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Determinant of Rehospitalization among Tuberculosis Patients: A Recurrent-Event Survival Analysis

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ABSTRACT

Background: Tuberculosis (TB) remains a major public health burden, and recurrent hospitalization signals inefficiency and potential care-quality gaps within Indonesia's National Health Insurance (NHI) scheme. This study analyzed factors affecting the hazard of recurrent hospitalization among TB patients at advanced referral health facilities (RHF).

Subjects and Method: This retrospective cohort study used NHI claims data (2022–2023) for tuberculosis (ICD-10 A15–A19) inpatients at advanced RHFs across Indonesia, selected through purposive sampling. From an initial 26,740 hospitalization episodes, screening for data completeness, INA-CBGs case groups, and ICD-10 TB diagnosis criteria yielded 1,574 recurrent hospitalization episodes from 1,202 eligible patients. The dependent variable was time to recurrent hospitalization with its event indicator. Independent variables were disease severity, TB type, NHI participant segment, length of stay, regional area, and referral hospital type. Data were analyzed using Kaplan–Meier estimation, the log-rank test, and the Andersen–Gill recurrent-event survival model in Stata 17.0.

Results: The 1,202 patients contributed 1,574 hospitalization episodes; 271 (22.55%) experienced at least one recurrent hospitalization. In bivariate analysis, patients in Regional 2 (HR= 1.55; 95% CI= 1.158 to 2.08; p= 0.003) and Regional 5 (HR= 1.54; 95% CI= 1.146 to 2.07; p= 0.004) had significantly higher hazard than those in Regional 1. After adjustment, both associations attenuated but remained significant (Regional 2: aHR= 1.54; p= 0.006; Regional 5: aHR= 1.44; p= 0.008). Hospital type, particularly Women and Children's Hospital, showed marginal significance (aHR= 1.7; p= 0.07). Disease severity, TB type, participant segment, and length of stay were not significantly associated with recurrent hospitalization.

Conclusion: Regional area is the strongest factor associated with recurrent hospitalization among TB patients at referral facilities, reflecting geographic disparities in referral care. These findings may inform NHI policy in strengthening the tiered referral system and equalizing service capacity and quality across regions.

Keywords: recurrent hospitalization, tuberculosis, survival analysis, referral facility, health insurance.

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BACKGROUND

Tuberculosis (TB) remains a leading global and national health challenge. This airborne disease, caused by *Mycobacterium tuberculosis*, primarily affects lung tissue, and roughly a quarter of the world's population is estimated to be infected (World Health Organization, 2025). Globally, TB cases in 2023 were projected at 10.8 million, keeping TB among the highest-burden infectious diseases worldwide. Indonesia ranks second globally, contributing about 10% of all cases, with approximately 885,000 cases recorded in 2024 (WHO, 2025). The magnitude of this burden demands a health service system, including its referral mechanism, that operates efficiently and on target.

TB control in Indonesia is delivered in tiers, from first level health facilities to advanced referral health facilities. At referral health facilities, financing uses the Indonesian Case-Based Groups (INA-CBGs), a diagnosis based package payment in which hospitals receive an average tariff for each diagnostic group (Satibi et al., 2019). This packaging can generate tariff differences positive or negative relative to a hospital's real costs because hospital coding is sensitive to prices (Chalkley et al., 2021). Such financial pressure may incentivize suboptimal practices, including recurrent hospitalization, in which a single episode of care is claimed more than once as if it were a series of distinct episodes. High recurrent hospitalization rates create inefficiency that harms both the insurer and patients, and they are widely used as an indicator of poor inpatient care quality (Elasari et al., 2024; Horwitz et al., 2017).

National hospital performance standards require same-cause readmission to remain below one percent; however, readmission in Indonesia remains high, accounting for roughly eleven percent of inpatient claims in 2023 (Pratiwi and Djasri, 2024). Recurrent hospitalization can occur across all diseases, including tuberculosis and is influenced by both clinical and non-clinical determinants. Among clinical determinants case severity and TB type are frequently implicated. Greater clinical severity is associated with higher complication risk, more complex care needs, and post discharge instability, all of which raise the likelihood of readmission (Pratiwi and Djasri, 2024). TB type may also matter extrapulmonary TB has been reported to carry a substantially higher readmission risk than pulmonary TB, reflecting more extensive disease involvement (Feng et al., 2024).

Length of stay (LOS) is another clinical marker linked to readmission. Excessively short stays may discharge patients before full clinical recovery and thereby increase the frequency of return visits (Sari et al., 2018), whereas prolonged or comorbidity driven stays have likewise been associated with higher readmission risk and rising costs (Rinne et al., 2018; Wang et al., 2024; Tonko et al., 2020). Beyond clinical factors, access to financing reflected in the national health insurance participant segment may shape readmission patterns, since segments differ in service access, financial capacity, and continuity of care. Lower socioeconomic groups may face higher readmission risk than wage-earning participants (Englum et al., 2016; Duran et al., 2025; Bayer-Oglesby et al., 2022). In addition, INA-CBG tariffs vary by region and by hospital class, yet a higher tariff does not necessarily reflect greater capacity or better quality. Low-resource hospitals tend to have higher readmission rates (Joynt and Jha, 2011), and substantial regional disparities in hospital utilization and service quality persist across Indonesia (Laksono et al., 2023; Ramos et al., 2020).

Although TB research is abundant, most studies focus on incidence, treatment success, and morbidity or mortality, while comprehensive analyses of recurrent hospitalization

at referral health facilities particularly those using national health insurance claims data and a survival analysis approach remain limited. The present study was therefore conducted to analyze the factors affecting the hazard of recurrent hospitalization among tuberculosis patients at advanced referral health facilities, using a survival analysis of national health insurance data.

SUBJECTS AND METHOD

1. Study Design

This study employed a retrospective cohort design conducted as a desk study of secondary data obtained from official national health insurance. Health sample claims for the 2022–2023 period. The data covered inpatient services for tuberculosis patients at advanced referral health facilities across Indonesia. The study was carried out from February to April 2026.

2. Population and Sample

The source population comprised all national health insurance participants diagnosed with tuberculosis who underwent inpatient care at referral health facilities during 2022–2023 across Regional 1 to Regional 5. A total sampling approach was applied to 26,740 records from the health insurance claims database. A purposive sampling approach was applied for selection based on case group type and primary diagnosis filtering using ICD-10 codes for tuberculosis (A15–A19), the final analytic sample comprised 1,202 patients contributing 1,574 hospitalization episodes.

Inclusion criteria were inpatients with a TB diagnosis (ICD-10 A15–A19) registered as national health insurance participants with a participant identity and visit number, and complete claim variables. Exclusion criteria were records with missing values on any key variable, illogical or incomplete admission/ discharge dates (a discharge date earlier than the admission date), outpatient service types, unidentifiable duplicate claims, and illogical LOS values (zero or negative days).

3. Research Variables

The dependent variable was time to recurrent hospitalization, with recurrent hospitalization serving as the event indicator. A patient who was readmitted after a previous inpatient episode was classified as having an event, whereas a patient with only one inpatient episode during the observation period was treated as censored. The independent variables were case severity, TB type, national health insurance participant segment, length of stay, regional area, and referral hospital type.

4. Operational Definition

Recurrent hospitalization was defined as a return to inpatient care after a previous episode within the observation period (event= 1; censored= 0 at 31 December 2023).

Time to recurrent hospitalization was the interval (in days) between the prior discharge date and the next admission date, or until the end of the observation period for censored records.

Case severity followed the INA-CBG classification into Level I (mild), Level II (moderate), and Level III (severe).

TB type was classified as pulmonary TB (A15–A16) or extrapulmonary TB (A17–A19).

Participant segment reflected the JKN membership category APBD, APBN, wage-earning workers, non-wage workers, and non-workers.

Length of stay was the difference between admission and discharge dates within one episode.

Regional area grouped facilities into regional 1, regional 2, regional 3, regional 4, and Regional 5.

Hospital type classified facilities by class (Type A, B, C, D) and specialty (special lung hospital and mother and child hospital) per the Ministry of Health classification.

5. Study Instrument

The secondary data were obtained from the official national health insurance data portal. The raw data were provided as compressed files and extracted into a spreadsheet containing administrative, membership, and service variables (participant number, visit identifier, admission and discharge dates, length of stay, case-group type, severity level, participant segment, primary diagnosis, regional status, and referral hospital type). Data management and statistical analysis were performed using Stata software.

6. Data Analysis

Recurrent-event data were structured in a counting process format using start, stop, and event variables, allowing each participant to contribute more than one observation interval. Univariate descriptive analysis summarized the frequency and percentage of each categorical variable, together with the number of participants, number of episodes, number of recurrent events, and total time at risk. Kaplan Meier estimation described the probability of remaining free from the first recurrent hospitalization, and the log-rank test compared survival curves across groups. The proportional hazards assumption was examined using the Schoenfeld residual test. Bivariate and multivariate associations were estimated with the Cox proportional-hazards model in the Andersen–Gill framework, with robust (clustered) variance based on participant identity to account for within-patient correlation. Variables with $p< 0.25$ in bivariate analysis, together with substantively relevant variables, were entered into the multivariate model. The significance level was set at $\alpha= 0.05$ (Iskandar, 2015).

7. Research Ethics

This study used identified secondary claims data obtained through the official national health insurance data portal after the researcher completed account registration, submitted a formal data access request, and signed an integrity pact in accordance with the applicable regulations. The study received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Sebelas Maret, under Ethical Approval Number 62/UNS27.06.11/KEP/EC-/2026. Throughout the study, all research activities were conducted in accordance with established ethical principles, including maintaining data confidentiality, protecting the privacy of research subjects, and ensuring the responsible use of sensitive health information in compliance with applicable research ethics standards.

RESULTS

1. Sample Characteristics

A total of 1,202 patients met the study criteria, contributing 1,574 inpatient episodes. Most patients had mild case severity (60.0%), a pulmonary TB diagnosis (72.3%), and were enrolled in the APBD segment (57.6%). Half of the patients received care in Type C hospitals (50.0%), and the largest share came from Regional 1 (32.61%). The mean length of stay was 2.13 days (minimum 1 day, maximum 31 days). The detailed distribution of sample characteristics is presented in Table 1 (see Table 1).

Table 1. Sample characteristics (categorical data, n=1.202)

Characteristics	Frequency	%
Case Severity		
Mild	722	60.00
Moderate	320	26.60
Severe	160	13.30
TB Type		
Pulmonary TB	870	72.30

Characteristics	Frequency	%
Extrapulmonary TB	332	27.60
Participant Segment		
APBD	693	57.60
Wage earning workers	367	30.53
Non-wage Workers	96	7.99
APBN	39	3.24
Non-workers	7	0.58
Length of Stay		
≤ 4 days	1,377	87.48
> 4 days	197	12.52
Hospital Type		
Type A	93	7.74
Type B	334	27.79
Type C	601	50.00
Type D	103	8.57
Special lung hospital	27	2.25
Mother-and-child hospital	44	3.66
Regional Area		
Regional 1	392	32.61
Regional 2	293	24.38
Regional 3	84	6.99
Regional 4	173	14.39
Regional 5	269	21.60

The total time at risk during the study was 124,222 days, accumulated from 1,574 inpatient episodes across 1,202 patients. The median follow-up was 75 days (minimum 1 day, maximum 354 days). Most patients did not experience a recurrent hospitalization (77.45%), whereas 271 patients (22.55%) experienced at least one recurrent hospitalization. The distribution of observation time and recurrent-hospitalization events is presented in Table 2.

Table 2. Observation time and distribution of recurrent hospitalization, n=1.574

Parameter	Value
Total time at risk	124,222 days
Number of patients	1,202
Total number of inpatient episodes	1,574
Median follow-up	75 days
Minimum follow-up	1 day
Maximum follow-up	354 days
Patients without recurrent hospitalization	931 (77.45%)
Patients with ≥ 1 recurrent hospitalization	271 (22.55%)

2. Kaplan-Meier

Log-rank testing of the Kaplan–Meier curves indicated statistically significant differences in the probability of remaining free from the first recurrent hospitalization across regional areas (HR= 13.82; p= 0.008) and hospital types (HR= 14.45; p= 0.013). Case severity (p= 0.670), TB type (p= 0.820), participant segment (p= 0.604), and length of stay (p= 0.184) showed no significant differences (see Table 3). The proportional-hazards assumption was satisfied overall (global Schoenfeld test HR= 31.97; df= 33; p= 0.518), supporting the use of the Andersen–Gill model.

Table 3. Log-rank test of differences in freedom from the first recurrent hospitalization

Independent variables	HR	p
Case severity	0.80	0.670
TB type	0.05	0.820
Participant segment	2.73	0.605
Regional area	13.82	0.008
Length of stay	1.76	0.184
Hospital type	14.45	0.013

a) Kaplan–Meier Curve by Case Severity.

The Kaplan–Meier curves illustrate the probability of remaining free from the first recurrent hospitalization according to case severity (mild, moderate, and severe). Each downward step in the curve represents the occurrence of a recurrent hospitalization event, whereas the flat portions indicate periods during which no recurrent hospitalization occurred. Therefore, curves that remain at a higher level indicate a greater probability of remaining free from recurrent hospitalization throughout the follow-up period.

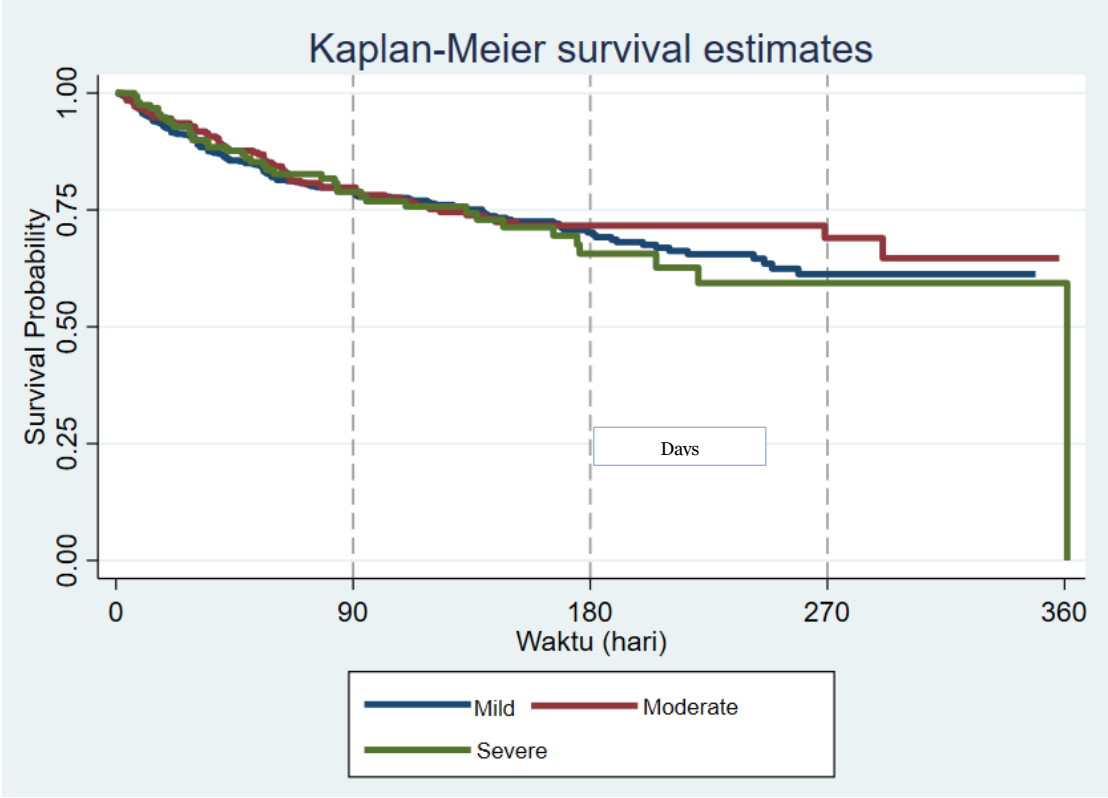


Figure 1. Kaplan–Meier Curve by Case Severity

As shown in figure 1, patients with moderate case severity appeared to experience the first recurrent hospitalization earlier than those with mild or severe disease. This pattern was reflected by an earlier decline in the Kaplan–Meier curve, resulting in a lower probability of remaining free from recurrent hospitalization in the moderate severity group up to approximately 270 days of follow-up. However, the log-rank test showed no

statistically significant difference in the time to first recurrent hospitalization among the three severity groups (p = 0.670).

b) Kaplan–Meier Curve by Tuberculosis Type

The Kaplan–Meier curves illustrate the probability of remaining free from the first recurrent hospitalization among patients with pulmonary tuberculosis (PTB) and extrapulmonary tuberculosis (EPTB)**.** Each downward step in the curve represents the occurrence of a recurrent hospitalization event, whereas the flat portions indicate intervals during which no recurrent hospitalization occurred. Consequently, curves that remain at a higher level indicate a greater probability of remaining free from recurrent hospitalization throughout the follow-up period.

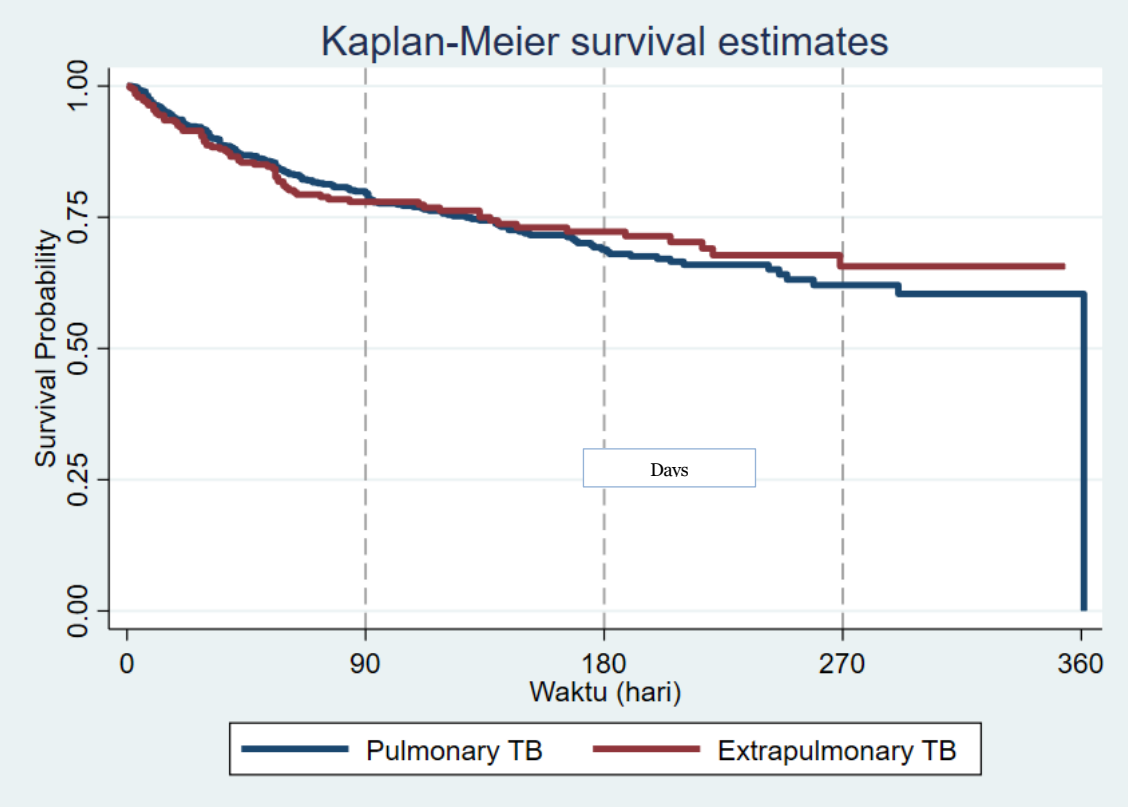


Figure 2. Kaplan–Meier Curve by Tuberculosis Type

As shown in figure 2 the Kaplan–Meier curves suggest that patients with pulmonary tuberculosis had a lower probability of remaining free from the first recurrent hospitalization than those with extrapulmonary tuberculosis during the follow-up period. This visual pattern indicates that patients with pulmonary tuberculosis tended to experience their first recurrent hospitalization earlier than patients with extrapulmonary tuberculosis.

c) Kaplan–Meier Curve by National Health Insurance Participant Segment

The Kaplan–Meier curves illustrate the probability of remaining free from the first recurrent hospitalization across the five National Health Insurance (NHI) participant segments: regional government beneficiaries (APBD), central government beneficiaries (APBN), salaried workers, non-salaried workers, and non-workers. Each downward step in the curve

represents the occurrence of a recurrent hospitalization event, whereas the flat portions indicate intervals during which no recurrent hospitalization occurred. Consequently, curves that remain at a higher level indicate a greater probability of remaining free from recurrent hospitalization throughout the follow-up period.

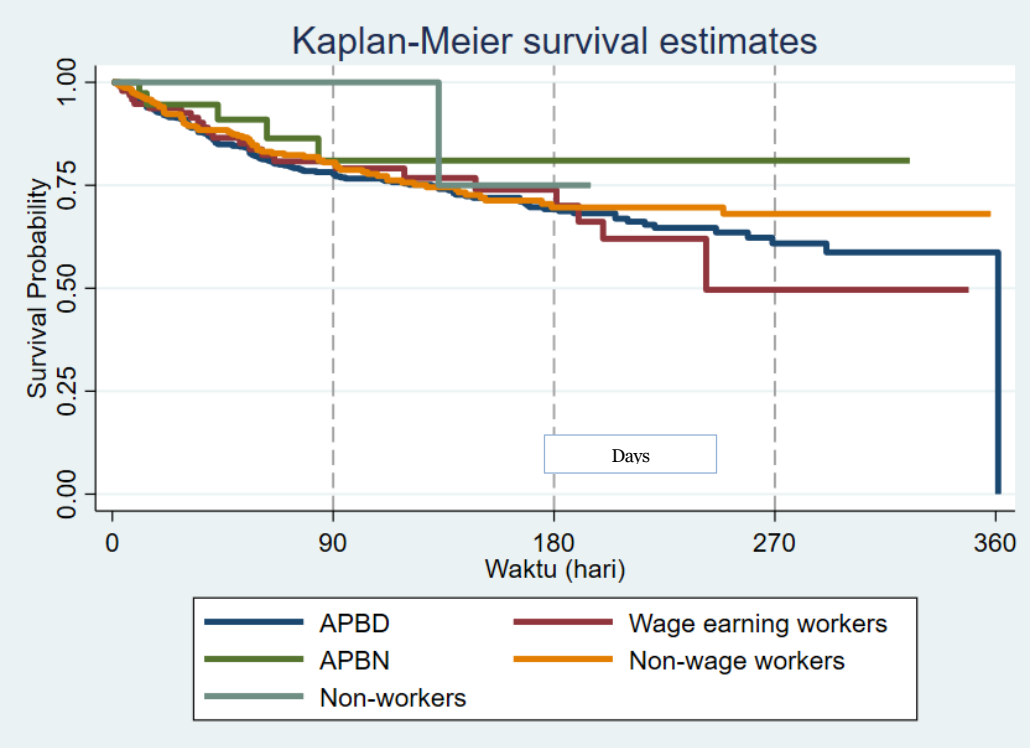


Figure 3. Kaplan–Meier Curve by National Health Insurance Participant Segment

As shown in figure 3 The Kaplan–Meier curves suggest that salaried workers tended to experience the first recurrent hospitalization earlier than participants in the other NHI segments. However, the log-rank test indicated that the difference in time to first recurrent hospitalization among the five participant segments was not statistically significant (p = 0.605).

d) Kaplan–Meier Curve by Length of Stay

The Kaplan–Meier curves illustrate the probability of remaining free from the first recurrent hospitalization according to the length of stay (LOS), which was categorized into ≤4 days and >4 days. The analysis was conducted to compare the time to first recurrent hospitalization between the two LOS groups. Each downward step in the curve represents the occurrence of a recurrent hospitalization event, whereas the flat portions indicate intervals during which no recurrent hospitalization occurred. Consequently, curves that remain at a higher level indicate a greater probability of remaining free from recurrent hospitalization throughout the follow-up period.

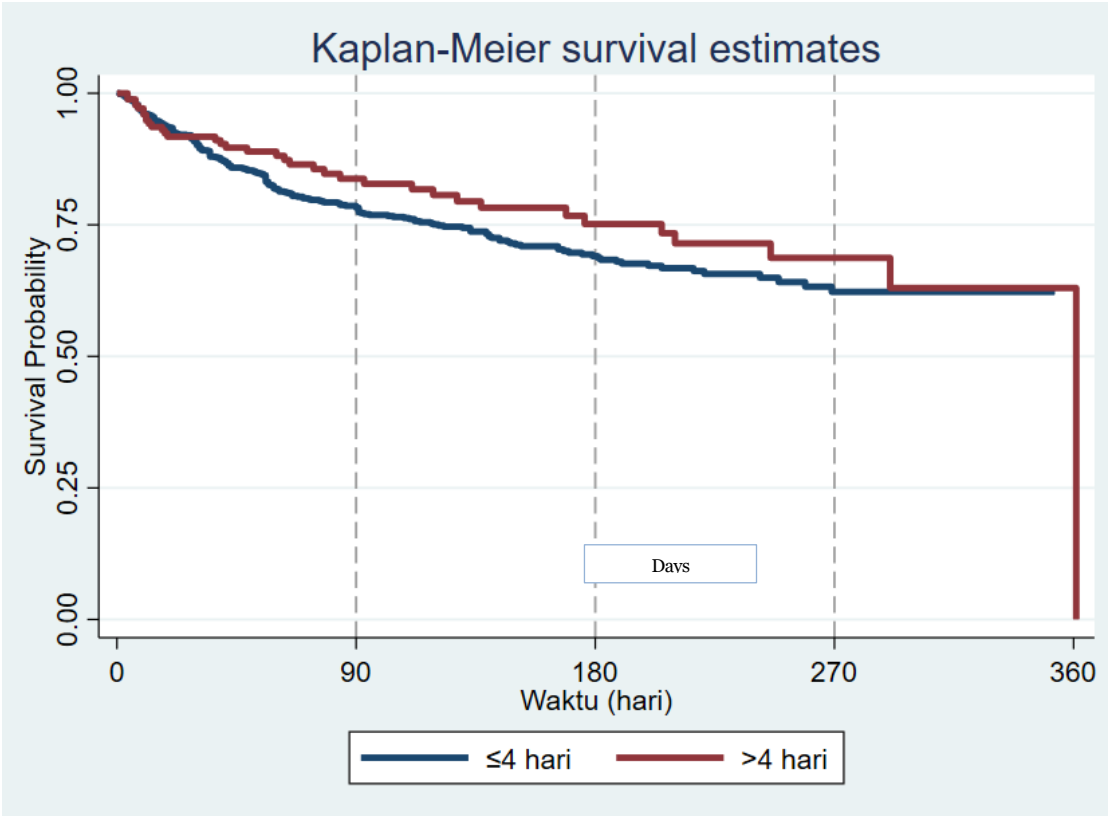


Figure 4. Kaplan–Meier Curve by Length of Stay

As shown in figure 4 patients with an initial hospital stay of ≤4 days appeared to experience the first recurrent hospitalization earlier than those with an initial hospital stay of >4 days, as indicated by the lower Kaplan–Meier curve throughout the follow-up period. However, the log-rank test showed that the difference in time to first recurrent hospitalization between the two groups was not statistically significant **(**p = 0.184).

e) Kaplan–Meier Curve by Regional Area

The Kaplan–Meier curves illustrate the probability of remaining free from the first recurrent hospitalization across the five regional areas regional 1, regional 2, regional 3, regional 4, regional 5. Each downward step in the curve represents the occurrence of a recurrent hospitalization event, whereas the flat portions indicate intervals during which no recurrent hospitalization occurred. Consequently, curves that remain at a higher level indicate a greater probability of remaining free from recurrent hospitalization throughout the follow-up period.

As shown in figure 5 the Kaplan–Meier curves demonstrated distinct patterns in the probability of remaining free from the first recurrent hospitalization across the five regional areas. Patients in Regional V had the lowest survival curve, indicating a lower probability of remaining free from recurrent hospitalization and a tendency to experience the first recurrent hospitalization earlier than patients in the other regional areas. The log-rank test revealed a statistically significant difference in time to first recurrent hospitalization among the five regional areas (p = 0.008).

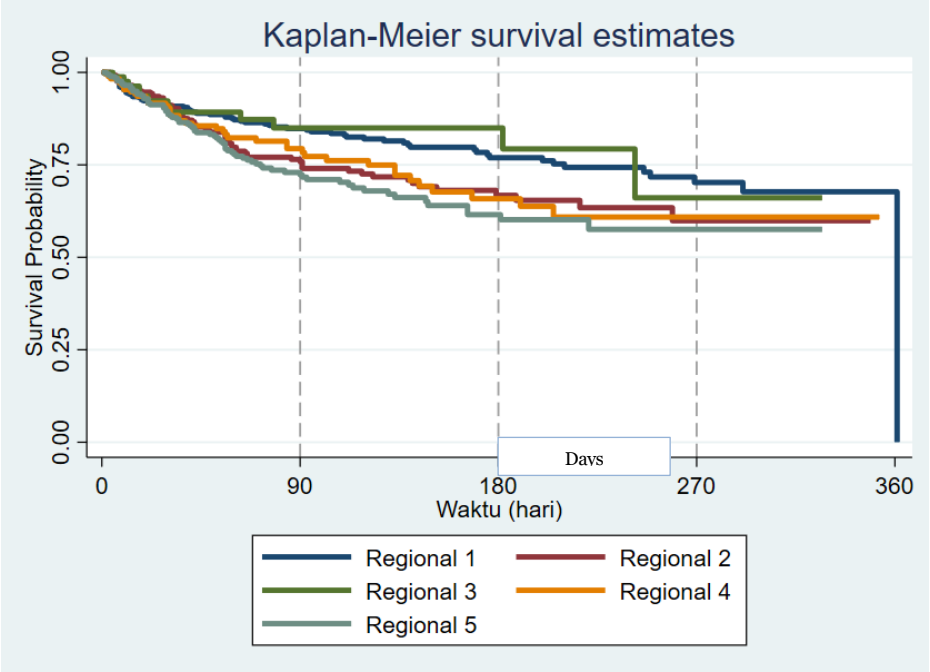


Figure 5. Kaplan–Meier Curve by Regional Area

f) Kaplan–Meier Curve by Referral Hospital Type

The Kaplan–Meier curves illustrate the probability of remaining free from the first recurrent hospitalization across the six referral hospital types: Type A, Type B, Type C, Type D, pulmonary specialty hospitals, and maternal and child hospitals.

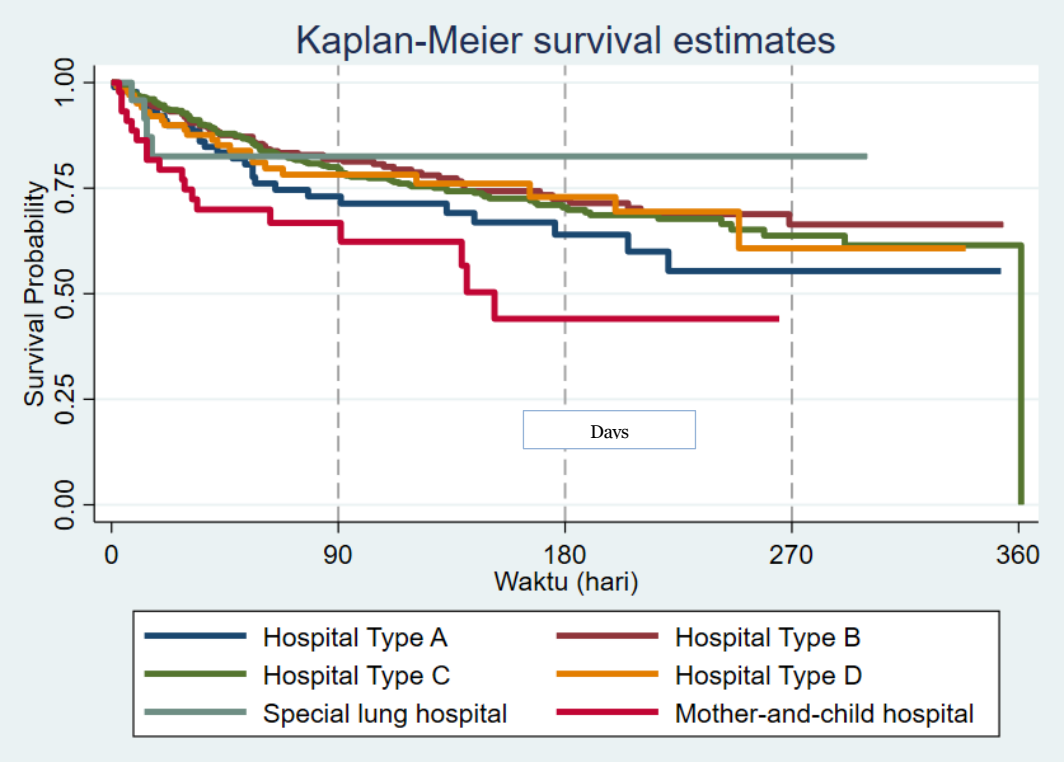


Figure 6. Kaplan–Meier Curve by Referral Hospital Type

Each downward step in the curve represents the occurrence of a recurrent hospitalization event, whereas the flat portions indicate intervals during which no recurrent hospitalization occurred. Consequently, curves that remain at a higher level indicate a greater probability of remaining free from recurrent hospitalization throughout the follow-up period.

As shown in figure 6, patients treated at maternal and child hospitals exhibited the steepest decline in the Kaplan–Meier curve, indicating a lower probability of remaining free from the first recurrent hospitalization and a tendency to experience recurrent hospitalization earlier than patients treated at other hospital types. The log-rank test showed a statistically significant difference in the time to first recurrent hospitalization among the referral hospital types (p = 0.013).

3. Bivariate Analysis

Bivariate analysis was performed using the Andersen–Gill recurrent-event model with robust variance estimation clustered by participant ID to identify factors associated with the risk of recurrent hospitalization among patients with tuberculosis. All independent variables were treated as time-varying covariates and were recorded at each hospitalization episode, allowing their values to change across episodes within the same individual. Consequently, the estimated hazard ratios represent the association between the characteristics observed during a given hospitalization episode and the risk of a subsequent recurrent hospitalization, rather than reflecting fixed baseline characteristics of the individual.

In the bivariate Andersen–Gill recurrent-survival model, regional area was significantly associated with recurrent hospitalization. Patients in Regional 2 had a 55% higher hazard than those in Regional 1 (HR= 1.55; CI 95%= 1.158 to 2.08; p= 0.003), and patients in Regional 5 had a 54% higher hazard (HR= 1.54; CI 95%= 1.146 to 2.07; p= 0.004). No category of case severity, TB type, participant segment, length of stay, or hospital type was significantly associated with recurrent hospitalization, although mother-and-child hospitals showed a borderline higher hazard (HR= 1.74; CI 95%= 0.98 to 3.09; p= 0.06) relative to Type A hospitals (see Table 4).

Table 4. Bivariate analysis of factors associated with recurrent hospitalization (Andersen–Gill recurrent-survival model)

Independent Variables	Recurrent hospitalization		HR	p
	N	%		
Case severity				
Mild	946	60.10	*Reff*	-
Moderate	433	27.51	0.854	0.200
Severe	195	12.39	0.933	0.610
TB type				
Pulmonary	1.156	73.44	*Reff*	-
Extrapulmonary	418	26.56	0.86	0.200
Participant segment				
Regional Revenue and Expenditure Budget (APBD) (ref.)	917	58.26	*Reff*	-
State Revenue and Expenditure Budget (National Budget/ APBN)	118	7.50	0.96	0.835
Wage-earning workers	47	2.99	0.58	0.185
Non-wage workers	485	30.81	0.94	0.613

Independent Variables	Recurrent hospitalization		HR	p
	N	%		
Non-workers	7	0.44	0.41	0.341
Regional area				
Regional 1 (ref)	457	29.03	*Reff*	-
Regional 2	419	26.62	1.55	0.003
Regional 3	106	6.73	0.95	0.845
Regional 4	232	14.74	1.27	0.166
Regional 5	360	22.87	1.54	0.004
Length of stay				
> 4 days (ref)	1.377	87.48	*Reff*	-
≤ 4 days	197	12.52	1.31	0.097
Hospital type				
Type A	120	7.62	*Reff*	-
Type B	438	27.83	0.70	0.085
Type C	796	50.57	0.90	0.562
Type D	135	8.58	0.87	0.595
Special lung hospital	35	2.22	0.98	0.932
Mother-and-child hospital	50	3.18	1.74	0.062

4. Multivariate Analysis

Variables with a p-value of <0.25 in the bivariate analysis and those considered substantively important based on theoretical considerations were entered into the multivariable Andersen–Gill model. In the multivariate Andersen–Gill model, the regional associations attenuated to borderline significance: Regional 2 (aHR= 1.54; CI 95%= 1.13 to 2.09; p= 0.006) and Regional 5 (aHR= 1.52; CI 95%= 1.11 to 2.07; p= 0.008) relative to Regional 1. After adjustment, these regional variables were significantly associated with recurrent hospitalization at the 5% level, and the regional pattern persisted in direction and magnitude (see Table 5).

Table 5. Multivariate analysis of factors associated with recurrent hospitalization (Andersen–Gill recurrent-survival model)

Independent Variables	Full Model				Reduced Model			p
	aHR	95% CI		p	aHR	95% CI		
		Lower limit	Upper limit			Lower limit	Upper limit	
Case severity								
Mild	*Reff*	-	-	-	-	-	-	-
Moderate	0.87	0.68	1.11	0.271	-	-	-	-
Severe	0.94	0.69	1.31	0.745	-	-	-	-
TB type								
Pulmonary	*Reff*	-	-	-	-	-	-	-
Extrapulmonary	0.91	0.71	1.17	0.481	-	-	-	-
Participant segment								
Regional Revenue and Expenditure Budget (APBD)	*Reff*	-	-	-	-	-	-	-
State Revenue and Expenditure Budget (APBN)	0.94	0.64	1.38	0.740	-	-	-	-

Independent Variables	Full Model				Reduced Model			
	aHR	95% CI		p	aHR	95% CI		p
		Lower limit	Upper limit			Lower limit	Upper limit	
Wage-earning workers	0.64	0.28	1.48	0.312	-	-	-	-
Non-wage workers	0.95	0.75	1.21	0.733	-	-	-	-
Non-workers	0.50	0.09	2.74	0.422	-	-	-	-
Regional area								
Regional 1	*Reff*	-	-	-	*Reff*	-	-	-
Regional 2	1.44	0.98	2.12	0.066	1.54	1.13	2.09	0.006
Regional 3	0.93	0.50	1.69	0.806	0.97	0.57	1.69	0.941
Regional 4	1.25	0.82	1.90	0.305	1.29	0.91	1.94	0.144
Regional 5	1.44	0.98	2.11	0.067	1.52	1.11	2.07	0.008
Length of stay								
≤ 4 days	*Reff*	-	-	-	-	-	-	-
> 4 days	1.00	0.66	1.52	0.996	-	-	-	-
Hospital type								
Type A	*Reff*	-	-	-	*Reff*	-	-	-
Type B	0.72	0.48	1.10	0.129	0.76	0.51	1.14	0.192
Type C	0.83	0.56	1.25	0.379	0.89	0.60	1.30	0.553
Type D	0.83	0.49	1.39	0.476	0.89	0.54	1.48	0.664
Special lung hospital	1.00	0.41	2.42	0.96	1.11	0.46	2.68	0.814
Mother-and-child hospital	1.57	0.85	2.92	0.145	1.70	0.94	3.08	0.074

Following model simplification, model fit was assessed by comparing the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) between the full model and the final model. Based on the information criteria, the final model, which included only regional area and referral hospital type (df = 9), demonstrated a better fit than the full model (df = 17). This was evidenced by a reduction in the AIC from 4915.311 to 4903.119 and a substantial decrease in the BIC from 5006.454 to 4951.371. Lower AIC and BIC values indicate a more parsimonious model that achieves a better balance between model fit and complexity. These findings suggest that the model simplification process successfully removed variables that contributed little to explaining the risk of recurrent hospitalization while maintaining an adequate model fit.

DISCUSSION

Case severity was not significantly associated with recurrent hospitalization in either bivariate (Level II: HR= 0.85; p= 0.175; Level III: HR= 0.93; p= 0.655) or multivariate analysis (Level II: aHR= 0.87; p= 0.266; Level III: aHR= 0.95; p= 0.769). This contrasts with earlier reports that more severe cases tend to be readmitted more frequently (Pratiwi and Djasri, 2024). Several explanations are plausible: the predominance of Level I cases (60.0%) and the small proportion of severe cases (13.3%) limited the contrast the model could detect; under coding of severity in INA-CBG claims may have weakened the discriminatory power of this variable; and the Andersen–Gill approach, which models the entire recurrent process with within-patient correction, yields more conservative estimates than cross-sectional designs.

TB type was likewise not significantly associated with recurrent hospitalization

(bivariate HR= 0.86; p= 0.190; multivariate aHR= 0.91; p= 0.481). This differs from Feng et al. (2024), who reported a higher readmission risk for extrapulmonary TB. The divergence may stem from differences in population and method that study focused on elderly patients using propensity score matching and from the fact that ICD-10 claim coding does not capture intra-category clinical severity, bacteriological status, or drug resistance, so the average effect over the observation period approached the null.

Participant segment showed no significant association with recurrent hospitalization across all categories (all p> 0.05; log-rank p= 0.605). This does not align with the theoretical expectation that lower income segments face higher readmission risk than wage earning participants (Englum et al., 2016; Duran et al., 2025). Possible explanations are that segment is a coarse proxy for socioeconomic status that does not capture within segment variation in income, treatment adherence, or social support; that TB treatment is partly financed by the national program outside the INA-CBG scheme, attenuating the influence of class entitlements; and that the small numbers in some segments reduced estimation precision, as reflected in wide confidence intervals. Socioeconomic effects appear to be observed more consistently on length of stay and clinical outcomes than on the frequency of recurrent hospitalization (Bayer Oglesby et al., 2022).

Length of stay was not significantly associated with recurrent hospitalization (bivariate HR= 1.31; p= 0.097; multivariate aHR= 1.00; p= 0.996). This differs from reports linking longer or comorbidity driven stays to higher readmission risk (Sari et al., 2018; Rinne et al., 2018). The main explanation is the highly concentrated LOS distribution (median 1 day), which narrowed between patient variation and the detectable contrast. Moreover, LOS is only an indirect marker of clinical complexity; for TB patients, recurrence is driven more by post-discharge treatment continuity, adherence to anti-TB therapy, and comorbid conditions that are not captured in claims data.

Regional area produced the strongest association signal. In bivariate analysis, patients in Regional 2 (HR= 1.55; CI 95%= 1.16 to 2.08; p= 0.003) and Regional 5 (HR= 1.54; CI 95%= 1.15 to 2.07; p= 0.004) had significantly higher hazards than those in Regional 1, and the difference across regions was confirmed by the log-rank test (p= 0.006). After adjustment, both associations attenuated to borderline significance (Regional 2: p= 0.066; Regional 5: p= 0.065). This pattern is consistent with evidence of geographic disparities in service availability, workforce distribution, and accessibility, which can affect the speed and completeness of TB management and post-discharge continuity of care (Laksono et al., 2023; Ramos et al., 2020). Higher INA-CBG tariffs in certain regions do not necessarily reflect better capacity or quality, underscoring the value of region-sensitive monitoring of recurrent hospitalization.

Hospital type showed mixed results across methods. The log-rank test indicated a significant difference between hospital types (HR^2= 14.85; p= 0.011), and mother-and-child hospitals showed a near-significant elevated hazard in bivariate analysis (HR= 1.74; p= 0.057). After adjustment, however, no hospital-type category was significant at the 5% level (mother-and-child: aHR= 1.58; p= 0.145). The direction is consistent with the observation that patients discharged from lower-resource hospitals tend to be readmitted more often (Joynt and Jha, 2011). The attenuation after adjustment suggests overlap between hospital type and regional variation, given the uneven geographic distribution of hospital types, while the small

numbers in specialty hospitals limited precision.

These findings carry practical and policy implications. The proportion of patients experiencing at least one recurrent hospitalization (22.55%) highlights room for improvement in discharge planning and post-discharge care for TB patients at Referral Health Facilities. For national health insurance and TB program managers, the regional disparity signal can inform strengthening of the tiered referral system, more equitable distribution of service capacity and quality, and consideration of payment mechanisms that are more responsive to readmission risk.

This study has limitations. The administrative claims data do not contain detailed clinical variables such as bacteriological status, drug resistance, treatment adherence, nutritional status, comorbidities, and discharge status, so a large part of the recurrence risk arises from unmeasured factors. Administrative right-censoring at 31 December 2023 meant that some late-occurring events were not observed. In conclusion, regional area was the factor most consistently associated with recurrent hospitalization among TB patients at referral health facilities, indicating geographic disparities in referral care; future research integrating administrative data with clinical records and social-behavioral determinants is recommended to obtain a more comprehensive understanding of recurrent hospitalization in tuberculosis patients

AUTHOR CONTRIBUTION

All authors have made significant contributions to the data analysis and preparation of the final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest in this research.

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