Risk Factor of Lost To Follow-Up Treatment In Drug-Sensitive Pulmonary TB Patients

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Abstract.
Background: Loss to follow-up (LTFU) treatment remains a critical challenge in tuberculosis control in Indonesia, accounting for approximately 50% of treatment failure cases among pulmonary TB patients. Objectives: To identify independent predictors of LTFU among drug-sensitive TB (DS-TB) patients in Medan, Indonesia. Methods: This cross-sectional analytical study enrolled 100 DS-TB patients (40 with LTFU, 60 treatment-completed) from two hospitals. Purposive sampling technique was employed. Data were collected using validated questionnaires assessing sociodemographic characteristics, patient perspective toward TB treatment, social support (using MSPSS scale), and healthcare services quality. Bivariate analysis used chi-square and Fisher's exact tests; multivariate analysis employed multiple logistic regression. Statistical significance was set at p < 0.05. Results: Multivariate analysis identified two independent predictors of LTFU: social support (odds ratio 128.632; 95% confidence interval 13.809 to 1,198.216; p < 0.001) and treatment perspective (odds ratio 25.415; 95% confidence interval 5.569 to 115.985; p < 0.001). Low to moderate social support was the most dominant risk factor, conferring approximately 128.7 times greater odds of treatment discontinuation compared to high social support. Poor treatment perspective was the second dominant predictor, with 90% of LTFU patients demonstrating negative perspectives. Conclusion: Poor treatment perspective and low to moderate social support are significantly associated with LTFU treatment discontinuation in DS-TB patients. Psychosocial interventions addressing these factors should be prioritized in TB control programs to improve treatment completion rates and achieve WHO treatment success targets.
Keywords: *Adherence; Drug-Sensitive Tuberculosis; Loss To Follow-Up; Social Support and Treatment Perspective.*

I.   INTRODUCTION

Research Phenomenon

Tuberculosis (TB) remains a critical public health challenge globally, with persistent burden despite decades of disease control efforts. According to the Global Tuberculosis Report 2023, TB is the 13th leading cause of death worldwide and the second leading infectious cause of mortality after COVID-19, superseding HIV/AIDS in this ranking. In Indonesia, the situation is particularly concerning, with an estimated 969,000 TB cases detected annually, making the country one of the highest TB-burden nations globally. Recent epidemiological data from 2015 to 2023 demonstrate an alarming 19% increase in estimated TB incidence and a 26% increase in TB-related deaths in Indonesia, underscoring the urgency of effective disease management strategies. Despite the availability of effective short-course chemotherapy regimens, treatment success rates remain suboptimal, with Indonesia achieving only 74% treatment success in 2022, falling substantially short of the World Health Organization's 90% target.

This treatment gap is predominantly attributed to loss to follow-up (LTFU), which accounts for approximately 50% of treatment failure cases among pulmonary TB patients in Indonesia.The problem of LTFU during TB treatment represents a critical barrier to achieving TB elimination by 2035, as outlined in the End TB Strategy framework adopted by Indonesia. Loss to follow-up among drug-sensitive TB (DS-TB) patients not only perpetuates individual morbidity and mortality but also escalates the public health threat through continued transmission of Mycobacterium tuberculosis to community members and, critically,

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facilitates the emergence of drug-resistant TB (DR-TB) strains. The phenomenon of treatment discontinuation in DS-TB patients is multifactorial, involving complex interactions between patient-level factors, health system characteristics, and socio-environmental determinants. Recent research has identified that LTFU is not merely a consequence of inadequate disease awareness but rather reflects intricate psychosocial and structural barriers that require systematic investigation to develop targeted interventions.

Problem Statement

Existing literature and epidemiological surveillance data have documented that multiple factors contribute to treatment discontinuation among TB patients, including socioeconomic constraints, adverse drug reactions, extended treatment duration, limited healthcare access, and inadequate knowledge regarding TB. However, previous descriptive studies in similar populations have primarily characterized the demographic profile and behavioral features of patients who discontinued treatment without conducting rigorous inferential analyses to identify independent predictors and establish causal or associative relationships among variables. The distinction between descriptive identification of characteristics and analytical determination of risk factors is crucial for developing evidence-based interventions. In Indonesia's context, while demographic data on LTFU TB patients have been documented through surveillance systems, the underlying psychosocial and attitudinal mechanisms driving treatment abandonment remain incompletely understood.Contemporary research increasingly emphasizes that patient perspective toward treatment and social support mechanisms represent critical psychosocial determinants influencing treatment adherence outcomes.

Recent evidence from Indonesia and comparable resource-limited settings suggests that negative attitudes or pessimistic beliefs regarding TB treatment efficacy, combined with insufficient family and community support structures, constitute powerful risk factors for treatment discontinuation. However, the relative magnitude and independent contribution of these psychosocial factors compared to demographic and health system variables remain inadequately characterized in the Indonesian context, particularly for DS-TB patients. Furthermore, the intersection and potential synergistic effects of multiple psychosocial determinants on LTFU outcomes require clarification to optimize intervention strategies.Previous research by Soedarsono and colleagues demonstrated that negative attitude toward treatment and limitation of social support were significantly associated with LTFU in drug-resistant TB patients, with social support emerging as a particularly powerful correlate. Similarly, recent systematic reviews and meta-analyses have consistently identified social support as a crucial mediating factor in TB treatment adherence, with family support, peer support, and healthcare worker support all demonstrating independent positive associations with treatment completion. However, comparative analysis of the relative strength of psychosocial versus demographic predictors of LTFU in drug-sensitive TB populations, and the extent to which findings from DR-TB research generalize to DS-TB cohorts, remains limited. Additionally, the specific mechanisms through which social support influences adherence behavior, whether through psychological empowerment, practical assistance, or enhanced health literacy, warrant deeper investigation.

Study Objectives and Significance

This analytical follow-up study was designed to extend preliminary descriptive findings from a prior investigation in the same population by applying rigorous bivariate and multivariate statistical methodologies to identify and quantify independent predictors of loss to follow-up treatment among DS-TB patients in Medan, Indonesia. The primary objectives were to determine the magnitude of association between demographic, psychosocial, and health system variables and LTFU incidence, and to identify the most dominant risk factors influencing treatment discontinuation through multiple logistic regression analysis. The research addresses a recognized gap in the Indonesian TB epidemiological literature by providing quantified estimates of the independent effects of patient perspective toward treatment and social support on LTFU outcomes in DS-TB populations. Given that DS-TB patients constitute greater than 90% of all TB cases in Indonesia and are particularly vulnerable to acquired drug resistance upon treatment discontinuation, identification of modifiable psychosocial risk factors has substantial implications for developing targeted interventions to improve treatment completion rates and ultimately reduce TB incidence, mortality, and transmission in Indonesian communities. The novelty of this study lies in its rigorous analytical approach to

quantifying the relative contributions of multiple putative risk factors and in establishing a more robust evidence foundation for intervention strategies aimed at reducing TB treatment dropout rates in Indonesia's healthcare system.

II. METHODS

Study Design and Research Type

This study employed a cross-sectional analytical design, which represents a quantitative research approach that observes and measures variables at a single point in time to examine associations between multiple independent variables and a dependent outcome variable. According to Sugiyono (2021), cross-sectional studies investigate the correlation between risk factors (exposure variables) and outcomes (effects) through simultaneous data collection using a point-in-time approach, wherein each research subject is observed only once and measurements are conducted at the same temporal point.

The analytical nature of this design distinguishes it from purely descriptive surveys by enabling researchers to conduct inferential statistical analyses and determine the strength and directionality of associations between variables. Following the methodological framework outlined by Creswell and Creswell (2023), this study implemented specific quantitative procedures encompassing systematic variable identification, structured instrument development, standardized data collection protocols, and rigorous multivariate statistical analysis to address research questions regarding predictors of loss to follow-up in drug-sensitive TB patients. The study was conducted over a seven-month period at two tertiary-level hospitals in Medan, Indonesia: Adam Malik General Hospital and Prof. Dr. Chairuddin P. Lubis Universitas Sumatera Utara Hospital. The research received ethical approval from the Health Research Ethics Commission of the Faculty of Medicine, Universitas Sumatera Utara (No. 246/KEPK/USU/2024), ensuring adherence to research ethics standards for human subjects research.

Population, Sampling Strategy, and Study Participants

The target population comprised drug-sensitive pulmonary TB (DS-TB) patients aged 18 years or older who were undergoing TB treatment at either of the two study hospitals and who initiated treatment between May 2023 and May 2024. Inclusion criteria encompassed DS-TB patients who had discontinued treatment or experienced loss to follow-up (LTFU), were aged 18 years or older at the time of treatment initiation, and voluntarily agreed to participate in the study by providing written informed consent. Exclusion criteria included patients who could not be contacted or located during the data collection period. The study sample comprised 100 DS-TB patients total, consisting of 40 patients who experienced loss to follow-up treatment and 60 patients who completed their TB treatment course, providing a comparison group for inferential analysis. A non-probability purposive sampling technique was employed to recruit study participants. According to contemporary methodological literature, purposive sampling is a deliberate, non-random selection strategy wherein researchers intentionally select participants or cases according to predefined inclusion and exclusion criteria designed to align with specific research objectives.

This approach was selected to ensure the inclusion of both LTFU and treatment-completed DS-TB patients who could provide meaningful data regarding the factors associated with treatment discontinuation. Among the 40 LTFU patients, 18 received TB medication from the Medan health center, 11 patients from private hospitals, 9 patients from independent doctor's practices, and 2 patients from Medan regional government hospitals. In contrast, the 60 DS-TB patients who completed treatment received care at Prof. Dr. Chairuddin P. Lubis Universitas Sumatera Utara Hospital. While non-probability sampling methods compromise some aspects of generalizability compared to probability sampling, purposive sampling in this context enabled researchers to systematically target the specific population of interest and capture comprehensive information from individuals with direct experience of the phenomena under investigation. The rationale for using purposive sampling was strengthened by the need to access a specific subpopulation (LTFU TB patients) that would be difficult to identify through probabilistic methods, particularly given the distributed nature of TB treatment provision across multiple facilities in Medan.

Research Instruments and Data Collection Methods

Data were collected using a structured, self-administered questionnaire comprising four primary components: sociodemographic characteristics, patient perspective toward TB treatment, social support assessment, and healthcare services evaluation. Following Emzir's (2021) recommendations for instrumentation in quantitative research, all questionnaire components were based on validated instruments adapted to the Indonesian context and were administered in [translate:Bahasa Indonesia] to ensure participant comprehension and reduce response bias.The sociodemographic questionnaire section gathered information on age, gender, education level, employment status, marital status, and family history of TB. The attitude questionnaire assessing patient perspective toward TB treatment was adapted from research by Yuda and had undergone rigorous validity and reliability testing. This instrument comprised eight yes-no items scored dichotomously (yes equals 1 point, no equals 0 points), with a maximum possible score of 8 and minimum score of 0. Patients were categorized as having a positive (good) attitude if their questionnaire score exceeded 56%, and a negative (poor) attitude if the score fell at or below 56%. Validity testing demonstrated a Pearson Correlation coefficient greater than 0.444 (indicating acceptable item-total correlation), while internal consistency reliability was assessed using Cronbach's Alpha coefficient of 0.178. Although the Cronbach's Alpha value reported is lower than the conventional threshold of 0.70, this may reflect the heterogeneity of the attitude construct or the brevity of the instrument. The questionnaire design maintained validity through expert consensus and prior validation in similar TB populations.The social support questionnaire was developed by Soedarsono and adapted by Pandini based on the Multidimensional Scale of Perceived Social Support (MSPSS), originally developed by Zimet and colleagues to measure the adequacy of perceived social support across multiple dimensions.

This 12-item instrument is organized into three subscales assessing social support from: (1) family members, (2) friends, and (3) other special persons. Each item is rated on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Total scale scores range from 12 to 84 points, with subscale scores for each dimension ranging from 4 to 28 points. Scoring categorization was operationalized as follows: high social support if total score was 61 to 84 points, moderate social support if score was 36 to 60 points, and low social support if score was 12 to 35 points. Validity testing of the Indonesian-adapted MSPSS demonstrated Pearson Correlation coefficients exceeding 0.444 across all items, confirming adequate item-total correlation. Internal consistency reliability was confirmed by Cronbach's Alpha coefficient of 0.80, indicating strong reliability. The psychometric properties of the MSPSS have been extensively validated across diverse cultural and health contexts, including TB-affected populations, consistently demonstrating its validity and reliability as a multidimensional measure of perceived social support.The healthcare services questionnaire evaluated the quality of TB treatment support provided by healthcare workers and consisted of six items assessing whether TB officers demonstrated specified supportive practices during treatment. Healthcare services were categorized as supportive when TB officers performed five to six of the specified actions documented in the questionnaire items, and as less supportive when fewer than five actions were performed. This instrument had been previously utilized by Armelia and colleagues and underwent validity testing with Pearson Correlation values exceeding 0.444 and Cronbach's Alpha values exceeding 0.70, confirming its validity and reliability.

Data Analysis and Statistical Procedures

Data analysis was conducted using IBM SPSS Statistics version 26.0 (International Business Machines Corporation, 2021). Following the analytical framework recommended by Sudaryono and contemporary quantitative methodology literature, the analysis proceeded through sequential stages: (1) descriptive analysis of sociodemographic characteristics, (2) bivariate analysis to identify statistically significant associations, and (3) multivariate logistic regression to determine independent predictors. Bivariate analysis was performed using chi-square (χ^2) tests to examine associations between each independent variable (age, gender, education level, employment status, marital status, family history of TB, patient perspective toward treatment, social support, and healthcare services) and the dependent variable (loss to follow-up treatment status). The chi-square test is the appropriate bivariate statistical procedure for examining associations between categorical variables in cross-sectional study designs. When chi-square test assumptions were not met, specifically when expected frequencies in contingency table cells were less than

five, Fisher's exact test was employed as an alternative nonparametric procedure to determine statistical significance. Results were deemed statistically significant when p-value was less than 0.05, with 95% confidence intervals calculated for all estimates.

Variables demonstrating statistical significance in bivariate analysis (p < 0.05) were subsequently entered into multivariate analysis using multiple logistic regression. Multiple logistic regression is the appropriate multivariate procedure for identifying independent predictors when the dependent variable is dichotomous (loss to follow-up: yes or no), as it does not require the assumption of a normal distribution of independent variables and can accommodate both continuous and categorical predictor variables. The logistic regression model was constructed using the enter method, wherein all significant bivariate variables were simultaneously included in the initial model. Sequential backward elimination procedures were applied to refine the model by removing variables with non-significant p-values while monitoring for changes in model fit and the estimates of retained variables. The strength of associations was quantified using odds ratios (OR) with 95% confidence intervals, which represent the magnitude of increased or decreased odds of experiencing loss to follow-up associated with each predictor variable. The crude model (Selection 1) included all variables with significant bivariate associations, and subsequent models (Selections 2 through 6) were progressively refined through backward elimination, with the final optimal model (Selection 6) retaining only the most parsimonious set of independent predictors demonstrating statistical significance. Model fit and diagnostic adequacy were evaluated using appropriate statistics and procedures available in SPSS version 26. Statistical significance for all analyses was established at the $\alpha = 0.05$ level (95% confidence), representing a conventional threshold for hypothesis testing in health sciences research.

Research Procedures and Implementation

The research procedures followed a systematic sequence designed to ensure data quality, participant protection, and methodological rigor. Participants were identified through clinical records at the two study hospitals and contacted by trained research assistants. Following explanation of the study purpose, procedures, and confidentiality protections, written informed consent was obtained from all willing participants. Questionnaire administration was conducted in-person or via structured interview by trained interviewers fluent in [translate:Bahasa Indonesia] to minimize response bias and ensure comprehension of all items.

Data quality measures implemented throughout the study included standardized questionnaire training for all data collectors to ensure consistency in administration protocols, systematic review of completed questionnaires for completeness and logical consistency before data entry, and use of electronic data entry with built-in range and logic checks to prevent coding errors. All raw data were securely stored in locked, accessible only to authorized research personnel, with computer files encrypted and password-protected. Statistical analyses were conducted by a trained biostatistician blind to participant identification information to minimize analytical bias. The complete research protocol and all instruments were evaluated and approved by the institutional ethics review board prior to participant recruitment, ensuring compliance with ethical principles for human subjects research including autonomy, beneficence, non-maleficence, and justice.

III.   RESULT AND DISCUSSION
Results

This study involved 100 patients with DS-TB. From 40 patients who had LTFU, 18 patients received TB medication from the Medan health centre, 11 patients from a private hospital, 9 patients received treatment from an independent doctor's practice, 2 patients from the Medan regional government hospital, and 60 DS-TB patients who complete of treatment received treatment at Prof. Dr. Chairuddin P. Lubis Universitas Sumatera Utara Hospital.Table 1 presents the results of the bivariate analysis of association between age, gender, education level, employment status, marital status, family history of having TB, perspective towards TB treatment, social support, health worker services on the incidence of LTFU in DS-TB patients. Significant association were found between age (p=0.034, PR = 0.706, 95 % CI: 0.509-0.979), gender (p=0.001, PR=1.688, 95 % CI: 1.229-2.319), employment status (p=0.041, PR = 0,714, , 95 % CI:

0.513-1.00), marital status (p=0.039, PR = 0.706, , 95 % CI: 0.523-0.951), perspective towards TB treatments (p<0.001, PR=2.852, , 95 % CI: 1.909-4.261), social support (p<0.001, PR=3.52, , 95 % CI: 2.286-5.426) and health care services (p<0.001, PR=2.642, , 95 % CI: 1.742-4.008) with the incidence of LTFU in DS-TB patients. [Table 1]

Table 1. Association of Study Variables with The Incidence of LTFU In DS-TB Patients Compared with Treatment Completed Control.

Variable	Lost to follow up		Total (n)	P value	PR (CI 95%)
	Yes n (%)	No n (%)			
Subjects	40 (39.6)	60 (59.4)	100		
Age					
18-45 years	14 (29.2)	34 (70.8)	48	0.034[b]	0.706
46-65 years	26 (50)	26 (50)	52		(0.509-0.979)
Gender					
Male	31 (53.4)	27 (46.6)	58	0.001[b]	1.688
Female	9 (21.4)	33 (78.6)	42		(1.229-2.319)
Education					
≤12 years (ES. JHS. SHS)	31 (38.8)	49 (61.3)	80	0.610[b]	0.898
>12 years (College)	9 (45)	11 (55)	20		(0.582-1.385)
Employment Status					
Unemployment	15 (30)	35 (70)	50	0.041[b]	0.714
Working	25 (50)	25 (50)	50		(0.513-1.00)
Marital status					
Married	7 (24.1)	22 (75.9)	29	0.039[b]	0.706
Not married	33 (46.5)	38 (53.5)	71		(0.523-0.951)
Familiy history of having TB					
Yes	4 (36.4)	7 (63.6)	11	1.000[a]	0.936
No	36 (40.4)	53 (59.6)	89		(0.580-1.510)
Perpective towards TB treatment					
Bad	36 (68)	17 (32)	53	0.001[b]	2.852
Good	4 (8.5)	43 (91.5)	47		(1.909-4.261)
Social Support					
Low-Medium	39 (72.2)	15 (27.8)	54	0.001[b]	3.522
High	1 (2.2)	45 (97.8)	46		(2.286-5.426)
Health care services					
Less supportive	33 (67.3)	16 (32.7)	49	0.001[b]	2.642
Supportive	7 (13.7)	44 (86.3)	51		(1.742-4.008)

[a]Analyzed using Fischer's Exact.

[b]Analyzed using Chi Square

Notes: ES, Elementary School; JHS, Junior High School; SHS, Senior High School

The results of multivariate analysis are presented in table 2. Two independent variables have a significant effect on incidence of LTFU in DS-TB patient, namely the perspective towards TB treatment (p-value of 0.000 with an Exp (B) value of 25.415; 95% CI 5.569 - 115.985) and social support (p-value of 0.000 with an Exp (B) value of 128.632; 95% CI 13.809 - 1198. 216) which means that respondents with a poor perspective towards TB treatment will have higher chance of LTFU treatment which 25.415 more than respondents with a good perspective towards TB treatment and respondents with a low-medium social support category also have higher chance of LTFU treatment which 128.632 more than respondents with a high social support category. Most of LTFU patient (90%) have poor perspective towards TB treatment. [Table 2]

Table 2. Multivariate analysis of factors associated with incidence of LTFU in DS-TB patients.

Variable	B	p	Exp(B)	95% CI for EXP(B)	
				Lower	Upper
Selection 1					
Age	-0.931	0.258	0.394	0.079	1.975
Gender	0.558	0.587	1.747	0.234	13.042
Employment status	0.217	0.843	1.242	0.145	10.647
Marital status	-1.062	0.275	0.346	0.051	2.331
Perspective towards treatment	2.691	0.014	14.740	1.714	126.777
Social support	4.858	0.000	128.708	12.253	1352.029

Health care services	0.826	0.420	2.285	0.307	17.034
Constant	-5.754	0.000	0.003		
Selection 2					
Age	-0.917	0.263	0.400	0.080	1.988
Gender	0.440	0.598	1.553	0.303	7.958
Marital status	-0.990	0.273	0.372	0.063	2.182
Perspective towards treatment	2.652	0.014	14.181	1.705	117.968
Social support	4.870	0.000	130.325	12.435	1365.894
Health care services	0.823	0.424	2.276	0.303	17.096
Constant	-5.581	0.000	0.004		
Selection 3					
Age	-0.989	0.220	0.372	0.076	1.808
Marital status	-1.038	0.257	0.354	0.059	2.130
Perspective towards treatment	2.768	0.009	15.932	2.026	125.275
Social support	4.948	0.000	140.907	13.325	1490.080
Health care services	0.900	0.370	2.459	0.345	17.546
Constant	-5.469	0.000	0.004		
Selection 4					
Age	-1.059	0.184	0.347	0.073	1.653
Marital status	-1.062	0.238	0.346	0.059	2.020
Perspective towards treatment	3.376	0.000	29.259	5.621	152.290
Social support	4.869	0.000	130.191	12.779	1326.383
Constant	-5.214	0.000	0.005		
Selection 5					
Age	-1.211	0.121	0.298	0.065	1.375
Perspective towards treatment	3.286	0.000	26.729	5.433	131.498
Social support	4.932	0.000	138.622	13.953	1377.186
Constant	-5.416	0.000	0.004		
Selection 6					
Perspective towards treatment	3.235	0.000	25.415	5.569	115.985
Social support	4.857	0.000	128.632	13.809	1198.216
Constant	-5.899	0.000	0.003		

The most dominant variable influencing Lost to Follow-up Treatment in drug-sensitive TB patient is low-moderate social support with the largest Exp (B) value of 128.708 (p=<0.001, 95% CI 12.253-1352.029), meaning that low-to-moderate social support is associated with a 128.708 times greater risk of TB Lost to Follow-up Treatment compared to patients with high social support. The second variable that influences TB Lost to Follow-up Treatment in SO is poor attitude, with an Exp (B) value of 14.74 (p=0.014, 95% 1.714-126.777). This means that patients with poor attitudes are 14.74 times more likely to experience TB Lost to Follow-up Treatment compared to patients with good attitudes.

Age as a Risk Factor for Loss to Follow-Up Treatment

This study demonstrated a statistically significant association between age and the incidence of loss to follow-up (LTFU) among drug-sensitive tuberculosis (DS-TB) patients ($p = 0.034$), with the largest proportion of treatment discontinuation occurring in the 45 to 65 years age group. These findings align with previous research by Rahayu et al. (2023), which documented that age represents a significant predictor of treatment discontinuation, with a p-value less than 0.001, indicating a strong statistical relationship. Furthermore, research conducted by Walker et al. (2019) examining 4,099 multidrug-resistant pulmonary tuberculosis patients in diverse geographic settings found that patients aged over 40 years exhibited a 1.37-fold greater risk of experiencing loss to follow-up compared to patients aged less than 40 years. The biological mechanisms underlying this age-related effect involve the patient's overall physical condition and presence of comorbid diseases, which accumulate with advancing age and compromise treatment tolerance. Additionally, elderly patients demonstrate increased susceptibility to adverse effects of anti-tuberculosis medications, which commonly include hepatotoxicity, gastrointestinal disturbances, and peripheral neuropathy. Since these medication side effects represent a frequently cited reason for loss to follow-up treatment discontinuation among TB patients, their increased prevalence in older adults substantially contributes to elevated rates of non-adherence in this population. Recent systematic evidence synthesis

indicates that age-related medication side effect susceptibility represents one of the primary mechanisms through which advancing age influences treatment abandonment in pulmonary TB cohorts.

Gender as a Demographic Predictor of Treatment Discontinuation

This study identified a statistically significant association between gender and incidence of LTFU among DS-TB patients ($p = 0.001$), with male patients demonstrating substantially higher rates of treatment discontinuation compared to female patients. These findings are consistent with research by Birhane et al. (2023), which reported that male patients demonstrated approximately 2 times higher likelihood of discontinuing TB treatment compared to female patients. This finding was further corroborated by the analysis of Masita and Andriani (2023), who documented that approximately 64.3% of all observed LTFU cases occurred among male TB patients. The association between patient gender and loss to follow-up treatment is predominantly mediated through psychosocial, socioeconomic, and cultural factors rather than biological mechanisms. In many societies, including the Indonesian context of this study, gender roles position men as the primary economic providers for their families, creating competing demands on their time and financial resources. This socioeconomic responsibility frequently results in prioritization of income-generating employment activities over medical appointments and clinical follow-up visits, thereby limiting adherence to scheduled TB treatment regimens. Furthermore, gender-related stigma influences treatment-seeking behavior differently between men and women. Male TB patients frequently experience concern regarding occupational stigma and potential discrimination from employers or colleagues if TB status becomes known in workplace settings, leading some patients to conceal their disease diagnosis. This concealment frequently prevents patients from communicating their treatment requirements to employers or adjusting work schedules to accommodate medical appointments. The intersection of occupational concerns with economic pressures creates formidable barriers to sustained treatment engagement among employed male TB patients.

Education Level and Treatment Adherence

In contrast to expectations from educational attainment literature, this study did not identify a statistically significant association between education level (categorized as 12 years or less versus greater than 12 years) and incidence of LTFU among DS-TB patients ($p = 0.610$). These results are consistent with research conducted by Soedarsono et al. (2021), which similarly failed to identify a significant relationship between educational attainment (general education level) and loss to follow-up incidence among TB patients with drug resistance. The lack of association between general education level and LTFU outcomes can be explained by the theoretical distinction between general educational attainment and disease-specific health literacy. Loss to follow-up among TB patients appears to be more closely linked to disease-specific knowledge regarding tuberculosis pathophysiology, treatment necessity, and treatment duration rather than general academic education level. This finding suggests that health promotion and education efforts conducted by healthcare workers at treatment facilities have been sufficiently comprehensive and effective, contributing to adequate medication adherence regardless of patient educational background. When healthcare providers deliver holistic TB-specific education addressing patient concerns and misconceptions, the influence of baseline general education level may be substantially diminished. However, these results contrast with research by Absor et al. (2020), which demonstrated that education level among TB patients significantly influences the level of knowledge and willingness to engage in TB treatment, suggesting that context-specific factors may moderate the relationship between education and treatment outcomes.

Employment Status and Treatment Continuity

The present study identified a statistically significant association between employment status and incidence of LTFU among DS-TB patients ($p = 0.041$). Consistent with prior research by Kondoy et al. (2014), which evaluated five public health centers in Manado, Indonesia, patients with permanent employment demonstrated elevated susceptibility to LTFU incidence. The mechanism underlying this occupational risk factor involves the continuous daily demands of formal employment, which frequently prevent patients from attending scheduled TB treatment clinic visits during operating hours. Patients maintaining permanent employment positions often face rigid work schedules that conflict with healthcare facility appointment times, and taking extended medical leave to accommodate treatment regimens may

adversely impact job security or income. Moreover, patients frequently conceal their TB diagnosis from employers due to concern regarding workplace discrimination and potential adverse effects on employment status. When patients choose to pursue medical leave to continue their treatment course, this decision often creates direct financial hardship through reduced income. The interplay between occupational time demands, economic vulnerability, and employment discrimination creates substantial barriers to treatment adherence among formally employed TB patients. These findings underscore the need for TB programs to implement flexible treatment scheduling and employment-sensitive service delivery models to accommodate working TB patients.

Marital Status and the Role of Partner Support

This study demonstrated a statistically significant association between marital status and incidence of LTFU among DS-TB patients (p = 0.039). Married patients demonstrated substantially lower rates of treatment discontinuation compared to unmarried patients. This protective effect is theoretically attributed to the social and emotional support provided by marital partners, who can facilitate treatment adherence through medication reminders, encouragement, and emotional reinforcement. Marital status serves as a marker of social support availability from intimate partnership relationships, and partner support has been documented as a critical factor that helps patients maintain routine medication-taking behavior and prevents treatment abandonment. The presence of a supportive spouse can ameliorate the psychosocial burden of prolonged TB treatment and facilitate problem-solving related to treatment obstacles. In contrast, this study identified no statistically significant association between family history of tuberculosis and incidence of LTFU (p = 1.000), findings consistent with research by Jiang et al. (2023) examining 5-year TB observation data from China. The absence of association between familial TB history and LTFU suggests that prior family experience with TB disease does not independently predict treatment discontinuation rates, possibly because such experience may simultaneously increase both motivation for treatment adherence and psychological distress related to TB outcomes.

Healthcare Worker Services and Patient Treatment Engagement

This study identified a statistically significant association between quality of healthcare services and incidence of LTFU among DS-TB patients (p < 0.001). The quality and supportiveness of healthcare worker services demonstrated one of the most influential effects on treatment discontinuation. These findings align with research by Masita and Andriani (2023) and other studies demonstrating that unsupportive healthcare services and inadequate counseling skills of health workers represent major factors undermining continuity of TB treatment. According to theoretical frameworks in health behavior and research by Mirawati et al. (2019), a significant association exists between healthcare provider attitudes and patient medication adherence. Positive attitudes demonstrated by healthcare providers, encompassing characteristics such as respectful interpersonal interactions, genuine acceptance, establishment of trust relationships, empathetic communication, maintenance of confidentiality, demonstration of respect, and responsiveness to patient concerns, effectively foster patient trust and provider credibility. The bidirectional relationship between healthcare providers and patients substantially impacts treatment success outcomes, with one critical determinant of pulmonary TB treatment adherence being the quality of support provided by healthcare professionals during the prolonged treatment process. Mirawati's work introduces a theoretically important framework suggesting that individual behavior change is most effectively achieved through a process of internalization, wherein the influencing figure, in this case the healthcare provider, must be perceived as trustworthy and possessing high credibility. When TB patients perceive their healthcare providers as genuinely supportive, respectful, and credible, they are substantially more likely to continue treatment despite challenges and maintain engagement with the healthcare system.

Social Support as the Primary Dominant Risk Factor

This study identified low to moderate social support as the most dominant variable influencing loss to follow-up treatment among drug-sensitive TB patients, with an odds ratio (OR) value of 128.708 (p < 0.001; 95% confidence interval [CI] 13.809 to 1,198.216). This finding indicates that patients with low to moderate social support experience approximately 128.7 times greater odds of treatment discontinuation

compared to patients with high social support. These findings demonstrate substantial consistency with research by Tola et al. (2015), which conducted a systematic review of TB treatment non-adherence and loss to follow-up among TB patients with or without human immunodeficiency virus (HIV) in developing countries, concluding that lack of social support plays a major role in the incidence of treatment discontinuation. This finding aligns with research by Rahayu et al. (2023), documenting Maharja's observation that family support represents one of the strongest determinants of LTFU incidence in DS-TB patients, with lack of family support increasing LTFU risk by 5.1 times compared to TB patients with adequate family support. A comprehensive literature review synthesizing findings from 10 previous studies reached consensus that family support plays a crucial and irreplaceable role in facilitating medication adherence among pulmonary TB patients, with this effect substantially impacting patient recovery outcomes. Family support functions as the primary form of social support available to TB patients, providing both physical assistance (such as medication reminders and help with treatment facility access) and psychological comfort to individuals confronting the substantial stress of prolonged illness and treatment. Recent research by Alinaitwe et al. (2025) examining 147 pulmonary TB patients in Uganda documented that 68.7% of patients perceived high family support levels, with 78.9% receiving some form of actual family assistance, most commonly in the form of medication reminders (65.3%), material support (55.8%), encouragement to take TB drugs (48.3%), emotional support (21.8%), and help with prescription refills (21.8%). The multidimensional nature of family support, encompassing informational, emotional, instrumental, and appraisal dimensions, provides comprehensive assistance addressing the various challenges encountered during TB treatment. Additionally, research by Soleman et al. (2021) demonstrated that a significant relationship exists between family support and TB patient adherence behavior ($p = 0.025$), with strong and significant associations between family support and TB treatment compliance levels.

Patient Perspective and Attitude Toward Treatment

The second most dominant variable influencing loss to follow-up treatment among DS-TB patients was poor attitude or negative perspective toward TB treatment, with an odds ratio of 14.74 ($p = 0.014$; 95% CI 1.714 to 126.777). Notably, 90% of all observed LTFU patients demonstrated poor perspective toward TB treatment. This finding demonstrates substantial consistency with research by Mishra et al. (2021), which conducted a qualitative study among the Saharia vulnerable tribal population in Madhya Pradesh, India, documenting that patient perspective toward TB treatment is closely linked to incidence of TB resistance arising from patient treatment discontinuation. The association between negative treatment perspective and treatment dropout aligns with Lawrence Green's theoretical framework on health behavior, which identifies patient perspective toward treatment as a primary predisposing factor for achieving treatment adherence behavior. Poor treatment perspective typically develops through complex interactions with diverse psychosocial and sociocultural factors. When patients hold pessimistic beliefs regarding treatment effectiveness, when they underestimate TB disease severity, when they experience inadequate health literacy regarding TB transmission dynamics and disease consequences, or when they encounter psychosocial barriers such as depression or low self-efficacy, such negative perspectives substantially reduce motivation for sustained treatment engagement. These attitudinal barriers frequently occur concurrently with other socioeconomic and structural obstacles, creating cumulative barriers to treatment continuation.

Study Limitations and Future Research Directions

This study acknowledges several important limitations requiring consideration in interpreting findings. First, the research was conducted exclusively at two hospital facilities located in Medan City over a relatively brief seven-month period; consequently, the generalizability of findings to broader geographical regions, different healthcare settings, or extended time periods remains limited. Results may not adequately represent LTFU patterns among DS-TB patients in other Indonesian provinces or different healthcare system contexts. Second, this study assessed only a limited array of variables potentially contributing to LTFU among drug-sensitive TB patients. Additional psychosocial, economic, health system, and clinical variables not examined in this investigation may substantially influence treatment discontinuation outcomes. Third, the research employed a cross-sectional study design, which involves only a single-time assessment of variables and therefore fundamentally limits the ability to observe temporal relationships, determine causal

directionality, or assess how variables may change or influence each other across time. Longitudinal designs with repeated measurements would strengthen causal inference capabilities.

Fourth, data collection through self-reported questionnaires introduces potential for recall bias, wherein patients may inaccurately remember past experiences or events, and social desirability bias, wherein patients may provide responses they believe are socially acceptable rather than truthful responses. Future research should address these limitations by involving larger numbers of geographically diverse study sites, incorporating more comprehensive variable assessment including economic, health system, and clinical factors, adopting longitudinal study designs enabling temporal observation of variable relationships, and implementing objective data collection methods where feasible to reduce bias. Future investigations should also examine potential mediating and moderating mechanisms through which social support and treatment perspective influence treatment outcomes, investigate culturally specific interventions addressing poor treatment perspective, and evaluate implementation effectiveness of health system strengthening initiatives designed to improve healthcare provider support and patient engagement.

IV.   CONCLUSION

This analytical investigation identified poor perspective toward tuberculosis treatment and low to moderate social support as independent predictors of loss to follow-up (LTFU) treatment among drug-sensitive pulmonary TB patients in Medan, Indonesia. The multivariate logistic regression analysis demonstrated that low to moderate social support emerged as the most dominant variable influencing treatment discontinuation, conferring approximately 128.7 times greater odds of LTFU compared to patients with high social support (odds ratio 128.632; 95% confidence interval 13.809 to 1,198.216). Patient perspective toward treatment represented the second dominant predictor, with poor treatment attitudes increasing LTFU odds by approximately 25.4 times compared to patients holding positive treatment perspectives (odds ratio 25.415; 95% confidence interval 5.569 to 115.985). Additionally, the study confirmed significant associations between LTFU and age, gender, employment status, marital status, and healthcare worker services, whereas education level and family history of TB did not demonstrate statistically significant effects. These findings underscore that psychosocial factors, particularly social support and treatment perspective, substantially outweigh demographic characteristics in determining treatment continuation outcomes among DS-TB patients.

The study acknowledges several methodological limitations that warrant consideration when interpreting results. The research was conducted exclusively in two hospitals in Medan City over a seven-month period, limiting generalizability to broader geographical regions and diverse healthcare settings. The cross-sectional design enabled only single-time measurement of variables, preventing observation of temporal relationships or causal determination. Self-reported questionnaire data may introduce recall bias and social desirability bias in participant responses. These limitations notwithstanding, findings have important practical implications for TB control programs. Healthcare systems should prioritize implementation of comprehensive psychosocial support interventions, including family-centered treatment approaches and peer support programs, to enhance treatment adherence among TB patients. Healthcare providers require training in patient-centered communication, establishment of trust relationships, and delivery of TB-specific health education to address negative treatment perspectives. Future research should employ longitudinal designs, incorporate geographically diverse study sites, assess additional economic and health system variables, and implement objective data collection methods. Investigating culturally tailored interventions addressing poor treatment perspectives and evaluating health system strengthening initiatives will strengthen the evidence base for achieving the World Health Organization's target of 90% TB treatment success rates in Indonesian communities.

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