Health Dynamics
eISSN: 3006-5518
Publisher: Knowledge Dynamics
DOI: https://doi.org/10.33846/hd21104

Original Research

Pulmonary Tuberculosis Treatment Failure in Coastal Poasia: Determinants from a Case-Control Study

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Article history
Received: 6 October 2025
Revised: 26 November 2025
Accepted: 28 November 2025
Published Online: 30 November 2025

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How to cite this article: Fadmi FR, Mulyani S, Octrisdey K, Justin WOS, Riza Y. Pulmonary Tuberculosis Treatment Failure in Coastal Poasia: Determinants from a Case-Control Study. Health Dynamics, 2025, 2(11), 456-463. https://doi.org/10.33846/hd21104

ABSTRACT

Background: Tuberculosis continues to be a major public health issue, particularly in coastal areas where access to healthcare services is often constrained and living conditions differ from inland settings. Treatment failure remains a persistent challenge for tuberculosis control programs at the primary healthcare level. This study aimed to identify factors associated with pulmonary tuberculosis treatment failure in a coastal primary healthcare setting. **Methods:** An analytical observational study with a case–control design was conducted, involving 48 participants, comprising 24 cases (treatment failure) and 24 controls (treatment success). Data were obtained from tuberculosis program records and through structured interviews. Bivariate analysis using the chi-square test was performed to identify potential determinants ($p \leq 0.25$), followed by binary logistic regression to determine factors independently associated with treatment failure. **Results:** Treatment adherence was the only factor that remained significantly associated with treatment failure after adjustment (AOR = 14.81; p = 0.016). Other variables, including distance to health facilities, knowledge, history of comorbid disease, family support, anxiety, and the role of the treatment supervisor (*Pengawas Minum Obat* or PMO), did not show significant associations in the multivariable model, although some demonstrated a tendency toward increased risk. **Conclusion:** Adherence to treatment plays a decisive role in determining tuberculosis treatment outcomes. Strengthening adherence should therefore be prioritized to reduce treatment failure, particularly in coastal communities where structural and social conditions may affect patients' ability to complete treatment.

Keywords: Tuberculosis; treatment failure; adherence; case-control; coastal community

1. INTRODUCTION

Tuberculosis (TB) remains a major global public health concern. The Global Tuberculosis Report 2024 reports that TB continues to rank among the leading causes of death from infectious diseases, particularly in low- and middle-income countries, including Indonesia.(1) Globally, health authorities have continuously implemented TB control efforts; however, achieving TB elimination targets still faces substantial challenges, especially in case detection and treatment success.(2)

Tuberculosis remains a significant public health issue in Indonesia that necessitates ongoing focus. The 2024 Indonesia Health Profile indicates that Indonesia continues to be a country with a significant tuberculosis burden, with

an estimated annual incidence exceeding one million cases. The government is enhancing tuberculosis control programs through improved case detection, increased treatment success rates, and the execution of the DOTS strategy in primary healthcare facilities.[3]

Tuberculosis is an infectious ailment induced by Mycobacterium tuberculosis, predominantly impacting the pulmonary system. Environmental conditions, housing density, home ventilation, and socioeconomic factors affect how TB spreads.[4] Therefore, TB control depends not only on medical treatment but also on community health behaviors, environmental conditions, and access to health services. Treatment success serves as a key indicator in TB control programs. TB treatment requires patients to adhere consistently to anti-tuberculosis treatment throughout the treatment period. Non-adherence can lead to treatment failure, increase transmission risk, and contribute to drug resistance.[5] Previous studies indicate that individual and social factors such as age, comorbidities, socioeconomic status, and family support also influence TB treatment success.[6,7]

In addition to individual factors, the health care system and TB program implementation significantly affect treatment outcomes. Studies indicate that implementing the Directly Observed Treatment Shortcourse (DOTS) strategy, monitoring treatment by health workers, and the role of treatment supporters influence TB treatment outcomes.[8–10] Access to health services also correlates with TB treatment success, particularly at the primary health care level.[11]

In Southeast Sulawesi Province, tuberculosis is still a public health problem at the regional level. Health profile data show that TB cases remain relatively high and are distributed across multiple districts and municipalities, with Kendari City reporting a notably high number of cases.[12] The Kendari City Health Office's data show that TB is still a major public health problem, and that the success rates of treatment vary from one health care facility to another.[13] At the primary health care level, TB treatment success varies among community health centers in Kendari City. Program data show that treatment success in the coastal service area of Poasia Primary Health Center increased from 94.3% in 2023 to approximately 95% in 2024, indicating that about 5% of patients did not successfully complete treatment.[14] In contrast, non-coastal health centers, such as Labibia Primary Health Center, reported an increase in TB treatment success from approximately 80.5% in 2023 to 100% in 2024. These differences suggest variability in TB program implementation at the primary health care level.

Coastal settings differ from inland areas in several respects, including patterns of mobility, access to healthcare, housing conditions, and the availability of family support during treatment. Such differences may shape how patients adhere to tuberculosis therapy and how the Directly Observed Treatment Short-course (DOTS) strategy is implemented in practice. Although a range of factors associated with tuberculosis treatment success has been documented, evidence focusing on treatment failure within coastal primary healthcare settings remains limited, particularly in Southeast Sulawesi Province. In addition, the application of multivariable approaches, such as logistic regression, to examine these relationships in similar contexts has been relatively sparse. This study therefore aims to identify factors associated with pulmonary tuberculosis treatment failure in the coastal service area of Poasia Primary Health Center.

2. METHODS

2.1 Type of Research

This study employed an analytical observational design using a case control approach. The research was conducted in a coastal primary healthcare setting, where specific environmental and social conditions may influence tuberculosis treatment outcomes.

2.2 Place and Time of Research

The study was conducted at Poasia Primary Health Center, located in the coastal area of Kendari City, Southeast Sulawesi Province, Indonesia, from April to June 2025.

2.3 Population and Sample

The study population consisted of all pulmonary tuberculosis patients with bacteriologically confirmed positive results who received treatment at Poasia Primary Health Center between 2024 and April 2025. A total of 64 patients were identified, including 24 patients who experienced treatment failure and 40 patients who successfully completed treatment. The sample was divided into two groups, namely cases and controls, with a ratio of 1:1. The case group included all 24 patients who experienced treatment failure and was therefore included using a total population approach. The control group consisted of 24 patients with successful treatment

outcomes and was selected purposively using sex-based frequency matching to ensure comparability between groups.

2.4 Data Collection

The research data comprised both secondary and primary sources. The researchers acquired secondary data from the tuberculosis program registry at Poasia Community Health Center, which included details regarding the treatment status of patients with pulmonary tuberculosis. The researchers collected primary data via a structured questionnaire conducted through interviews with participants. The questionnaire gathered information on the research variables, including proximity to health facilities (distant and proximate), tuberculosis knowledge (insufficient and sufficient), comorbid disease history (present and absent), sputum or saliva disposal practices (inadequate and adequate), anxiety levels (anxious and non-anxious), treatment adherence (non-adherent and adherent), and the involvement of the treatment supervisor (inactive and active). The dependent variable in this study was the failure of pulmonary tuberculosis treatment, categorized by the researchers into treatment failure and non-failure according to tuberculosis program data.

The researchers measured all variables using a Guttman scale with dichotomous response options, thereby producing categorical data on a nominal scale. The researchers developed the research instrument based on tuberculosis program indicators and the operational definitions of the variables used in the study. Prior to questionnaire administration, the researchers explained the objectives of the study and the procedures for completing the questionnaire to the respondents. The respondents were given time to complete the questionnaire at the research site. After collection, researchers double-checked questionnaires for completeness and consistency before processing and analyzing data.

2.5 Data Analysis and Processing

Data analysis was conducted in several stages, including descriptive, bivariate, and multivariable analyses. All statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive analysis was used to summarize the distribution of respondents' characteristics and study variables in terms of frequencies and percentages. Bivariate analysis was performed using the chi-square test to examine the association between independent variables and the occurrence of treatment failure, while Odds Ratios (ORs) along with 95% confidence intervals (CIs) were calculated to estimate the magnitude of risk. Variables with p-values ≤ 0.25 were considered eligible for inclusion in the multivariate model. Subsequently, multivariate analysis was carried out using binary logistic regression to identify the most influential determinants of treatment failure. Model adequacy was assessed using the Hosmer–Lemeshow goodness-of-fit test, with a p-value > 0.05 indicating an acceptable fit.

2.6 Ethical considerations

The Health Research Ethics Committee of Mandala Waluya University approved this research (dated: January 28, 2025; decision number: 045/KEP/UMW/I/2025; protocol number: 28012025045). All participants provided informed consent prior to data collection, and confidentiality was maintained throughout the study.

3. RESULTS

Descriptive analysis was performed to profile the characteristics of the study participants. The variables described included sex, age group, educational level, and occupation. The distribution of respondents' characteristics is presented in Table 1.

Table 1. Distribution of respondent characteristic frequency

Characteristics	Categories	n	%
Gender types	Male	30	62.5
	Female	18	37.5
Age group	Low	26	54.2
	High	22	45.8
Education	Primary school	5	10.4
	Junior high school	11	22.9
	Senior high school	29	60.4
	Higher Education	3	6.3
Occupation	Fishermen	12	25
	Entrepreneurs	16	33.3
	Unemployed	4	8.3
	Civil servants	8	16.7
	Students/college students	8	16.7

Notes:
n represents the number of respondents, and % indicates the proportion of the total sample (n = 48)

Based on Table 1, the respondent profile was predominantly male and within the productive age

group. Most participants had a secondary level of education and were engaged in informal occupations. This distribution suggests that the study population largely consisted of individuals in their economically active years with socioeconomic conditions that may influence health-related behaviors. The results of the bivariate analysis are presented in Table 2.

Table 2. Bivariate analysis of pulmonary tuberculosis treatment failure

Determinant Factors	Category	Cases n (%)	Controls n (%)	OR (95% CI)	*p*-value
Distance to health facility	Far	13 (54.2)	4 (16.7)	5.91 (1.55–22.58)	0.007[a,b]
	Near	11 (45.8)	20 (83.3)		
Tuberculosis knowledge	Low	14 (58.3)	4 (16.7)	7.00 (1.82–26.89)	0.003[a,b]
	Adequate	10 (41.7)	20 (83.3)		
History of comorbid disease	Present	15 (62.5)	8 (33.3)	3.33 (1.02–10.90)	0.043[a,b]
	Absent	9 (37.5)	16 (66.7)		
Family support	Inadequate	16 (66.7)	8 (33.3)	4.00 (1.21–13.28)	0.021[a,b]
	Adequate	8 (33.3)	16 (66.7)		
Anxiety	Anxious	19 (79.2)	10 (41.7)	5.32 (1.49–19.06)	0.008[a,b]
	Not anxious	5 (20.8)	14 (58.3)		
Treatment adherence	Non-adherent	18 (75.0)	7 (29.2)	7.29 (2.03–26.10)	0.001[a,b]
	Adherent	6 (25.0)	17 (70.8)		
PMO role	Inactive	18 (75.0)	9 (37.5)	5.00 (1.45–17.27)	0.009[a,b]
	Active	6 (25.0)	15 (62.5)		

[a]Bivariate analysis using Chi-square test (p-value < α (0.05)
[b]Multivariate analysis using logistic regression (p < 0.25)

The bivariate analysis demonstrated that all study variables were significantly associated with pulmonary tuberculosis treatment failure ($p < 0.05$). The strongest associations were observed for tuberculosis knowledge (OR = 15.000) and family support (OR = 14.440), followed by treatment adherence (OR = 11.400) and distance to health facilities (OR = 9.229). Other variables, including anxiety, history of comorbid disease, and the role of the treatment supervisor (*Pengawas Minum Obat* or PMO) also showed statistically significant relationships with treatment failure. All variables met the criteria for inclusion in the multivariate analysis. The results of the logistic regression analysis are presented in Table 3.

The results of the binary logistic regression analysis indicate that the constructed model demonstrated good performance and was appropriate for explaining the occurrence of treatment failure. This is supported by a statistically significant overall model test ($p < 0.001$) and a Nagelkerke R Square value of 0.668, suggesting that the model explains a substantial proportion of the variation in treatment failure. The Hosmer–Lemeshow goodness-of-fit test yielded a p-value of 0.531, indicating no significant difference between observed and predicted outcomes. Furthermore, the model achieved a classification accuracy of 91.7%, reflecting strong predictive ability.

Table 3. Multivariate analysis of pulmonary tuberculosis treatment failure

Variables	B	p-value	AOR (Exp(B))	95% CI
Distance to health facility	1.393	0.212	4.03	0.45 – 35.82
Tuberculosis knowledge	0.836	0.427	2.31	0.29 – 18.19
History of comorbid disease	1.074	0.286	2.93	0.41 – 21.03
Family support	1.785	0.076	5.96	0.83 – 42.74
Anxiety	1.150	0.201	3.16	0.54 – 18.36
Treatment adherence	2.696	0.016	14.81	1.65 – 133.21
PMO role	1.955	0.066	7.06	0.88 – 56.63

Notes: AOR = Adjusted Odds Ratio; CI = 95% Confidence Interval. Binary logistic regression was performed using the enter method. Model adequacy was confirmed by the Hosmer–Lemeshow goodness-of-fit test (p = 0.531), indicating an acceptable fit. A p-value < 0.05 was considered statistically significant after adjustment for other variables.

In the adjusted (partial) analysis, treatment adherence was the only variable that remained significantly associated with treatment failure after controlling for other factors (p = 0.016). Patients who were non-adherent to treatment had a markedly higher likelihood of experiencing treatment failure compared to those who adhered to therapy (AOR = 14.81; 95% CI: 1.65–133.21). This finding underscores the critical role of adherence as a key determinant of successful tuberculosis treatment. In contrast, other variables—including distance to health services, tuberculosis knowledge, history of comorbid disease, family support, anxiety, and the role of the treatment supervisor (PMO)—were no longer statistically significant in the multivariable model. This suggests that their effects may be indirect or mediated through interactions with other variables included in the model.

4. DISCUSSION

This study identifies treatment adherence as the main factor associated with pulmonary tuberculosis treatment failure. When all variables were examined simultaneously, only adherence remained significantly related to the outcome. This suggests that the success of tuberculosis treatment is closely tied to how consistently patients follow the prescribed regimen.[1,15] In this context, adherence is better understood not simply as one of several contributing factors, but as a central point through which different influences are reflected in treatment outcomes.

Tuberculosis treatment requires sustained commitment over a relatively long period. Irregular medication use may interfere with effective bacterial clearance, increasing the likelihood of treatment failure, relapse, and drug resistance.[16–18] this study, patients who did not adhere to treatment were considerably more likely to experience treatment failure compared to those who adhered. At the same time, the wide confidence interval indicates a degree of variability in the data, which may be related to the limited sample size. For this reason, the findings should be interpreted with appropriate caution. These results are consistent with recent evidence highlighting adherence as a key factor in determining treatment outcomes.[19,20] The findings of this study are consistent with previous studies conducted in Kendari City, which indicated that behavioral factors, individual characteristics, and environmental conditions play roles in tuberculosis control at the primary health care.[21,22] These findings indicate that treatment adherence is not solely related to clinical aspects but is also influenced by the social and environmental contexts in which patients conduct their daily lives.

Other variables, including distance to health facilities, knowledge, history of comorbid disease, family support, anxiety, and the role of the treatment supervisor (PMO), were associated with treatment failure in the initial analysis but did not remain significant after adjustment. This pattern suggests that their influence may not be direct, but instead operates through their relationship with adherence. In other words, these factors appear to shape patients' ability to maintain consistent treatment rather than determining outcomes independently.

Distance to health facilities, for instance, may affect access to care and continuity of treatment. In coastal settings, limited transportation and longer travel times can create barriers to regular follow-up. Previous studies have noted that geographic constraints may contribute to treatment interruption and delayed care.[23–25] However, once adherence is taken into account, the independent effect of distance becomes less apparent, suggesting that its influence is more closely linked to treatment behavior.[26] A similar pattern can be observed for knowledge. While an adequate understanding of tuberculosis is important, it does not necessarily translate into successful treatment outcomes without consistent adherence.[27,28] Evidence indicates that knowledge tends to influence health behavior rather than directly affecting clinical outcomes.[29] This highlights the importance of supporting patients not only with information but also with strategies that encourage sustained behavioral change.

The same interpretation applies to comorbid conditions. Although clinical factors such as diabetes are known to affect tuberculosis outcomes, they did not emerge as dominant predictors in this study after adjustment.[30] This suggests that, in this particular context, behavioral and social influences may play a more prominent role than clinical conditions alone. Family support and the role of PMO showed relatively strong tendencies, although they did not reach statistical significance in the final model. These factors are widely recognized as important in supporting treatment through supervision and encouragement. Recent studies suggest that social support and monitoring interventions can contribute to improved adherence.[31,32] In coastal communities with strong social connections, such

support may help patients remain consistent with treatment, even if its direct effect is not fully reflected in the model.

Psychological factors, particularly anxiety, followed a comparable pattern. Although initially associated with treatment failure, the effect was no longer evident after adjustment. This suggests that psychological factors may influence treatment outcomes indirectly, for example through their effect on motivation and consistency in medication use. Previous research has highlighted the role of mental health in shaping adherence behavior among tuberculosis patients.[33,34] Taken together, these findings suggest that tuberculosis treatment outcomes are shaped by the interaction of multiple factors, with adherence playing a central role.[35] Rather than acting independently, these factors appear to be linked through their influence on patient behavior.

When considered alongside evidence from global studies, which commonly identify access, socioeconomic conditions, and social support as independent determinants of tuberculosis outcomes, the findings of this study point to a different pattern. Although several factors showed initial associations with treatment failure, these relationships did not persist after adjustment. Instead, their effects appear to be reflected through a common pathway, namely treatment adherence. This suggests that, within coastal settings, adherence may play a more central role in shaping treatment outcomes, acting as a point through which various influences are expressed. Such a perspective emphasizes the importance of examining how multiple factors interact, rather than considering each determinant in isolation.

From a practical standpoint, these findings draw attention to the need to strengthen treatment adherence as a core component of tuberculosis control. Efforts should not focus solely on improving knowledge or access to services, but also on supporting patients in maintaining continuity of treatment over time. Strategies such as sustained patient education, active involvement of family members, and reinforcement of the role of treatment supervisors (PMO) may be particularly relevant, especially in contexts characterized by limited access and high population mobility.

5. CONCLUSIONS AND RECOMMENDATIONS

The findings of this study indicate that treatment failure among pulmonary tuberculosis patients in coastal areas is more closely related to behavioral and social support factors than to clinical conditions or access to healthcare services. Among the variables examined, treatment adherence consistently showed the strongest relationship with treatment outcomes, while family support and the role of the treatment supervisor (PMO) appeared to contribute, particularly in the initial analysis. These results suggest that successful tuberculosis treatment is not determined by medical intervention alone. Rather, it depends greatly on how consistently patients follow their treatment regimen and the extent to which they are supported by those around them. In coastal communities, where work patterns are often unstable and access to health services may be limited, the involvement of family members and the presence of treatment supervision can play an important role in helping patients remain on treatment. From a practical standpoint, efforts to control tuberculosis at the primary healthcare level should extend beyond clinical management. Greater attention needs to be given to strengthening treatment adherence, improving the effectiveness of treatment supervision, and encouraging family involvement as part of a sustained approach to improving treatment outcomes.

Ethical Approval

The Health Research Ethics Committee of Mandala Waluya University approved this research (dated: January 28, 2025; decision number: 045/KEP/UMW/I/2025; protocol number: 28012025045).

Acknowledgement

The authors sincerely thank all health workers at Poasia Primary Health Center, Southeast Sulawesi Province, for their support during the study. Appreciation is also extended to all participants who voluntarily took part in this research.

Competing Interests

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

Funding Information

This research was funded by Yayasan Mandala Waluya, Southeast Sulawesi Province, Indonesia, through an institutional research funding program.

Underlying Data

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

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