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**Original Article**

# Tuberculosis treatment outcomes and associated factors: A retrospective study in West Nusa Tenggara, Indonesia

**Meiyanti Meiyanti[1,2*], Adang Bachtiar[3], Rina K. Kusumaratna[4], Arifah Alfiyyah[3], Machrumnizar Machrumnizar[5] and Pusparini Pusparini[6]**

[1]Philosophy Doctor in Public Health Program, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia; [2]Department of Pharmacology and Pharmacy, Faculty of Medicine, Universitas Trisakti, Jakarta, Indonesia; [3]Department of Health Policy and Administration, Faculty of Public Health, Universitas Indonesia, Depok, Indonesia; [4]Department of Public Health, Faculty of Medicine, Universitas Trisakti, Jakarta, Indonesia; [5]Department of Parasitology, Faculty of Medicine, Universitas Trisakti, Jakarta, Indonesia; [6]Department of Clinical Pathology, Faculty of Medicine, Universitas Trisakti, Jakarta, Indonesia

*Corresponding author: meiyanti@trisakti.ac.id

## Abstract

Successfully treating tuberculosis (TB) could significantly help reduce its spread. The aim of this study was to identify factors associated with successful TB treatment. A retrospective study was conducted in West Nusa Tenggara, Indonesia, using data from the National TB Information System (SITB) covering patients from January 1 to December 31, 2022. Patients were classified into two groups: those with successful treatment outcomes (cured or completed treatment) and those with unsuccessful outcomes (including treatment failure, loss to follow-up, or death). Univariate and multivariate logistic regression analyses were performed to identify factors associated with treatment outcomes, providing odds ratios (OR) and adjusted odds ratios (aOR) with 95% confidence intervals (CIs). A total of 2,225 TB patients (1,382 males and 843 females) were included in the study. Of these, 2,048 (92.1%) achieved successful treatment outcomes. Univariate analysis indicated that older age (OR: 0.47; 95%CI: 0.28–0.78) and a high number of AFB in sputum smears (OR: 0.23; 95%CI: 0.09–0.66) were associated with a higher likelihood of unsuccessful TB treatment. In contrast, having no HIV infection (OR: 13.44; 95%CI: 6.22–29.08), clinical TB cases (diagnosed clinically rather than bacteriologically) (OR: 1.50; 95%CI: 1.04–2.20) and longer duration of TB treatments were associated with successful treatment outcomes. Multivariate analysis suggested that the TB treatment durations of 4–6 months (aOR: 1256.95; 95%CI: 431.89–3658.19) and 7–12 months (aOR: 575.5; 95%CI: 99.1–3342.06) were associated with a significantly higher likelihood of success compared to durations of 0–3 months. In conclusion, this study highlights that a minimum treatment duration of three months was crucial for increasing the likelihood of successful TB treatment. These findings emphasize the importance of comprehensive support programs to ensure adherence to treatment guidelines and improve outcomes.

**Keywords**: Tuberculosis, treatment success, patient, risk factors, Indonesia

## Introduction

Since 1991, the World Health Assembly has identified tuberculosis (TB), a preventable and curable infectious disease, as a major global health concern, leading to intensified international efforts for its effective management [1]. TB is classified into pulmonary TB, involving the lungs or



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tracheobronchial tree, and extrapulmonary TB, affecting organs outside the lungs, such as the pleura, lymph nodes, or abdominal area [2-4]. According to the World Health Organization (WHO), 87% of global TB cases in 2022 were concentrated in high-burden countries, including India (27%) and Indonesia (10%), where coronavirus disease 2019 (COVID-19) disruptions contributed to a >60% reduction in diagnosed TB cases from 2020 to 2021 [5]. The COVID-19 pandemic-related challenges threaten the global TB elimination goal, highlighting the need for robust TB control efforts. One of the United Nations Sustainable Development Goals (SDGs) aims to end the TB epidemic by 2030 [1,6]. WHO has set a TB treatment success rate target of 90% by 2025, emphasizing effective, prompt treatment initiation and adherence [7-9].

In West Nusa Tenggara, Indonesia, a lower-middle-income region with a population of 5 million, achieved a 91.4% TB treatment success rate in 2022 despite challenging socio-demographic conditions [10]. Treatment adherence and post-treatment factors, such as completion rate, mortality risk, and cure rate, are critical for evaluating TB program success and improving clinical outcomes [11-12]. Factors such as age, sex, alcohol use, smoking, sputum conversion results, and human immunodeficiency virus (HIV) status influence TB treatment success globally, with current rates still below the 85% target [13]. In many regions around the globe, treatment protocols fail to meet the standards necessary for curing TB patients and preventing the spread of drug-resistant *Mycobacterium tuberculosis* strains, an issue driven by various contributing factors [14]. The aim of this study was to assess TB treatment outcomes and the factors associated with treatment success among TB patients in West Nusa Tenggara, Indonesia. The findings of this study would be valuable for both local and national governments in reducing TB infection rates and improving knowledge to enhance successful treatment outcomes.

# Methods

## Study design and setting

A retrospective study was conducted in West Nusa Tenggara, Indonesia, utilizing data from the National TB Information System or *Sistem Informasi Tuberkulosis* (SITB) covering TB patients from January 1 to December 31, 2022. SITB, an application-based platform that records and reports TB cases across the country, is serving as a mandatory reporting tool for all healthcare stakeholders, including primary healthcare facilities, hospitals, independent practitioners, clinics, laboratories, and pharmacies. The data analyzed in this study pertained to TB treatment registrations, encompassing information on participants who sought treatment for TB and the outcomes of their treatments. This retrospective approach facilitated a thorough evaluation of treatment patterns and effectiveness, providing valuable insights into TB management in the region.

## Patients and criteria

This study included data from patients aged 19 years and older in West Nusa Tenggara diagnosed with TB. All patients were actively receiving anti-TB treatment during the study period, with comprehensive data securely stored in the SITB database. Patients were excluded from the analysis if their records contained incomplete information, defined as any missing values in the following variables: age, sex, the year of treatment initiation, or treatment outcomes (cured, completion, treatment failure, and death).

## Data collection processes

Data for this study were sourced from the SITB encompassing multiple datasets. The first dataset included the sociodemographic variables of patients. The second, the healthcare utilization database, contained data from TB screenings, TB type, sputum smear results, chest X-ray findings, and relevant comorbidities, specifically HIV infection and diabetes.

To have a better understanding of the TB treatment outcomes among the patients, the outcomes were classified into five categories (cured, treatment completed, failed, lost to follow-up, and died) based on the modified 2021 WHO definitions and the National TB Control Program [15]. Patients were classified as 'cured' if they began treatment with a bacteriologically confirmed

strain and completed the regimen without evidence of treatment failure. 'Treatment completed' referred to patients who adhered to the prescribed TB regimen until the end but did not meet the criteria for cure or experienced treatment failure. 'Treatment failure' was defined as a regimen that was permanently halted or changed due to lack of clinical improvement or due to the presence of adverse reactions. Patients classified as 'died' for any reason when the patient has been registered in SITB included those who passed away for any reason, either during treatment or before initiating treatment. Individuals were classified as 'lost to follow-up' if they missed eight consecutive weeks of TB treatment after starting the regimen [10]. Patients who were registered in the SITB database but had not yet begun treatment were not included in this category. Additionally, when a definitive treatment outcome could not be determined, typically due to patient transfer to another facility, the outcome was recorded as 'not evaluated. These two categories were excluded from the study.

## Study variables

The dependent variable in this study was the treatment outcomes that were classified as successful or unsuccessful based on WHO criteria [15]. A successful treatment outcome was defined when a patient was either cured of TB or has resolved all TB-related symptoms, demonstrated by a negative smear microscopy result at the end of treatment and during follow-up evaluations (i.e., cured and treatment completed groups). An unsuccessful treatment outcome included patients who continued to show TB-related symptoms after treatment, as evidenced by a positive smear result after five months, along with those who were lost to follow-up or who died due to TB-related complications (i.e., failed, lost to follow-up, and died groups).

To have a better understanding of factors associated with treatment outcomes; plausible associated variables (independent variables) were collected and analyzed. The independent variables included were sex, age, type of healthcare facility, TB anatomical location, chest X-ray, sputum smear, type of diagnosis confirmation, rifampicin resistance, HIV status, diabetes status, and duration of treatment. Age was grouped into four groups: 19–34, 35–50, 51–65, and over 65 years. Healthcare facility type referred to whether the patient was treated at a primary healthcare center (first level of health facilities in Indonesia including community health centers (*Puskesmas*) and private clinics) or a secondary healthcare center (advanced referral health facilities such as hospitals). TB anatomical location was classified as either pulmonary TB or extrapulmonary TB (TB infection outside the lungs, such as in lymph nodes or bones). Chest X-ray results were classified as positive (indicating signs of TB), negative (no signs of TB), or not conducted (no X-ray performed). Sputum smear results were categorized as negative (no TB bacteria found), not conducted (test not performed), or graded based on bacterial load: 1–9 acid-fast bacilli (AFB), 1+, 2+, and 3+ based on the levels of bacterial presence [15-16]. Diagnosis confirmation was categorized as bacteriologically confirmed (confirmed through lab tests detecting TB bacteria) or clinical diagnosis (based on symptoms and clinical assessment without bacteriological test confirmation). Rifampicin resistance was assessed using molecular tests like GeneXpert or line probe assay, which detect genetic markers associated with resistance to rifampicin. HIV and diabetes status were recorded as either positive or present (yes) and negative or absent (no). Treatment duration was categorized into 0–3 months, 4–6 months, 7–12 months, and over 12 months.

## Statistical analysis

In this study, univariate logistic regression was used initially to assess the association of each independent variable with TB treatment outcomes individually, identifying those with significant relationships based on unadjusted odds ratios (OR) with 95% confidence intervals (95%CI) to be considered in the multivariate analysis. Variables with $p<0.05$ in univariate logistic regressions were then included in a multivariate logistic regression model, where the adjusted odds ratio (aOR) with their 95%CI was calculated. Statistical significance was considered with a $p<0.05$. All data analyses were conducted using STATA 16 (StataCorp LLC, College Station, USA).

# Results

## Characteristics of the patients

In total, 2,483 patients diagnosed with various forms of TB from SITB were collected in this study. Among these, 258 patients remained in treatment progress and were excluded. A total of 2,225 patients had complete data on treatment outcomes and were included in the analysis. The characteristics of the patients included in this study are presented in **Table 1**. The majority of patients were male (62.1%), with a peak age incidence between 35 and 50 years, accounting for 702 patients (31.5%). Primary healthcare centers were the main sites for TB management, providing care to 1,845 patients (82.9%). Among the 2,225 TB patients, 2,166 cases (97.4%) had pulmonary TB and a notable proportion of patients, 1,176 (52.8%), did not undergo chest X-ray examinations. Out of the total, 1,604 (72.1%) had bacteriologically confirmed diagnoses and rifampicin-sensitive TB cases were confirmed in the vast majority of patients, with 2,216 patients (99.6%) showing no resistance. The prevalence of comorbidities was low, with 2,198 patients (98.8%) free of HIV and 2,004 patients (90.1%) without diabetes. The predominant treatment duration was 4 to 6 months, encompassing 92.1% of the total patients (**Table 1**).

Table 1. Characteristics and clinical characteristics of the TB patients included in this study (n=2,225)

| Characteristic | Frequency | Percentage |
|---|---|---|
| Sex | | |
| Male | 1382 | 62.1 |
| Female | 843 | 37.9 |
| Age (year) | | |
| 19–34 | 637 | 28.6 |
| 35–50 | 702 | 31.5 |
| 51–65 | 642 | 28.9 |
| >65 | 244 | 11.0 |
| Healthcare facility | | |
| Secondary healthcare | 380 | 17.1 |
| Primary healthcare | 1845 | 82.9 |
| Anatomical location | | |
| Pulmonary TB | 2166 | 97.4 |
| Extrapulmonary TB | 59 | 2.6 |
| Chest X-ray | | |
| Positive | 963 | 43.3 |
| Negative | 86 | 3.9 |
| Not conducted | 1176 | 52.8 |
| Sputum smear | | |
| Negative | 143 | 6.4 |
| Not conducted | 1821 | 81.8 |
| 1–9 | 8 | 0.4 |
| 1+ | 121 | 5.4 |
| 2+ | 76 | 3.4 |
| 3+ | 56 | 2.5 |
| Type of diagnosis confirmation | | |
| Bacteriological | 1604 | 72.1 |
| Clinical | 621 | 27.9 |
| Rifampicin resistance | | |
| Yes | 9 | 0.4 |
| No | 2216 | 99.6 |
| HIV status | | |
| Positive | 27 | 1.2 |
| Negative | 2198 | 98.8 |
| Diabetes status | | |
| Yes | 221 | 9.9 |
| No | 2004 | 90.1 |
| Duration of treatment | | |
| 0–3 months | 128 | 5.7 |
| 4–6 months | 2049 | 92.1 |
| 7–12 months | 44 | 2.0 |
| >12 months | 4 | 0.2 |
| Treatment outcome | | |
| Unsuccessful | 177 | 7.9 |
| Successful | 2048 | 92.1 |

## Treatment outcomes

The treatment outcomes of TB patients included in this study are presented in **Figure 1**. The overall treatment success rate was 92.1% (2048/2,225) of which 1083 (48.7%) achieved a cure, and 965 (43.4%) completed their treatment. The unsuccessful treatment rate, therefore, was 7.96% (177/2,225) of which 3.7% (83 patients) were lost to follow-up, 0.1% (3 patients) experienced treatment failure, and 4.1% (91 patients) died (**Figure 1**). This study indicated that the successful treatment outcomes from 2,225 patients were more than 90%.

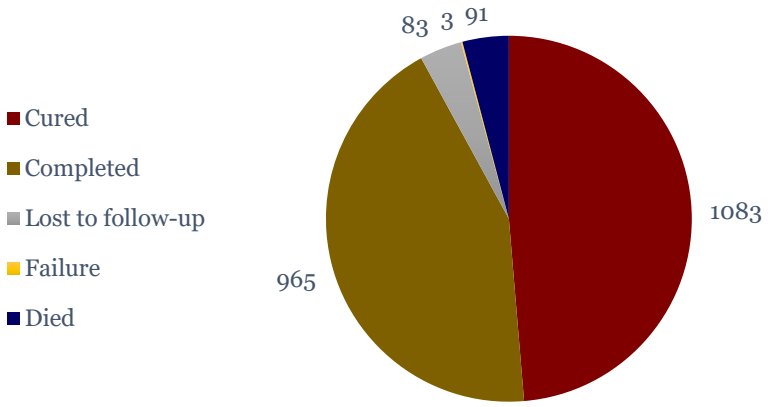


Figure 1. Treatment outcomes of the tuberculosis patients in West Nusa Tenggara, Indonesia, from National TB Information System (SITB), 2022 (n=2,225).

## Factors associated with successful TB treatment outcomes: Univariate analyses

Based on the treatment outcomes, patients were then categorized as either successful or unsuccessful. Successful outcomes included patients who were cured, demonstrating recovery based on bacteriological evidence, or who completed the prescribed treatment regimen with clinical improvement, even without bacteriological confirmation. Unsuccessful outcomes encompassed patients who were lost to follow-up, experienced treatment failure, or died during treatment. Univariate logistic regression showing factors associated with treatment outcomes among tuberculosis patients included in the study is presented in **Table 2**.

Our data indicated that older age and a higher number of AFB in sputum smear were associated with the chance of unsuccessful TB treatment (**Table 2**). Being HIV positive was significantly associated with unsuccessful TB treatment compared to those without HIV infection (OR: 13.44; 95%CI: 6.22–29.08). In addition, patients who were diagnosed clinically and those who received a longer duration of TB treatment had a higher chance of having successful TB treatment compared to patients diagnosed bacteriologically and those treated with a shorter treatment duration (**Table 2**).

Table 2. Univariate logistic regression showing factors associated with treatment outcomes among tuberculosis patients included in the study (n=2,225)

| Variable | Treatment outcomes | | Univariate analysis | |
|---|---|---|---|---|
| | Successful (n=2048) | Unsuccessful (n=177) | OR (95%CI) | *p*-value |
| | Frequency (%) | Frequency (%) | | |
| Sex | | | | |
| Male (*R*) | 1274 (62.2) | 108 (61.0) | | |
| Female | 774 (37.8) | 69 (39.0) | 0.95 (0.69–1.30) | 0.754 |
| Age (year) | | | | |
| 19–34 (*R*) | 599 (29.2) | 38 (21.5) | | |
| 35–50 | 654 (31.9) | 48 (27.1) | 0.86 (0.56–1.34) | 0.516 |
| 51–65 | 580 (28.3) | 62 (35.0) | 0.59 (0.39–0.90) | 0.015 |
| >65 | 215 (10.5) | 29 (16.4) | 0.47 (0.28–0.78) | 0.004** |
| Healthcare facility | | | | |
| Secondary healthcare (*R*) | 346 (16.9) | 34 (19.2) | | |
| Primary healthcare | 1702 (83.1) | 143 (80.8) | 1.17 (0.79–1.73) | 0.433 |
| Anatomical location | | | | |

| Variable | Treatment outcomes | | Univariate analysis | |
|---|---|---|---|---|
| | Successful (n=2048) | Unsuccessful (n=177) | OR (95%CI) | *p*-value |
| | Frequency (%) | Frequency (%) | | |
| Extrapulmonary TB (*R*) | 54 (2.6) | 5 (2.8) | | |
| Pulmonary TB | 1994 (97.4) | 172 (97.2) | 1.07 (0.42–2.72) | 0.881 |
| Chest X-ray | | | | |
| Positive (*R*) | 888 (43.4) | 75 (42.4) | | |
| Not conducted | 1081 (52.8) | 95 (53.7) | 0.96 (0.70–1.32) | 0.805 |
| Negative | 79 (3.9) | 7 (4.0) | 0.95 (0.42–2.14) | 0.907 |
| Sputum smear | | | | |
| Negative (*R*) | 136 (6.6) | 7 (4.0) | | |
| Not conducted | 1675 (81.8) | 146 (82.5) | 0.59 (0.27–1.29) | 0.185 |
| 1–9 | 7 (0.3) | 1 (0.6) | 0.36 (0.04–3.35) | 0.369 |
| 1+ | 114 (5.6) | 7 (4.0) | 0.83 (0.29–2.46) | 0.748 |
| 2+ | 70 (3.4) | 6 (3.4) | 0.60 (0.19–1.86) | 0.376 |
| 3+ | 46 (2.2) | 10 (5.6) | 0.23 (0.09–0.66) | 0.006** |
| Type of diagnosis confirmation | | | | |
| Bacteriological (*R*) | 1464 (71.5) | 140 (79.1) | | |
| Clinical | 584 (28.5) | 37 (20.9) | 1.50 (1.04–2.20) | 0.031* |
| Rifampicin resistance | | | | |
| Yes (*R*) | 8 (0.4) | 1 (0.6) | | |
| No | 2040 (99.6) | 176 (99.4) | 1.44 (0.18–11.65) | 0.727 |
| HIV status | | | | |
| Positive (*R*) | 13 (0.6) | 14 (7.9) | | |
| Negative | 2035 (99.4) | 163 (92.1) | 13.44 (6.22–29.08) | <0.001** |
| Diabetes status | | | | |
| Yes (*R*) | 202 (9.9) | 19 (10.7) | | |
| No | 1846 (90.1) | 158 (89.3) | 1.09 (0.67–1.81) | 0.710 |
| Duration of treatment | | | | |
| 0–3 months (*R*) | 4 (0.2) | 124 (70.1) | | |
| 4–6 months | 1998 (97.6) | 51 (28.8) | 1214.5 (431.9–3414.5) | <0.001** |
| 7–12 months | 42 (2.1) | 2 (1.1) | 651 (115.0–3683.3) | <0.001** |
| >12 months | 4 (0.2) | 0 (0.0) | 1 | |

*Statistically significant at $p$=0.05
**Statistically significant at $p$=0.01

## Factors associated with successful TB treatment outcomes: Multivariate analysis

All variables with $p$<0.05 in univariate analysis (age, sputum smear, type of diagnosis confirmation, HIV status, and duration of TB treatment) were included in multivariate analysis, and the results are presented in **Table 3**. Our data indicated that older patients (aged more than 65 years old) had a lower chance of having TB treatment success compared to those aged between 19 and 34 years (OR: 0.39; 95%CI: 0.16–0.97; $p$=0.043). In addition, there was a significant association between treatment duration and success of TB treatment of which patients receiving treatment for 4–6 months (aOR: 1256.95; 95%CI: 431.89–3658.19) and 7–12 months (aOR: 575.5; 95%CI: 99.1–3342.06) had a substantially higher likelihood of achieving treatment success compared to those treated for 0–3 months (**Table 3**).

Table 3. Multivariate logistic regression showing factors associated with treatment outcomes among tuberculosis patients included in the study (n=2,225)

| Variable | Treatment outcomes | | Multivariate analysis | |
|---|---|---|---|---|
| | Successful (n=2048) | Unsuccessful (n=177) | Adjusted odds ratio (95%CI) | *p*-value |
| | Frequency (%) | Frequency (%) | | |
| Age (year) | | | | |
| 19–34 (*R*) | 599 (29.2) | 38 (21.5) | | |
| 35–50 | 654 (31.9) | 48 (27.1) | 0.56 (0.27–1.19) | 0.135 |
| 51–65 | 580 (28.3) | 62 (35.0) | 0.63 (0.30–1.37) | 0.250 |
| >65 | 215 (10.5) | 29 (16.4) | 0.39 (0.16–0.97) | 0.043* |
| Sputum smear | | | | |
| Negative (*R*) | 136 (6.6) | 7 (4.0) | | |
| Not done | 1675 (81.8) | 146 (82.5) | 0.56 (0.12–2.63) | 0.469 |
| 1–9 | 7 (0.3) | 1 (0.6) | 4.01 (0.00–12131.9) | 0.734 |
| 1+ | 114 (5.6) | 7 (4.0) | 1.35 (0.16–11.30) | 0.782 |

| Variable | Treatment outcomes | | Multivariate analysis | |
|---|---|---|---|---|
| | Successful (n=2048) | Unsuccessful (n=177) | Adjusted odds ratio (95%CI) | *p*-value |
| | Frequency (%) | Frequency (%) | | |
| 2+ | 70 (3.4) | 6 (3.4) | 0.59 (0.076–4.61) | 0.618 |
| 3+ | 46 (2.2) | 10 (5.6) | 0.25 (0.04–1.76) | 0.166 |
| Type of diagnosis confirmation | | | | |
| Bacteriological (*R*) | 1464 (71.5) | 140 (79.1) | | |
| Clinical | 584 (28.5) | 37 (20.9) | 1.79 (0.87–3.70) | 1.794 |
| HIV status | | | | |
| Positive (*R*) | 13 (0.6) | 14 (7.9) | | |
| Negative | 2035 (99.4) | 163 (92.1) | 5.08 (0.80–32.47) | 0.085 |
| Duration of treatment | | | | |
| 0–3 months (*R*) | 4 (0.2) | 124 (70.1) | | |
| 4–6 months | 1998 (97.6) | 51 (28.8) | 1256.95 (431.8–3658.1) | <0.001** |
| 7–12 months | 42 (2.1) | 2) (1.1) | 575.5 (99.1–3342.1) | <0.001** |
| >12 months | 4 (0.2) | 0 (0.0) | 1 | |

*R:* reference group
*Statistically significant at $p$=0.05
**Statistically significant at $p$=0.01

## Discussion

This study identified a high treatment success rate (92.1%) among TB patients treated in West Nusa Tenggara, Indonesia. However, TB case findings remain below the national target, which requires efforts for early detection and more effective and optimal interventions to achieve TB elimination [10]. This gap reflects a persistent challenge in high TB-burden countries, suggesting that targeted public health interventions could further bolster case detection and improve overall treatment success [5].

Our univariate analysis identified age, diagnostic type, comorbid conditions, and treatment duration as factors influencing treatment outcomes. However, multivariate logistic regression underscored treatment duration as the only statistically significant predictor, emphasizing the critical role of prolonged therapy adherence for optimal TB management. Effective treatment outcomes are indicative of not only disease progression but also healthcare system efficiency, particularly in managing patient adherence, preventing default, and reducing transfer-out rates. These findings reinforce the importance of consistent patient follow-up and support mechanisms to sustain prolonged treatment adherence.

Sex disparities in TB treatment outcomes have been variably reported. While studies in Indonesia suggested higher success rates among male patients, studies from Finland, Ethiopia, Malaysia, India, China, and South Korea reported that male sex was associated with higher risks of unfavorable outcomes, including mortality [17-22]. In contrast, this study found minimal sex-based differences, likely attributable to the single-year data collection period, which may not fully capture the outcomes for all patients throughout an entire treatment cycle [23]. Additionally, age emerged as a significant factor in TB treatment outcomes, of which older patients had a higher failure rate of treatment. Other studies indicated that older age may increase susceptibility to TB recurrence [24-26]. However, some studies from urban settings reported a higher risk of unsuccessful treatment among middle-old adults (45–54 years) [21,27-31]. These differing findings suggest that age may act as a confounding variable in TB outcomes, warranting further investigation to determine age-related risks in treatment efficacy and long-term recovery [32-34].

Access to and affordability of TB services are essential for promoting adherence and achieving successful treatment outcomes [31]. Although the present study did not establish a direct correlation between healthcare facility access and TB outcomes, other studies have highlighted that the quality of care and facility accessibility can significantly impact treatment success rates [21,35-40]. Future studies evaluating TB service quality in relation to patient outcomes could provide a more comprehensive perspective on these determinants within the Indonesian healthcare system [32-33].

Diagnostic tools, particularly chest X-ray, play an increasingly critical role in active TB case finding and ensuring equitable access to care [38]. Abnormal chest X-ray findings, which are suggestive of TB, show a strong correlation with positive sputum smears and diagnostic confirmation [39]. Although chest X-ray findings were not directly associated with treatment

outcomes in our study, chest X-rays remain valuable for initial TB detection. When used in conjunction with molecular diagnostics, such as the Xpert test, chest X-rays enhance early detection capabilities and diagnostic accuracy, reinforcing their role in comprehensive TB management strategies [40]. Furthermore, sputum smear testing, valued for its high sensitivity and specificity, plays a critical role in monitoring bacteriologically confirmed pulmonary TB cases [41-45]. Routine smear assessments at two, five, and six months into treatment serve as important benchmarks for evaluating treatment progress and outcomes [43]. However, in this present study, the limited availability of comprehensive sputum smear data restricted our ability to fully assess the correlation between smear results and treatment success.

Comorbid conditions, particularly diabetes and HIV, significantly impact TB treatment outcomes. For instance, several studies have reported that TB patients with DM frequently experience higher rates of mortality and unsuccessful treatment outcomes, underscoring the complex challenges posed by diabetes in TB management [46-51]. Conversely, while HIV is typically associated with poorer TB outcomes, some studies indicate that patients with HIV can achieve favorable results when provided with consistent monitoring and support, as regular follow-up enhances treatment adherence [48-49,52-55]. These findings highlight the importance of integrated comorbidity management and ongoing healthcare provider support throughout the TB treatment process [53].

A minimum treatment duration of three months with consistent medication adherence was found to significantly improve the likelihood of treatment success, in line with standard TB treatment guidelines that emphasize prolonged adherence to fully eradicate infection and prevent recurrence or drug resistance. Rifampicin-resistant TB presents considerable challenges to successful treatment due to an elevated risk of treatment failure and relapse [56-58]. Recent studies suggest that shorter, optimized treatment regimens for rifampicin-resistant TB can improve outcomes [58-59]. Nevertheless, our study did not find any association between rifampicin resistance and TB treatment outcomes.

This study utilized the data from national surveillance, which may have limitations, such as reporting delays or biases, including underreporting of treatment outcomes in certain regions or among specific populations. These could affect the accuracy and generalizability of the findings. Although important factors were included in our analysis, other variables, such as socio-economic status and underlying health conditions, were not thoroughly explored. Future studies should incorporate a broader range of factors that could influence treatment success. Additionally, the data might reflect regional or local healthcare differences, which could limit the applicability of the findings to other regions with differing healthcare infrastructures.

## Conclusion

This study demonstrated that older age, a high number of AFB in sputum smears, and HIV infection were associated with a higher likelihood of unsuccessful TB treatment. In contrast, clinical TB cases (diagnosed clinically rather than bacteriologically) and a longer duration of TB treatment (more than three months) were associated with a higher likelihood of successful treatment outcomes. These findings highlight the need for tailored interventions to improve TB treatment outcomes, particularly for high-risk groups such as older patients, those with high AFB counts, and individuals with HIV infection. Enhanced monitoring, early detection of treatment challenges, and integrated care for co-infections like HIV could help mitigate these risks. Additionally, the positive association between extended treatment duration and successful outcomes underscores the importance of maintaining adherence to longer treatment regimens when clinically appropriate.

### Ethics approval

This study was approved by the Directorate General of Communicable Disease Prevention and Control, Ministry of Health Indonesia (PM.01.01/C.III/4651/2024). The ethics and review committee approved that informed consent was not applicable due to the retrospective nature of the study. All data were kept confidential and used only for the intended purpose.

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**Competing interests**

All the authors declare that there are no conflicts of interest.

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**Underlying data**

Derived data supporting the findings of this study are available from the corresponding author on request.

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