Research Article

Predictors of unsuccessful treatment outcomes among adults with pulmonary tuberculosis in a resource-limited setting

Tri Agus Yuarsa[1], Malehah Mohd Noh[2], Richard Avoi[3], Meryl Grace Lansing[2], Putra Agina Widyaswara Suwaryo[4]

Author Affiliation:

1. Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kinabalu, Malaysia.
2. Department of Medicine, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kinabalu, Malaysia.
3. Department of Public Health, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kinabalu, Malaysia.
4. Department of Nursing, Faculty of Health Science, Universitas Muhammadiyah Gombong, Kebumen, Central Java, Indonesia

Correspondence:
Tri Agus Yuarsa
agusyuarsa@yahoo.com

Submitted: June 2026
Accepted: June 2026
Published: August 2026

Citation: Yuarsa et al. Predictors of unsuccessful tuberculosis treatment outcomes in a resource-limited setting. South Sudan Medical Journal, 2026;19(3):172-178 DOI: https://dx.doi.org/10.4314/ssmj.v19i3.6

ABSTRACT

Introduction: Tuberculosis (TB) remains a major health burden in low- and middle-income countries, where successful treatment is central to control efforts. This study aimed to determine the predictors of unsuccessful TB treatment in a resource-limited setting.

Method: A retrospective, record-based study was conducted at a district general hospital in Banten Province, Indonesia, and included 231 adults with pulmonary TB who were registered between January 2020 and December 2023. Outcomes were classified as successful (cured or treatment completed) or unsuccessful (treatment failure, loss to follow-up, or death) according to WHO definitions. Factors associated with unsuccessful outcome were assessed using chi-square tests, and variables with $p < 0.25$ were entered into a multivariable logistic regression model.

Results: Of 231 patients, 34 (14.7%) had an unsuccessful treatment outcome, comprising 18 deaths, 11 lost to follow-up, and 5 treatment failures. Independent predictors of unsuccessful outcome were age ≥60 years (adjusted odds ratio [aOR] 2.81, 95% CI 1.14–6.92), underweight nutritional status (aOR 2.47, 95% CI 1.08–5.65), previously treated TB (aOR 3.56, 95% CI 1.39–9.11), and HIV-positive status (aOR 5.74, 95% CI 1.71–19.24). HIV-positive status demonstrated the strongest association with unsuccessful treatment outcome.

Conclusion: Older age, undernutrition, retreatment, and HIV co-infection independently predicted unsuccessful TB treatment outcomes in this district setting. These factors help frontline clinicians to identify high-risk patients early and target nutritional support, integrated TB-HIV care, and closer monitoring.

Keywords: pulmonary tuberculosis; treatment outcome; unsuccessful outcome; predictor; HIV

Introduction

Tuberculosis (TB) remains one of the most pressing global health challenges. TB returned to being the world's leading cause of death from a single infectious agent.[1] The burden is concentrated in low- and middle-income countries

(LMICs): just five nations accounted for 56% of global cases, with Indonesia ranking second and contributing an estimated 10% of the world's TB burden.[2,3] This concentration reflects the close link between TB and poverty, undernutrition, and constrained health systems, making the disease a defining condition of socioeconomic deprivation.[4]

Successful completion of treatment is the cornerstone of TB control and a key indicator tracked under the World Health Organization (WHO) End TB Strategy.[5] Unsuccessful outcomes comprising treatment failure, loss to follow-up, and death prolong infectiousness, facilitate the emergence of drug-resistant strains, and impose substantial costs on patients and health systems. Identifying patients at risk of unsuccessful outcomes early in their treatment course is therefore essential for targeting supportive interventions.[6,7] Although Indonesia reports a high national treatment success rate, this aggregate figure conceals considerable variation across regions and patient subgroups, and outcomes remain poorer among vulnerable populations.[8]

Most data on the determinants of TB treatment outcomes in Indonesia derive from national datasets or tertiary referral centres.[8,9] Far less is known about district-level hospitals, where the majority of patients are actually diagnosed and treated but where data are seldom reported and published. This represents an important gap, because the local determinants of unsuccessful treatment in a resource-limited district setting may differ from those identified in large, aggregated datasets and may be more directly actionable by frontline clinicians. The present study addresses this gap by examining treatment outcomes at a district hospital in Indonesia.

The aim of this study was to determine the predictors of unsuccessful TB treatment outcomes for pulmonary TB in a resource-limited district setting.

Method

This was a retrospective record-based study conducted at a district general hospital in Banten Province, Indonesia. The hospital is a referral facility for the surrounding district and provides TB diagnosis and treatment under the national TB programme. Banten is a densely populated province adjacent to greater Jakarta, with a mixed urban–rural population, representing a typical resource-limited district context.

All patients with pulmonary TB who were registered for anti-TB treatment at the hospital between 1 January 2020 and 31 December 2023 were included. Data extraction was performed only after treatment outcomes had been recorded in the TB register. Consequently, even patients registered at the end of 2023 were followed through routine programme records until a final treatment outcome was available, typically after completion of the standard treatment course. Inclusion criteria were: (1) a diagnosis of pulmonary TB (bacteriologically confirmed or clinically diagnosed) according to national guidelines; (2) age ≥ 18 years; and (3) a documented final treatment outcome in the medical records. Exclusion criteria were: (1) extrapulmonary TB only; (2) patients transferred out to another facility whose final outcome could not be ascertained; and (3) records with incomplete data on key variables.

Data were extracted from hospital medical records and/or the TB register using a standardised form. Information collected included demographic characteristics, clinical variables, and treatment outcomes. To ensure data accuracy, a proportion of entries were re-checked against the original medical records, and discrepancies were resolved through source-document verification.

The primary outcome was TB treatment outcome, classified according to WHO definitions. Outcomes were divided into successful (cured or treatment completed) and unsuccessful (treatment failure, lost to follow-up, or died).

The dependent variable was unsuccessful treatment outcome. Independent variables comprised age, sex, residence/address, body weight or nutritional status, TB classification (new or previously treated), bacteriological status (smear- or rapid molecular test-positive vs clinically diagnosed), HIV status, diabetes mellitus status, and treatment regimen category.

Statistical analysis

Data were analysed using SPSS version 30. Categorical variables were summarised as frequencies and percentages, and continuous variables as mean ± standard deviation. The distribution of continuous variables was assessed using the Shapiro–Wilk test and visual inspection of histograms. Variables with approximately normal distributions were presented as mean ± standard deviation. The association between each independent variable and unsuccessful treatment outcome was first assessed using the chi-square test for categorical variables. Variables with a p-value < 0.25 in bivariate analysis were entered into a multivariable logistic regression model to identify independent

predictors of unsuccessful outcome. Adjusted odds ratios (aOR) with 95% confidence intervals (CI) were calculated. A two-sided p-value ≤ 0.05 was considered statistically significant. Model performance was evaluated using the Hosmer–Lemeshow goodness-of-fit test and Nagelkerke's R^2. The overall classification accuracy of the model was also assessed.

Ethical Approval

Ethics approval was obtained from the Health Research Ethics Committee of Banten Regional General Hospital, protocol number 98/KEPK-RSUD/8/2024. Because this study used retrospective and anonymized data, the requirement for informed consent was waived. This study was conducted in accordance with the Declaration of Helsinki.

Results

A total of 254 patients with pulmonary TB were registered during the study period: 231 met the inclusion criteria for analysis. Twenty-three patients were excluded (8 extrapulmonary TB only; 6 transferred out with unknown outcome; 9 incomplete data) (Figure 1).

Of the 231 patients included, 197 (85.3%) had a successful treatment outcome (cured or treatment completed), 34 (14.7%) had an unsuccessful outcome, comprising 5 treatment failures, 11 lost to follow-up, and 18 deaths. The baseline characteristics of the study population are presented in Table 1.

The mean age was 46.8 ± 15.2 years, and 142 (61.5%) were male. Most patients were newly diagnosed cases (198; 85.7%), 33 (14.3%) had previously received TB treatment. The majority were bacteriologically confirmed (171; 74.0%), whereas 60 (26.0%) were clinically diagnosed. HIV positivity was identified in 12 patients (5.2%), and diabetes mellitus was present in 49 (21.2%). In bivariate analysis, age group (p = 0.018), nutritional status (p = 0.006), TB classification (p = 0.002), HIV status (p < 0.001), and diabetes mellitus (p = 0.097) were associated with unsuccessful treatment outcome (Table 2). Older age, underweight nutritional status, previously treated TB, and HIV positivity were associated with a greater proportion of unsuccessful outcomes.

The logistic regression model demonstrated acceptable fit to the data (Hosmer–Lemeshow χ^2 = 6.84, df = 8, p = 0.553). The model explained 28.7% of the variation in unsuccessful treatment outcomes according to Nagelkerke's R^2 (Cox & Snell R^2 = 16.8%) and correctly

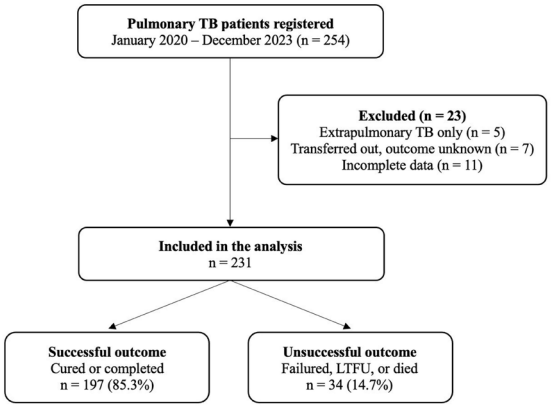

Figure 1. Flow diagram of patient selection. (LTFU = Lost to follow-up)

Table 1. Baseline characteristics of pulmonary TB patients and treatment outcomes (N = 231)

Variable	Category	n (%)
Age (years)	Mean ± SD	46.8 ± 15.2
	<40	87 (37.7)
	40–59	96 (41.6)
	≥60	48 (20.7)
Sex	Male	142 (61.5)
	Female	89 (38.5)
Residence	Urban	139 (60.2)
	Rural	92 (39.8)
Nutritional status	Underweight	102 (44.2)
	Normal/above	129 (55.8)
TB classification	New	198 (85.7)
	Previously treated	33 (14.3)
Bacteriological status	Confirmed	171 (74.0)
	Clinically diagnosed	60 (26.0)
HIV status	Positive	12 (5.2)
	Negative	201 (87.0)
	Unknown	18 (7.8)
Diabetes mellitus	Yes	49 (21.2)
	No	182 (78.8)
Treatment regimen	Category 1	206 (89.2)
	Category 2	25 (10.8)
Treatment outcome	Successful	197 (85.3)
	Unsuccessful	34 (14.7)

classified 86.1% of cases, indicating satisfactory predictive performance. In the multivariable logistic regression model, independent predictors of unsuccessful treatment outcome were age ≥60 years (aOR 2.81, 95% CI 1.14–6.92, p = 0.025), underweight nutritional status (aOR 2.47, 95% CI 1.08–5.65, p = 0.032), previously treated TB (aOR 3.56, 95% CI 1.39–9.11, p = 0.008), and HIV-positive status (aOR 5.74, 95% CI 1.71–19.24, p = 0.005) (Table 3). HIV-positive status demonstrated the strongest association with unsuccessful treatment outcome.

Discussion

In this retrospective record-based study of 231 patients with pulmonary TB treated at a district hospital in Indonesia, 14.7% experienced an unsuccessful treatment outcome. Four factors were independently associated with unsuccessful outcomes: age ≥60 years, underweight nutritional status, previously treated TB, and HIV-positive status, with HIV infection showing the strongest association. These findings identify readily measurable, routinely available characteristics that frontline clinicians can use to recognise patients at higher risk early in the treatment course.

The treatment success rate of 85.3% in this cohort fell just below the WHO End TB Strategy target of ≥90% and was broadly consistent with the national Indonesian figure of approximately 86%.[9] This suggests that, despite operating in a resource-limited district setting, the hospital achieved outcomes comparable to national performance, while still leaving a meaningful gap relative to the global target. Notably, deaths accounted for the largest share of unsuccessful outcomes (18 (53%) of 34), followed by loss to follow-up, a pattern that points to the clinical severity of cases rather than programmatic dropout alone.

HIV-positive status was the strongest independent predictor of unsuccessful outcome (aOR 5.74). This is consistent with a large body of evidence across high-burden settings. A six-year Ethiopian cohort reported substantially lower treatment success among TB-HIV co-infected patients than among HIV-negative patients,[10]

Table 2. Bivariate analysis of factors associated with unsuccessful TB treatment outcome

Variable	Category	Successful n (%)	Unsuccessful n (%)	p-value
Age	<40	80 (92.0)	7 (8.0)	0.018
	40–59	84 (87.5)	12 (12.5)	
	≥60	33 (68.8)	15 (31.2)	
Sex	Male	118 (83.1)	24 (16.9)	0.284
	Female	79 (88.8)	10 (11.2)	
Residence	Urban	121 (87.1)	18 (12.9)	0.391
	Rural	76 (82.6)	16 (17.4)	
Nutritional status	Underweight	79 (77.5)	23 (22.5)	0.006
	Normal/above	118 (91.5)	11 (8.5)	
TB classification	New	175 (88.4)	23 (11.6)	0.002
	Previously treated	22 (66.7)	11 (33.3)	
Bacteriological status	Confirmed	149 (87.1)	22 (12.9)	0.217
	Clinically diagnosed	48 (80.0)	12 (20.0)	
HIV status	Positive	6 (50.0)	6 (50.0)	<0.001
	Negative	177 (88.1)	24 (11.9)	
	Unknown	14 (77.8)	4 (22.2)	
Diabetes mellitus	Yes	37 (75.5)	12 (24.5)	0.097
	No	160 (87.9)	22 (12.1)	
Treatment regimen	Category 1	179 (86.9)	27 (13.1)	0.118
	Category 2	18 (72.0)	7 (28.0)	

Chi-square test was used for categorical variables. Variables with p < 0.25 were entered into the multivariable logistic regression model.

Table 3. Multivariable logistic regression of independent predictors of unsuccessful TB treatment outcome

Variable	aOR	95% CI	p-value
Age			
40–59 years (vs <40)	1.42	0.52–3.89	0.491
≥60 years (vs <40)	2.81	1.14–6.92	0.025
Nutritional status			
Underweight (vs normal/above)	2.47	1.08–5.65	0.032
TB classification			
Previously treated (vs new)	3.56	1.39–9.11	0.008
Bacteriological status			
Clinically diagnosed (vs confirmed)	1.48	0.61–3.60	0.385
HIV status			
Positive (vs negative)	5.74	1.71–19.24	0.005
Unknown (vs negative)	1.59	0.44–5.77	0.482
Diabetes mellitus			
Yes (vs no)	1.76	0.77–4.01	0.181
Treatment regimen			
Category 2 (vs Category 1)	1.94	0.69–5.43	0.207

aOR = adjusted odds ratio; CI = confidence interval. Variables with p < 0.25 in bivariate analysis were entered into the multivariable logistic regression model.

and a Cameroonian study found HIV positivity to be the strongest predictor of death during TB treatment.[11] The biological basis is well established: HIV-related immunosuppression increases the risk of disseminated disease, treatment complications, and mortality. The relatively high proportion of unsuccessful outcomes among the small number of HIV-positive patients in our cohort reinforces the importance of integrated TB-HIV care, including early antiretroviral therapy, in district settings.

Previously treated TB was also an independent predictor (aOR 3.56), in keeping with findings from both Indonesian and other LMIC studies, where retreatment cases consistently show poorer outcomes than new cases.[12,13] Patients requiring retreatment may harbour drug-resistant strains, have a history of poor adherence, or carry a higher burden of comorbidity all impacting cure. This underscores the value of drug-susceptibility testing and closer monitoring for retreatment patients, particularly where rapid molecular diagnostics may not be uniformly available.

Underweight nutritional status independently predicted an unsuccessful outcome (aOR 2.47). This aligns with a multisite Indonesian cohort that reported being underweight as an independent risk factor for unfavourable outcomes (aOR 1.93),[8,14] and a similar Ethiopian study.[10] The relationship between undernutrition and TB is bidirectional: malnutrition impairs cell-mediated immunity and worsens treatment response, while active TB accelerates wasting. This supports the integration of nutritional assessment into routine TB care, an intervention that is low-cost and feasible in constrained settings.

Older age (≥60 years) was likewise an independent predictor (aOR 2.81), consistent with the same multisite Indonesian study (age ≥50 years, aOR 2.54)[8,9] and with broader evidence that elderly patients experience higher mortality and poorer outcomes owing to comorbidity, frailty, atypical presentation, and reduced treatment tolerance. As populations age in many LMICs, tailored care for older adults with TB is likely to become increasingly important.

The findings in this study are consistent with much larger national and multisite studies, despite originating from a single district hospital. This strengthens confidence that the determinants of unsuccessful treatment identified here are not artefacts of the local setting but reflect generalisable risk factors that operate even at the district level where most patients are actually managed. The practical implication is that a simple risk profile based on age, nutritional status, treatment history, and HIV status could help district clinicians prioritise intensified support without requiring sophisticated tools.

Study limitations

This study has several limitations. First, its retrospective single-centre design limits generalisability and is subject to the completeness and accuracy of routinely recorded data; patients with incomplete records were excluded, which may have introduced selection bias. Second, the number of unsatisfactory outcomes was relatively small (n = 34), limiting the statistical power and stability of the multivariable model, resulting in wider confidence intervals, particularly for HIV status. HIV status was unavailable for 18 patients (7.8%), which may have introduced some degree of misclassification. Therefore,

the magnitude of associations should be interpreted cautiously. Third, several potentially important variables were not available, including drug-susceptibility results, diabetes control (HbA1c), smoking, treatment adherence, and socioeconomic status, raising the possibility of residual confounding. Fourth, the study period (2020–2023) overlapped with the COVID-19 pandemic, which disrupted TB services in Indonesia and may have influenced follow-up and outcomes. Finally, the division of outcomes, while standard, may obscure differences between distinct unsuccessful outcomes such as death and loss to follow-up.

Recommendations and future research

The findings support several practical actions. District TB programmes should incorporate routine nutritional assessment and support, ensure HIV testing and timely antiretroviral therapy for all co-infected patients, and apply closer monitoring to retreatment cases and older adults. A simple, locally validated risk score incorporating these readily available predictors could help target limited resources to the patients most likely to benefit. Future research should include larger, multicentre, and prospective studies to confirm these associations with greater precision and to incorporate variables unavailable here, such as drug-susceptibility patterns, glycaemic control, and adherence. Studies evaluating whether targeted interventions, including nutritional support, enhanced adherence counselling, and integrated TB-HIV care, improve outcomes in district settings would be especially valuable for informing policy in resource-limited contexts.

Conclusion

In this resource-limited district hospital in Indonesia, nearly one in seven patients with pulmonary TB experienced an unsuccessful treatment outcome. Age ≥60 years, underweight nutritional status, previously treated TB, and HIV-positive status were independent predictors, with HIV co-infection carrying the greatest risk. Because these factors are routinely recorded and require no advanced technology to identify, they offer a practical basis for early risk stratification at the district level. Strengthening nutritional support, integrated TB-HIV care, and targeted monitoring of older and retreatment patients may help improve treatment success and advance progress towards the End TB Strategy targets.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the development of this manuscript, AI-assisted tools were utilized solely to support language refinement and clarity. All generated content was carefully reviewed, revised, and validated by the authors, who assume full responsibility for the accuracy and integrity of the final manuscript.

Conflicts of Interest: None.

Funding: None.

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