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Exploring Diabetes Mellitus' Impact on Tuberculosis Outcomes: A Comprehensive Comparative Study

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ABSTRACT

Background: Tuberculosis (TB) remains among the top ten global causes of mortality, with approximately 1.3 million deaths annually. Diabetes elevates the risk of active TB and treatment failure, potentially increasing drug-resistant TB (DR-TB). This study aimed to compare treatment success rates between TB patients with and without diabetes mellitus (DM) at Dr. Ramelan Central Naval Hospital, Surabaya.
Subjects and Method: This cross-sectional study was conducted from January 2019 to December 2023 at Dr. Ramelan Central Naval Hospital Surabaya. A total of 158 patients with TB-DM and TB-NonDM were selected using total sampling. The independent variables were the Presence of Diabetes Mellitus in TB patients (TB-DM vs. Non-TB-DM). The dependent variable was the treatment success rate. The data were collected from patient medical records and analyzed using a chi-square test to compare treatment outcomes between TB-DM and TB-Non-DM patients.
Results: The analysis included 158 medical records. Predominantly affecting those over 45 years, both TB-DM and TB-Non-DM patients commonly underwent six months of treatment, with success rates of 78% in TB-DM and 82.4% in TB-Non-DM cases. The chi-square test yielded a p-value of 0.511, indicating no significant difference in treatment success between the groups. However, older age and HIV-positive status were associated with lower odds of treatment success.
Conclusion: Success rates were similar between the groups, showing no significant difference based on DM status. Despite similar success rates, older age and HIV-positive status were associated with lower odds of treatment success.

Keywords: Infectious disease, tuberculosis, diabetes mellitus, therapeutic outcomes

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BACKGROUND

Tuberculosis can be influenced by several risk factors, one of which is diabetes, in patients with TB-DM have a risk of developing active tuberculosis, and often those who receive treatment will experience failure and even cause a high potential for multidrug resistant TB (MDR-TB), one type of DR TB (Rahmaida et al., 2019) According to the Indonesian Ministry of Health in 2020, MDR-TB conditions are when Mycobacterium Tuberculosis bacteria resistant to Isoniazid and Rifampicin class drugs can be used simultaneously with or without being followed by other first-line anti-TB drugs (Ministry of Health RI, 2020). Diabetes mellitus in TB patients may increase the risk of MDR-TB. Factors contributing to this include the difficulty in controlling blood sugar, which can hinder the healing process, and the potential for some diabetes medications to inhibit TB drugs, leading to reduced drug effectiveness and MDR-TB reactivation (Rahmaida et al., 2019). TB patients with DM also have a high risk of poor prognosis. In addition, the of DM can reduce the effectiveness of anti-TB drugs (Pasipanodya et al., 2012; Putra et al., 2020)

The prevalence of DM in patients with tuberculosis varies between 5.6% and 14.8%. About 35-61% of these patients are diagnosed with DM after the initial diagnosis of tuberculosis (Nirahua et al., 2021). Tuberculosis cases based on World Health Organization data, among the 30 countries with the highest incidence of tuberculosis in 2019, Southeast Asia had the highest number of cases at 44%, followed by Africa at 25% and the Western Pacific at 18%. Tuberculosis infection is one of the leading causes of death worldwide. In 2019, approximately 10 million people worldwide were infected with tuberculosis, including 5.6 million men, 3.2 million women, and 1.2 million children, with the infection affecting all age groups worldwide. Treatment of pulmonary tuberculosis is a key indicator of the achievement of the tuberculosis control program in health services. The treatment success rate is 85% for the national target. Pulmonary TB patients who have received comprehensive treatment but do not meet the requirements for cure or failure are incomplete treatment patients. Pulmonary TB patients who have received comprehensive treatment and then undergo sputum reexamination at the end of treatment are considered complete treatment patients. As a result, patients will be entered into the Treatment Success Rate (TSR) registry once they declare that they have been cured and have completed the treatment (Ministry of Health RI, 2020; Pasha et al., 2024)

Diabetes mellitus may increase the risk of tuberculosis treatment failure, mortality, and relapse rates after long-term treatment (Baker et al., 2011). A cohort study in Maryland showed that DM affects pulmonary tuberculosis treatment outcomes. TB patients with DM experienced 6.7% treatment failure, while 4.1% of patients without DM experienced treatment failure. The mortality rate of TB patients with DM is 6.5 times higher than that of TB patients without DM. Therefore, a study comparing the treatment success rate of patients with DM and non-DM TB was conducted at Dr. Ramelan Central Naval Hospital in Surabaya, Indonesia.

In order to create focused therapy, it is crucial to know how well treatment works in a particular area. This study will not only improve scientific understanding of DM and TB cases, but will also provide valuable guidance for healthcare practices specifically designed for patients suffering from both diseases. Ultimately, the findings of this study may aid public health interventions, improve diagnosis and treatment, and ultimately decrease poor prognosis outcomes.

Therefore, This study aimed to compare treatment success rates between TB patients with and without diabetes mellitus (DM) at Dr. Ramelan Central Naval Hospital, Surabaya.

SUBJECTS AND METHOD

1. Study Design

This study employed an analytical observational research methodology with a cross-sectional design. The study was conducted retrospectively using secondary data obtained from the medical records of patients diagnosed with Tuberculosis with Diabetes Mellitus (TB-DM) and Tuberculosis without Diabetes Mellitus (TB-Non DM) at Dr. Ramelan Central Naval Hospital Surabaya. The data were collected from medical records spanning the period from January 2019 to December 2023. The data collection period for this research spanned from July to September 2024.

2. Population and Sample

The target population was all patients diagnosed with TB, with or without DM whose medical records were available and complete from 2019 to 2023 at Dr. Ramelan Central Naval Hospital Surabaya. Total sampling (census) was used to include all eligible patients within the specified time frame. A total of 158 patients with TB-DM and TB-Non DM were included in the study.

3. Study Variables

The independent variables were the Presence of Diabetes Mellitus in TB patients (TB-DM vs. Non-TB-DM). The dependent variable was the treatment success rate. The data were collected from patient medical records. The confounding variables were Age, gender, clinical symptoms, radiological images, AFB sputum results, and treatment duration.

4. Operational Definition of Variables

Diabetes Mellitus (DM): Diagnosed by the attending physician and documented in the patient's medical record, based on established clinical and laboratory criteria.

Tuberculosis (TB): Diagnosed based on clinical symptoms, and radiological findings, and confirmed by positive AFB (Acid-Fast Bacili) sputum results, as documented in the patient's medical record.

Treatment Success Rate: Defined as the documented outcome of TB treatment, categorized as "treatment completed," "cured," or "treatment failure," as recorded in the patient's medical record.

Age: Patient's age in years, as recorded in the medical record.

Gender: Patient's biological sex (male or female), as recorded in the medical record.

Clinical Symptoms: Documented symptoms related to TB, such as cough, fever, weight loss, and night sweats, as recorded in the medical record.

Radiological Images: Findings from chest X-rays or CT scans, as recorded in the medical record.

AFB Sputum Results: Results of sputum smear microscopy for acid-fast bacilli (AFB), as recorded in the medical record.

Treatment Duration: The total length of time, in months, that the patient received TB treatment, as recorded in the medical record.

5. Study Instrument

Data were obtained from patient medical records. The data included DM diagnosis, TB diagnosis, treatment duration, treatment success, clinical symptoms, radiological images, and AFB sputum results.

6. Data Analysis

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the characteristics of the study population. To assess the association between the presence of tuberculosis (TB-DM vs. TB-Non-DM) and treatment success rate, a Chi-square test or Fisher's exact test was applied as appropriate. Differences in continuous variables,

such as age and treatment duration, between groups were analyzed using an independent t-test. Additionally, logistic regression analysis was considered to evaluate the influence of confounding variables. Statistical significance was set at $p<0.050$, and all data analyses were conducted using SPSS software.

7. Research Ethics

This study utilized secondary data from medical records, ensuring patient anonymity and confidentiality. Ethical approval was obtained from the Health Research Ethics Committee of RSPAL dr. Ramelan Surabaya, with reference number: 77/EC/-KEP/2024.

RESULTS

1. Sample Characteristics

The study population, consisting of patients with TB-DM and TB-Non-DM, presented with the following demographic and clinical characteristics shown in Table 1. Understanding these sample attributes is vital for interpreting the study's conclusions and assessing their generalizability. The age group with the highest percentage of individuals in both the TB-DM and non-TB-DM groups was >45 years old. In the TB-DM group, 70% of the patients were older than 45 years, while in the non-TB-DM group, 44.4% of the patients were in this age category. This indicates a higher prevalence of older individuals in both groups, although the proportion is notably higher in the TB-DM group.

The majority of patients in both the TB-DM and non-TB-DM groups were male. Specifically, 58% of the patients in the TB-DM group were male, and 56.5% of the patients in the non-TB-DM group were male. This suggests a slight male predominance in both groups, which is a common finding in TB studies.

The most frequent treatment duration reported for patients with TB-DM and non-TB-DM was 6 months. A substantial proportion of patients in both groups completed their treatment within this timeframe, with 82% of TB-DM patients and 72.2% of non-TB-DM patients having a treatment duration of 6 months. This finding is important in the context of TB treatment guidelines, which often recommend a 6-month regimen for drug-sensitive TB.

There was a notable difference in sputum AFB test results between the two groups. Most patients with TB-DM had positive sputum AFB test results (78%), indicating a higher proportion of bacteriologically confirmed TB in this group. In contrast, most patients with non-TB-DM had negative sputum AFB test results (53.7%). This suggests that patients with DM and TB are more likely to have microbiologically confirmed TB compared to those without DM.

The majority of patients in both the TB-DM and non-TB-DM groups experienced treatment success, defined as improved/cured. The treatment success rate was 78% in the TB-DM group and 82.4% in the non-TB-DM group. This high treatment success rate in both groups is encouraging, highlighting the effectiveness of TB treatment interventions.

Table 1. Characteristic distribution of age, gender, treatment duration, sputum AFB result, treatment success

Variable	Patient Characteristic	TB - DM (n=50)		TB - Non DM (n= 108)	
		N	%	N	%
Age	< 20 Years	0	0.0	15	13.9
	20 - 45 Years	15	30.0	45	41.6
	> 45 Years	35	70.0	48	44.4

Variable	Patient Characteristic	TB - DM (n=50)		TB - Non DM (n= 108)	
		N	%	N	%
Gender	Male	29	58.0	61	56.5
	Female	21	42.0	47	43.5
Duration of Treatment	6 Months	41	82.0	78	72.2
	9 Months	6	12.0	13	12.0
	> 9 Months	1	2.0	14	13.0
	Loss to follow-up	2	4.0	3	2.8
AFB Sputum Result	Positive	39	78.0	50	46.3
	Negative	11	22.0	58	53.7
Treatment Success	Improved/Successful	39	78.0	89	82.4
	Death/Loss to Follow-up/Failure	11	22.0	19	17.6
Clinical Symptoms	Bloody cough and shortness of breath	20	40.0	20	18.5
	Coughing up blood, shortness of breath, and weight loss	11	22.0	31	28.7
	Coughing up blood, shortness of breath, weight loss, and coughing > 1 month	17	34.0	50	46.3
	Coughing up blood, shortness of breath, weight loss, coughing >1 month and chest pain	2	4.0	7	6.5
Radiological Features	Fibroinfiltrate/Infiltrate	26	52.0	74	68.5
	Pleural Effusion	4	8.0	5	4.6
	Consolidation of Both Lung Fields (Cavities)	12	24.0	6	5.6
	Increased Bronchovascular Pattern (BVP)	8	16.0	23	21.3
Status of HIV infection	Positive	7	14.0	1	0.9
	Negative	43	86.0	107	99.1
Treatment Success	Improved/ Success	39	78.0	89	82.4
	Failure (Loss to follow-up/Death)	11	22.0	19	17.6

2. Bivariate Analysis

This section presents the results of bivariate analyses comparing characteristics between the TB-DM and non-TB-DM groups. The chi-square test was used to compare the distribution of categorical variables between the two groups. Table 2 summarizes the comparison of several characteristics between TB-DM and non-TB-DM patients. There was no statistically significant difference between the TB-DM and non-TB-DM groups in clinical symptoms (p= 0.516), radiological features (p= 0.363), AFB sputum result (p= 0.242), or treatment success (p=0.511). However, there was a statistically significant difference in the duration of treatment between the two groups (p<0.001). This suggests that diabetes mellitus has a significant influence on the duration of TB treatment.

Table 2. Comparison of Several Characteristics between DM vs Non-DM TB patients (The value displayed is the p-value)

Status	Clinical Symptoms	Radiological Features	Duration of Treatment	AFB Sputum Result
DM	0.516	0.363	<0.001	0.242
Non DM	0.388	0.438	0.881	0.363

Note: *AFB: Acid-Fast Bacili

Table 3 shows the comparison of treatment success between DM vs Non-DM TB patients. PR = (Prevalence of failure in DM group) / (Prevalence of failure in the non-DM group) = (11/50) / (19/108) = 0.22 / 0.17 = 1.25 (p-value= 0.636; 95% CI= 0.82 to 1.78). The

prevalence ratio of 1.25 indicates that the prevalence of treatment failure (loss to follow-up/death) is 25% higher in the DM group compared to the non-DM group. Combined with the non-significant p-value, we conclude that the observed difference in prevalence is likely due to chance. With the 95% confidence interval of 0.82 to 1.78, the interval includes the value 1, suggesting that the range of plausible values for the true prevalence ratio includes the possibility of no difference between the groups.

Table 3. Comparison of Treatment Success between DM vs Non-DM TB patients

Status of Diabetes Mellitus Comorbid in TB patients	Improved/ Success	Failure (Loss to follow-up/ Death)	Total	95% CI		p
				Lower Limit	Upper Limit	
TB-DM	39	11	50	0.82	1.79	0.636
TB-Non DM	89	19	108			
Total	128	30	158			

3. Multivariate Analysis

This section presents the results of the multivariate analysis examining the factors associated with treatment success in patients with and without TB-DM. A multiple logistic regression analysis was conducted to determine the independent effect of TB-DM status on treatment success while adjusting for potential confounding variables.

The dependent variable in this analysis was treatment success (Improved/ Successful = 1, Death/Loss to Follow-up/Failure = 0). The independent variables included TB-DM status (TB-DM= 1, Non-TB-DM= 0), age (categorized as <20 years, 20-45 years, and >45 years), gender (Male= 1, Female= 0), and HIV status (Positive= 1, Negative= 0). Duration of treatment was not included in this model due to its potential collinearity with treatment success and the primary focus on the impact of TB-DM status. The analysis revealed that, after adjusting for age, gender, and HIV status, TB-DM patients did not have a statistically significant difference in the odds of treatment success compared to non-TB-DM patients (OR= 0.85; 95% CI= 0.50 to 1.20; p = 0.350).

Age was found to be a significant predictor of treatment success. Patients older than 45 years had lower odds of treatment success compared to those younger than 20 years (OR= 0.50; 95% CI= 0.30 to 0.80; p= 0.005). Gender was not significantly associated with treatment success (OR= 0.90; 95% CI= 0.60 to 1.30; p= 0.580). HIV-positive patients had significantly lower odds of treatment success compared to HIV-negative patients (OR= 0.25; 95% CI= 0.10 to 0.50; p < 0.001).

Table 4. Multiple Logistic Regression Analysis of Factors Associated with Treatment Success

Variable	OR	95% CI		p
		Lower Limit	Upper Limit	
TB-DM Status (vs. Non-TB-DM)	0.85	0.50	1.20	0.350
Age (>45 vs. <20 years)	0.50	0.30	0.80	**0.005***
Gender (Male vs. Female)	0.90	0.60	1.30	0.580
HIV Status (Positive vs. Negative)	0.25	0.10	0.50	**<0.001***

DISCUSSION

The study population consisted of patients with TB-DM and non-TB-DM. An understanding of the sample's demographic and clinical characteristics is crucial for the interpretation of the study's findings and the assessment of their generalizability. The age group with the highest percentage of individuals in both the TB-DM and non-TB-DM groups was >45 years old. In the TB-DM group, 70% of the patients were older than 45 years, while in the non-TB-DM group, 44.4% were in this age category. This indicates a higher prevalence of older individuals in both groups, although the proportion is notably higher in the TB-DM group. These findings are consistent with previous research conducted by Arlinda et al., 2017 in Java and Bali, which also reported a higher prevalence of TB in middle-aged and older adults. Yanti (2017) also found that 31% of TB-DM patients were between 46-55 years old. The increased likelihood of developing TB in older individuals may be attributed to physiological changes, particularly in lung tissue, which can impair the body's defense system. Uncontrolled hyperglycemia in older DM patients can further contribute to pulmonary TB. The risk of reactivation of tuberculosis is also higher in older individuals due to increased susceptibility related to anatomical and physiological changes, comorbidities, and nutritional deficiencies. Furthermore, the reactivation of latent tuberculosis infection in older adults can be triggered by age-related decline in immune function, making it essential to consider this population's unique needs in TB prevention and control strategies.

The age factor is always important for TB patients as increasing age increases the likelihood of developing bacterial infections, including Mycobacterium tuberculosis. This can be caused by physiological changes that occur in the body, especially in the lung tissue. Changes in lung tissue impact the body's barrier or defense system. This will have an impact on how the bacteria are cleared in the body's respiratory system. Uncontrolled hyperglycemia affects beta cell disorders. Improper blood sugar control factors in pulmonary TB in older DM patients (Asare-Baah et al., 2024). The risk of developing infections increases with age, especially serious infections, which increase the likelihood of reactivation of tuberculosis. This is due to increased susceptibility with age, which includes various anatomical and physiological changes associated with aging, comorbidities, and nutritional deficiencies (Caraux-Paz et al., 2021).

The majority of patients in both the TB-DM and non-TB-DM groups were male (58% and 56.5%, respectively). This observation aligns with other studies (Arlinda et al., 2017; Panggayuh et al., 2019) that have reported a higher risk of tuberculosis in men, potentially due to lifestyle factors such as smoking and alcohol consumption. Smoking damages the cilia, which reduces the ability of MTB to be expelled from the lung. This occurs due to several factors, one of which is that smoking increases the likelihood of TB co-infection because it interferes with macrophage function, which inhibits the removal of MTB from the lung (Sundari et al., 2023).

The most frequent treatment duration reported for patients with TB-DM and non-TB-DM was 6 months (82% and 72.2%, respectively). This is important considering the standard 6-month treatment regimen recommended for drug-sensitive TB. However, it's important to note that some studies suggest that a longer treatment duration may be necessary for TB-DM patients. Wang et al. (2015) suggested that anti-tuberculosis therapy in TB patients with DM should consider several factors. They found that patients who received 6 months of anti-TB

therapy had a higher recurrence rate compared to those who received 9 months of therapy, although this reduction was not statistically significant. The difference in treatment duration between 6 months and 9 months may be attributed to the complexity of TB-DM comorbidity, where longer treatment may be required to ensure complete recovery and prevent recurrence. The 9-month regimen may be considered for patients with more severe disease or those with a history of treatment failure, while the standard 6-month regimen may be sufficient for patients with less complex diseases. This highlights the importance of regular and routine drug intake for at least six months to cure TB.

There was a notable difference in sputum AFB test results between the two groups. Most patients with TB-DM had positive sputum AFB test results (78%), indicating a higher proportion of bacteriologically confirmed TB in this group. In contrast, most patients with non-TB-DM had negative sputum AFB test results (53.7%). This finding is consistent with Arlinda et al., (2017), who reported a higher prevalence of positive AFB results in TB-DM patients. However, it contrasts with studies by Annisa and Hastono (2019) and Dewi et al. (2020), which found a higher proportion of AFB-negative (-) TB patients. The AFB test results mentioned in this study refer to the initial diagnosis, and not to the results after 2 months of treatment or at the end of treatment. The AFB test is typically used to confirm the diagnosis of TB, and its results are used to guide treatment decisions. In this study, the AFB test results were used to classify patients as having bacteriologically confirmed TB or not. It's important to note that patients with positive AFB results have a higher potential to transmit TB. Longer AFB conversion and an increased risk of drug resistance may also be associated with TB-DM. The majority of patients in both the TB-DM and non-TB-DM groups experienced treatment success, defined as improved/ cured (78% and 82.4%, respectively). This high treatment success rate in both groups is encouraging, highlighting the effectiveness of TB treatment interventions.

Bivariate analysis revealed no statistically significant difference between TB-DM and non-TB-DM groups in clinical symptoms (p= 0.516), radiological features (p= 0.363), BTA sputum result (p= 0.242), or treatment success (p= 0.511). These findings regarding clinical symptoms align with Arlinda et al. (2017). That study reported that the most common clinical symptoms in both groups were cough lasting more than two weeks, weight loss, loss of appetite, shortness of breath, chest pain, and coughing up blood. It is important to note that some symptoms of DM and TB overlap, such as weight loss and fatigue, and that respiratory symptoms may be less prominent in TB patients with DM.

The findings regarding radiological features are also consistent with previous research. Studies by Ramadhanty et al., (2020) and Fachri et al., (2021) found that infiltrates were the most common radiological finding in both TB-DM and non-TB-DM patients, as was observed in this study. However, there was a statistically significant difference in the duration of treatment between the two groups (p= 0.000), suggesting that diabetes mellitus has a significant influence on the duration of TB treatment. It is essential to consider the multifaceted interplay between diabetes mellitus and tuberculosis when analyzing clinical outcomes and treatment efficacy (Yorke et al., 2017). While the bivariate analysis indicated no statistically significant differences in clinical symptoms, radiological features, or sputum results between the TB-DM and non-TB-DM groups, this does

not negate the potential for subtle variations in disease presentation (Baluku et al., 2021; Dousa et al., 2018; Heffernan et al., 2020).

The convergence of tuberculosis and diabetes epidemics has been shown to have significant impacts, with data indicating that individuals with diabetes have a notably increased risk of contracting tuberculosis (Adefuye et al., 2022; Crevel and Critchley, 2021; Solá et al., 2016). These findings underscore the necessity for clinicians to maintain a heightened awareness of the potential for TB in diabetic patients, and vice versa (Yorke et al., 2017).

Multivariate analysis revealed that, after adjusting for age, gender, and HIV status, there was no statistically significant difference in treatment success between TB-DM and non-TB-DM patients (OR= 0.85; 95% CI= 0.50 to 1.20; p= 0.350). This is consistent with studies by Putra et al. (2021) and Rosdiana and Rosdiana (2017) which also reported no significant difference in treatment success between the two groups.

Older age (>45 years) and HIV-positive status were significantly associated with lower odds of treatment success (Caraux-Paz et al., 2021b; Dewi et al., 2024; Tewelde-medhin et al., 2018). The association between older age and poorer TB treatment outcomes may be attributed to a multitude of factors. Physiological changes associated with aging, such as immunosenescence and decreased lung function, can impair the body's ability to combat Mycobacterium tuberculosis. Older patients often have comorbidities and may experience polypharmacy, which can complicate TB treatment and increase the risk of drug interactions and adverse events (Caraux-Paz et al., 2021). Additionally, social factors such as frailty, malnutrition, and limited access to healthcare can contribute to poorer outcomes in older TB patients.

HIV infection is a well-established risk factor for poor TB treatment outcomes. HIV weakens the immune system, making individuals more susceptible to TB infection and reactivation. HIV-associated immune deficiency disrupts the body's ability to control TB infection, leading to higher rates of treatment failure, relapse, and mortality (Dewi et al., 2024; Tiberi et al., 2017). Furthermore, drug-drug interactions between antiretroviral therapy (ART) and anti-tuberculosis drugs can pose challenges in TB-HIV co-infected patients. The findings of this study underscore the importance of close monitoring and tailored management strategies for older TB patients and those with HIV co-infection.

In conclusion, this study found no significant difference in the level of treatment success between TB patients with DM and non-DM at the Ramelan Central Naval Hospital Surabaya during the 2019-2023 period. The majority of patients with TB-DM and non-TB-DM achieved treatment success, defined as improved/cured. However, older age and HIV-positive status were associated with lower odds of treatment success. These findings highlight the importance of considering patient characteristics, particularly age and HIV status, in the management of TB patients, even though diabetes mellitus status did not independently predict TB treatment success in this study.

While this study provides valuable insights into the treatment success rates of patients with TB-DM and non-TB-DM, it is essential to acknowledge certain limitations that may influence the interpretation and generalizability of the findings.

Firstly, the study's scope was confined to a limited set of variables. The analysis focused on age, gender, clinical symptoms, radiological features, treatment duration, sputum BTA results, and treatment success. Although HIV infection status was included

in the study, the analysis did not explore its potential interactions with other variables in detail. The exclusion of other potentially relevant factors, such as comorbid diseases (including heart disease, hypertension, and chronic obstructive pulmonary disease), adherence to treatment regimens, immune status, socioeconomic conditions, and the potential for drug resistance, could limit the comprehensiveness of the assessment of factors influencing treatment outcomes.

Secondly, the study was conducted at the Ramelan Central Naval Hospital Surabaya. As a tertiary care level hospital, it caters to a specific patient population, often with more complex or severe cases. This may limit the generalizability of the findings to primary or secondary care settings, or regions with different patient demographics or healthcare infrastructure. Thirdly, the retrospective nature of the study design introduces inherent limitations. Retrospective studies are susceptible to recall bias and may be affected by incomplete or inaccurate data recording. This could potentially impact the reliability and validity of the study's findings.

Acknowledging these limitations is crucial for a balanced interpretation of the study's results. While the findings contribute valuable information to the existing body of knowledge, particularly within the context of a tertiary care setting, these limitations highlight the need for future research to address these gaps. Future studies should aim to incorporate a broader range of variables, include more diverse populations, and employ prospective study designs to provide a more comprehensive understanding of the factors influencing treatment outcomes in patients with TB-DM and non-TB-DM.

AUTHOR CONTRIBUTION

A.P.D. and R.P.A. were responsible for the study design, data collection, data analysis, and drafting of the manuscript. R.B., S., H.P., and O.N.P. contributed equally to the study. Specifically, R.B., H.P., and O.N.P. provided substantial contributions to the study design, data interpretation, and critical revision of the manuscript for important intellectual content. S., an expert in the field, contributed immensely to the improvement of the manuscript by providing critical insights and expertise on the topic.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest regarding the publication of this study.

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