=2.07–77.68; p-value=0.006).It is recommended that individuals, especially DM patients, quit smoking by engaging in physical activities or participating in beneficial activities to prevent smoking behavior. Smokers should also consider seeking support or consulting healthcare professionals to assist in quitting smoking.In addition, healthcare workers are encouraged to promote smoking cessation among DM patients to reduce the risk of tuberculosis infection. Healthcare providers should also conduct screenings in communities near TB patients when new cases are identified and work to increase the coverage of BCG vaccinations.

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