The Relationship between Type 2 Diabetes Mellitus and the Success of Tuberculosis Treatment

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Abstract
Tuberculosis (TB) is a major health burden in Indonesia, with comorbidity of type 2 diabetes mellitus (DM) further worsening treatment outcomes due to impaired immunity and drug effectiveness. This study aims to analyze the relationship between type 2 DM and TB treatment success at Waled Regional Hospital in Cirebon in 2024. Using a retrospective cross-sectional design based on secondary data from medical records and TB SITB in 104 pulmonary TB patients (total sampling of 507 cases, inclusion: complete records and completed treatment; exclusion: HIV/AIDS or resistant TB), univariate analysis described the demographic distribution, while bivariate analysis applied Fisher's Exact Test ($p<0.05$). The results showed a significant association ($p=0.006$), with treatment failure of 17.1% in TB-DM versus 1.6% in TB without DM, and treatment duration >6 months was dominant (70.7%) in TB-DM. Initial characteristics were elderly (46–55 years), housewives, females, elementary school education, and marital status. The study concluded that type 2 diabetes mellitus (DM) reduces TB treatment success through immunological and pharmacokinetic mechanisms; routine DM screening, strict glycemic control, and strengthening DOTS adherence are recommended for the 2030 TB elimination target.

Keywords: *Diabetes Mellitus, Tuberculosis Treatment, Therapy Success, TB-DM Comorbidity and Cross-Sectional Study.*

I. INTRODUCTION

Tuberculosis (TB) remains a significant global public health threat, caused by infection with the Mycobacterium tuberculosis bacteria, which is transmitted through airborne droplets when an infected person coughs, sneezes, or talks. According to the WHO's Global Tuberculosis Report 2024, there are an estimated 10.8 million new TB cases globally in 2023, with Indonesia ranking second after India, with approximately 1.09 million cases and 130,927 deaths. At the national level, TB contributes to the second-largest infectious cause of death after COVID-19, with a treatment success rate of 86.5% in 2023, still below the 90% target set by the Ministry of Health's Strategic Plan.

Comorbidity with type 2 diabetes mellitus (DM) further exacerbates the burden of TB, as DM weakens immunity through chronic hyperglycemia, tissue inflammation, and reduced effectiveness of antituberculosis drugs such as rifampin. Globally, DM risk factors contribute to the increasing prevalence of TB. In Indonesia, West Java province recorded 184,406 confirmed TB cases in 2023 with 3,979 deaths, followed by Cirebon Regency with 8,328 cases and 154 deaths. IDF 2021 data shows 19.5 million cases of DM in Indonesia, projected to increase to 28.9 million by 2045, with West Java recording 645,390 cases and Cirebon 14,055 cases in 2023.

Recent studies confirm that TB-DM comorbidity increases the risk of treatment failure, including drug resistance, extensive lung lesions, and higher mortality. For example, a study in Jakarta showed that 20.8% of TB patients who screened positive for DM had a cure rate of 86.3%, despite increased detection of TB-DM cases following co-management interventions. Internationally, a meta-analysis by Huangfu et al. (2019, updated in a 2022 study) found DM to be associated with TB treatment failure, particularly mortality and primary MDR-TB, while a study by Ahmad et al. (2020) in Malaysia reported that TB-DM patients had a threefold increased risk of failure compared to non-DM patients.

However, findings across studies are inconsistent; Yanti's (2017) study in Surabaya found a significant effect of DM on TB treatment success ($p=0.012$; OR=2.056), but was limited to a community health center (Puskesmas) context with a small sample size and predominantly demographic variables. Common limitations include a lack of focus on measuring treatment duration, geographic variations (e.g.,

Malaysia vs. Indonesia), and a lack of comprehensive analysis in regional hospitals such as RSUD. A recent study in Indonesia (2024-2025) also highlighted that optimal glycemic control improves TB-DM outcomes, but data specific to rural hospitals is scarce.

However, a significant research gap exists: most previous studies are general retrospective studies without exploring the specific relationship between type 2 diabetes mellitus (T2DM) and the duration and success of TB treatment in the context of regional hospitals in Indonesia in 2024, particularly at Waled Regional Hospital in Cirebon, which recorded a treatment success rate of 91.2% (Jan-Sep 2024). This gap is exacerbated by the lack of local empirical data integrating drug resistance and adherence factors in TB-DM patients. Therefore, the research question is formulated as follows: "What is the relationship between type 2 diabetes mellitus and the success of tuberculosis treatment at Waled Regional Hospital in Cirebon in 2024?"

This study aims to analyze the general impact of type 2 DM on TB treatment success, with the specific objective of determining the number of TB-DM patients, the success rate of TB-DM treatment, and their relationship. The urgency is pressing given Indonesia's 2030 TB elimination target and the soaring burden of TB-DM comorbidities in West Java. The novelty lies in the specific cross-sectional design of Waled Regional Hospital that includes the variable of treatment duration—different from the studies of Ahmad et al. (focusing on general outcomes) and Yanti (health center context). Its theoretical contribution enriches the literature on TB-DM in rural hospitals, while its practical contribution provides co-management recommendations for the national DOTS and TOSS TB programs.

II. METHOD

This study employed a quantitative approach with a retrospective, cross-sectional observational design based on secondary data, allowing for data collection at a single point in time to analyze the association between type 2 diabetes mellitus and tuberculosis treatment success without researcher intervention. This approach aligns with the basic principles of health research methodology, emphasizing efficiency and replicability, as outlined by Sugiyono (2023) in his framework for cross-sectional designs for infectious disease comorbidity studies. Furthermore, this design has proven effective in similar studies of TB-DM outcomes in Indonesian hospitals, as reported by Pradipta et al. (2022) and Restrepo et al. (2024), demonstrating the power of bivariate analysis of medical record data to detect risk associations. A foundation in clinical pathology and pulmonary disease strengthens this study's focus on the immunological mechanisms and pharmacokinetics of antituberculosis drugs.

The target population of the study included all pulmonary tuberculosis patients registered at Waled Regional Hospital, Cirebon Regency, while the accessible population was limited to pulmonary outpatients from January 1 to December 31, 2024, with a total of 507 potential medical records. A total sampling technique was applied to ensure full representation of the accessible population who met the criteria, resulting in a final sample of 104 patients after screening for inclusion (complete medical records and treatment completion by December 31, 2024) and exclusion (diagnosis of HIV/AIDS or drug-resistant TB). This selection was based on Sudaryono's (2022) recommendation regarding total sampling for limited populations to avoid selection bias, and supported by cross-sectional studies in regional hospitals such as those conducted by Wijaya and Susanto (2023), which emphasized the exclusion of confunder comorbidities for inferential validity.

The primary research instrument was secondary data from patient medical records and the Indonesian Tuberculosis Information System (SITB), with the independent variable of type 2 diabetes mellitus operationally defined as a history of DM based on high HbA1c (nominal scale: with DM/without DM), and the dependent variable of tuberculosis treatment success as the final outcome (success/complete versus failure; nominal scale). The data extraction process involved cross-validation between sources to minimize input errors, in accordance with Emzir's (2021) protocol on the reliability of secondary data in medical research. This approach aligns with recent journal findings such as Baker et al. (2023), which demonstrated a 95% accuracy rate in digital medical records for comorbid TB studies, and Tambunan et al. (2024), which emphasized the usefulness of SITB in measuring treatment outcomes.

The research procedure began with a preparatory phase with a consultation with a supervisor, preliminary study, hypothesis formulation, and variable determination, followed by an ethical clearance application on January 24, 2025 (number 000.9.2/124/KEPK/I/2025) and coordination with the medical records department of Waled Regional Hospital. The main implementation included the gradual collection of secondary data from January to March 2025, with editing, coding, processing, tabulating, entry, and cleaning of the data to ensure quality. The final phase involved analysis and report preparation, following the chronological flow recommended by Sugiyono (2023) for replicability, and supported by a retrospective protocol in TB studies as reported by Nugroho and Hartati (2022).

Data analysis was conducted in stages, starting with univariate analysis to describe the frequency distribution of variables (e.g., proportion of TB-DM patients and treatment success rate) using tables and percentages. Inferential bivariate analysis applied the nonparametric Chi-Square test to examine the association between type 2 DM and treatment success, with Fisher's Exact Test as an alternative if the Chi-Square assumption (cell frequency ≥5) was not met; the significance threshold was set at $p<0.05$. Data processing used SPSS version 26 software, according to Sudaryono's (2022) standards for categorical analysis of medical record data, and has been validated in the context of TB-DM by studies such as Phung et al. (2024) and Indrasari et al. (2023).

Ethical considerations for the study included anonymity of patient data, confidentiality of personal information in accordance with the Helsinki principles, and no direct contact with subjects to avoid risks. Approval was obtained through ethical clearance from the Health Research Ethics Committee of Waled Regional Hospital, ensuring compliance with national regulations of the Indonesian Ministry of Health. This approach aligns with Emzir's (2021) guidelines and recent journal recommendations, as outlined by Setiawan et al. (2025), which emphasize ethical transparency in medical record studies to implicitly protect participants' rights.

III. RESULTS AND DISCUSSIONS

Univariate Analysis

Table 1. Age characteristics of TB patients

No	Age	TB-DM incidents			
		DM		No DM	
		N	%	N	%
1	Late teens 17-25 years old	0	0%	9	14.3%
2	Early adulthood 26-35 years	0	0.00%	13	20.6%
3	Late adulthood 36-45 years	3	7.3%	6	9.5%
4	Early elderly 46-55 years	21	51.2%	17	27%
5	Late elderly 56-65 years	9	22.0%	12	19.0%
6	Elderly (senior citizens) >65 years	8	19.5%	6	9.5%
Total		41	100.00%	63	100.00%

Based on Table 1 above, it shows that of the 41 patients in the DM group, the most common age was in the early elderly age group of 46-55 years, namely 21 patients (51.2%), while of the 63 respondents in the non-DM group, the most common age was in the early elderly age group of 46-55 years, namely 17 patients (27%).

Table 2. Gender characteristics of TB patients

No	**Work**	**TB-DM incidents**			
		DM		**No DM**	
		N	**%**	**N**	**%**
1	Laborer	6	14.6%	12	19.0%
2	Trade	2	4.9%	1	1.6%
3	Self-employed	8	19.5%	18	28.6%
4	Teacher	1	2.4%	1	1.6%

5	Private sector employee	1	2.4%	2	3.2%
6	Students	1	2.4%	2	3.2%
7	Doesn't work	2	4.9%	7	11.1%
8	civil servant	1	2.4%	0	0.00%
9	housewife	**19**	**46%**	20	31.7%
	Total	41	100.00%	63	100.00%

Based on Table 2. above, of the 41 patients in the DM group, the most common gender was female, with 25 patients (61.0%), while of the 63 respondents in the non-DM group, the most common gender was male, with 35 patients (55.6%).

Table 3. Occupational characteristics of TB patients

No	Gender	TB-DM incidents			
		DM		No DM	
		N	%	N	%
1	Man	16	39.0%	35	55.6%
2	Woman	**25**	**61.0%**	28	44.4%
	Total	41	100.00%	63	100.00%

Based on Table 3. above, it shows that of the 41 patients in the DM group, the most jobs were obtained by housewives, namely 19 patients (46%), while of the 63 respondents in the non-DM group, the most jobs were obtained by housewives, namely 20 patients (31.7%).

Table 4. Characteristics of Educational History in TB Patients

No	Educational background	TB-DM incidents			
		DM		No DM	
		N	%	N	%
1	Elementary School	**30**	**73.2%**	41	65.1%
2	Junior High School	5	12.2%	10	15.9%
3	Senior High School	5	12.2%	12	19.0%
3	D1	1	2.4%	0	0.00%
	Total	41	100.00%	63	100.00%

Based on Table 4. above, it shows that the 41 patients in the DM group had the highest educational history of elementary school, with 30 patients (73.2%), while of the 63 respondents in the non-DM group, the highest educational history was elementary school, with 41 patients (65.1%).

Table 5. Characteristics of marital status in TB patients

No	Marital status	TB-DM incidents			
		DM		No DM	
		N	%	N	%
1	Marry	**40**	**97.6%**	46	73.0%
2	Not married	0	0.00%	14	22.2%
3	Divorced	1	2.4%	3	4.8%
	Total	41	100.00%	63	100.00%

Based on Table 5. above, it shows that the 41 patients in the DM group had the highest marital status of 40 patients (97.6%) being married, while of the 63 respondents in the non-DM group, the highest marital status was 46 patients (73.0%).

Table 6. Characteristics of case categories in TB patients

No	Case Categories	TB-DM incidents			
		DM		No DM	
		N	%	N	%
1	New	**39**	**95.1%**	60	95.2%
2	Relapse	2	4.9%	3	4.8%
	Total	41	100.00%	63	100.00%

Based on Table 6. above, it shows that 41 patients in the DM group obtained the category of cases with the most new cases, namely 39 patients (95.1%), while from 60 respondents in the non-DM group, the category of cases with the most new cases was 60 patients (95.2%).

Table1. Characteristics of the final results of treatment in TB patients

No	Final Results of Treatment	TB-DM incidents			
		DM		No DM	
		N	%	N	%
1	Succeed	**34**	**82.9%**	62	98.4%
2	Fail	7	17.1%	1	1.6%
	Total	41	100.00%	63	100.00%

Based on Table 7. above, it shows that 41 patients in the DM group obtained the most successful final treatment results, namely 34 patients (82.9%), while from 63 respondents in the non-DM group, the most successful final treatment results were obtained, namely 62 patients (98.4%).

Table 8. Characteristics of the duration of treatment in TB patients

No	Treatment Duration	TB-DM incidents			
		DM		No DM	
		N	%	N	%
1	<6 Months	0	0.00%	2	3.2%
2	6 months	12	29.3%	38	60.3%
3	>6 Months	**29**	**70.7%**	23	36.5%
	Total	41	100.00%	63	100.00%

Based on Table 8. above, it shows that 41 patients in the DM group obtained a maximum treatment duration of >6 months for 29 patients (70.7%), while of the 63 respondents in the non-DM group, 38 patients (60.3%) obtained a maximum treatment duration of 6 months.

Bivariate Analysis

Table 9. Relationship between Type 2 DM and TB treatment success

No	Characteristics	Final Results of Treatment				Total		*p*
		Succeed		Fail				
		N	%	N	%	N	%	
1	DM	34	32.7%	7	6.7%	41	39.4%	0.006
2	No DM	62	59.6%	1	1%	63	60.7%	
	Total	96	92.3%	8	7.7%	104	100%	

Based on the Table**9.**The Fisher test to determine the relationship between Type 2 DM and TB treatment success yielded a p-value of 0.006 ($p<0.05$). This study indicates a significant association between Type 2 DM and TB treatment success.

IV. DISCUSSION

Univariate analysis showed that the most dominant age group in tuberculosis (TB) patients in both groups, namely TB with diabetes mellitus (DM) and TB without DM, was the early elderly aged 46–55 years, with a proportion of 51.2% in the TB-DM group and 27% in the TB-without DM group (Pangaribuan et al., 2020). This finding is in line with research by Pangaribuan et al. (2020) which stated that increasing age is correlated with a higher risk of developing TB, because the decline in body immunity with age makes individuals more susceptible to infection. The telomere shortening theory explains this phenomenon, where telomere shortening due to repeated mitotic divisions causes cellular aging, which in turn disrupts lymphocyte function and weakens the overall immune response (Purwaningsih, 2013; Mustofa, 2017).

In the DM patient group, early elderly individuals aged 46–55 years also dominated at 51.2%, consistent with the findings of Komariah and Rahayu (2020) who linked the risk of DM in those over 45 years of age to decreased physical activity, increased body weight, and progressive shrinkage of pancreatic β cells. Furthermore, there were differences in occupational characteristics and gender between groups; in TB-DM, housewives (IRT) dominated (46%) and the majority were women (61%), in line with Nur et al. (2022)

who found that women and IRT were at higher risk due to household environmental exposure, such as caring for sick family members. Conversely, the TB-without-DM group was dominated by men (55.6%), as reported by Pangaribuan et al. (2020) who linked smoking habits in men with higher TB susceptibility.

Occupational and gender characteristics in DM patients were also prominent in housewives (46%) and women (61%), which supports Siburian et al. (2024) that light housework contributes to insulin dysregulation and increased blood sugar levels. Similarly, Susanti et al. (2024) confirmed a higher risk of DM in women due to a higher body mass index (BMI), insulin resistance, and hormonal influences such as premenstrual syndrome that facilitate fat accumulation. Regarding education, elementary school graduates were the highest in TB-DM (73.2%) and TB-without-DM (65.1%), in accordance with Nurjannah et al. (2022) who linked low education with poor health behaviors and non-adherence to TB treatment. In DM patients, a similar proportion (73.2%) is in line with Pahlawati and Nugroho (2019), where low education is correlated with unhealthy eating patterns and lack of awareness of a healthy lifestyle.

Marital status in TB patients showed a predominance of those who were married (97.6% in TB-DM and 73% in TB-without DM), which is consistent with Talarima et al. (2021) that household interactions increase TB transmission through household exposure. Treatment outcome characteristics revealed 82.9% treatment success with a treatment duration of >6 months (70.7%) in TB-DM, compared to 98.4% success with a treatment duration of 6 months (60.3%) in TB-without DM, in line with Qoyyima et al. (2020) who stated that delayed sputum conversion in TB-DM results in longer treatment and a higher risk of failure.

Bivariate analysis in 104 TB patients confirmed a significant association between type 2 DM and TB treatment failure, with a p-value of 0.006 from Fisher's Exact Test ($p<0.05$), where treatment failure was highest in the TB-DM group. These results are supported by the meta-analysis by Khattak et al. (2024) who reported a negative impact of DM on TB outcomes (HR 0.76; 95% CI 0.60–0.87; $p\leq0.01$), and Ahmad et al. (2020) who found a threefold risk of failure in TB-DM (95% CI 2.47–3.58; $p=0.0012$). The biological mechanisms include decreased cellular immunity in DM due to reduced T lymphocytes, neutrophils, and Th1 cytokines such as TNF-α, TNF-β, IL-1, and IL-6, which inhibit the control of Mycobacterium tuberculosis (Gotera et al., 2021).

Hyperglycemia in DM also impairs macrophage function through inhibition of phagocytosis, limiting the elimination of TB bacteria (Boadu et al., 2024). Other factors contributing to TB-DM treatment failure include antituberculosis drug (OAT) resistance due to bacterial mutations resulting from non-compliance (Saputra et al., 2022; Wuritimur & Kainama, 2025), extensive lung lesions due to weak immunity (Ayub et al., 2025; Layani et al., 2019), and decreased rifampicin concentrations, where a study by Kariman (2019) found plasma rifampicin levels <50% in TB-DM compared to 89% in TB-without-DM. Treatment adherence remains key, as it includes the correct dosage, medication schedule, and timely refills to prevent resistance.

V. CONCLUSION

This study concluded that there was a significant association between type 2 diabetes mellitus and the success of tuberculosis treatment in patients at Waled Cirebon Regional Hospital in 2024, with a p-value of 0.006 from Fisher's Exact Test, where the TB-DM group showed a higher treatment failure rate (17.1%) compared to TB without DM (1.6%), as well as a longer treatment duration (>6 months in 70.7% of TB-DM cases). Demographic characteristics such as early elderly age (46–55 years), housewife occupation, female gender, elementary school education, and marital status dominated both groups, reflecting the local population's vulnerability to this comorbidity. These findings strengthen the evidence that DM hyperglycemia impairs cellular immunity, macrophage phagocytosis, and rifampicin pharmacokinetics, thereby increasing the risk of drug resistance and extensive lung lesions.

However, limitations of the study include the use of secondary medical record data prone to incomplete recording, a cross-sectional design that does not allow causal inference, and the exclusion of resistant TB and HIV, which limits generalizability to complex cases. Suggestions for further research include prospective cohort studies with real-time HbA1c measurements, TB-DM co-management interventions, and larger sample sizes in multiple hospitals. Practically, these results recommend routine DM screening in TB patients,

optimization of glycemic control, and strengthening the DOTS program with adherence education to support Indonesia's 2030 TB elimination target.

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