



Proxy-Based Classification of Care Patterns and Social Support Among TB Patients in Papua: A Routine Surveillance Data Analysis

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Abstract

Tuberculosis (TB) remains a major public health challenge in Indonesia, particularly in Papua. However, routine TB surveillance systems do not directly measure caregiver characteristics, limiting evidence on care patterns and social support. This study aimed to construct a proxy-based typology of care patterns and social support from routine TB surveillance data and assess its association with TB treatment success. A retrospective cohort study using secondary data was conducted at Puskesmas Waibhu, Jayapura Regency, Papua. A total of 768 TB treatment episodes from 729 unique patients were included using total sampling. Because the typology was derived from administrative proxies rather than direct caregiver assessment, it was considered exploratory and hypothesis-generating. Data were analyzed using descriptive statistics, chi-square tests, Fisher's exact test, and binary logistic regression. The Low Care–Low Support group was the largest typology. High social support was significantly associated with treatment success in bivariate analysis ($p = 0.012$) and multivariable analysis (adjusted OR = 2.22; 95% CI: 1.24–3.99; $p = 0.007$), whereas the care-pattern proxy was not significantly associated with treatment outcomes. Bacteriologically confirmed diagnosis and unknown diabetes mellitus status were independently associated with lower treatment success. These findings suggest the importance of family social support and the feasibility of a proxy-based typology from routine surveillance data. However, findings should be interpreted cautiously because some episodes originated from the same patients and model explanatory power was modest (pseudo- $R^2 = 0.067$). Prospective studies using direct caregiver assessment are needed for validation.

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1. INTRODUCTION

Tuberculosis (TB) remains one of the world's leading infectious causes of morbidity and mortality despite substantial progress in global TB control efforts. According to the World Health Organization (WHO) Global Tuberculosis Report 2025, an estimated 10.8 million people developed TB in 2024, with Indonesia accounting for approximately 10% of the global TB burden. Indonesia is among the eight countries contributing the largest proportion of TB cases worldwide, while the estimated incidence and mortality increased by 19% and 26%, respectively, between 2015 and 2023 (World Health Organization, 2025). Furthermore, Indonesia contributes nearly 10% of the global gap between estimated and reported TB cases, indicating persistent challenges in case detection, surveillance, and continuity of care (Saktiawati & Probandari, 2025).

The burden of TB remains particularly challenging in Papua Province, where geographical barriers, limited access to health services, and sociocultural diversity continue to affect TB control efforts. Provincial health records documented 6,644 TB cases in 2024, including 896 cases with HIV co-infection, while the provincial case detection rate reached only approximately 55% of the national target of 85%. At the district level, Jayapura Regency where Puskesmas Waibhu is located, reported 1,350 new TB cases in 2025, representing only about 71% of the expected target. These figures indicate potential gaps in TB case detection and access to timely diagnosis; a low case detection rate is consistent with the possibility of underdiagnosis but, on its own, does not establish that diagnosis or treatment initiation was actually delayed. Beyond health-system constraints, treatment adherence and successful completion of therapy are strongly influenced by patients' household environments, family involvement, and available social support.

Family caregivers play a central role in ensuring treatment adherence during the prolonged course of TB therapy, which generally lasts at least six months and may extend further in drug-resistant or clinically complicated cases (Fana & Sotana, 2021). Family nursing theory identifies health care as one of the fundamental functions of the family, encompassing the ability to recognize health problems, make appropriate health decisions, provide direct care, modify the home environment, and utilize available health services (Feinberg et al., 2022). Within TB care, these responsibilities include supervising medication intake, supporting nutritional needs, monitoring symptoms, promoting infection prevention practices, encouraging clinic attendance, and providing continuous emotional support (Sudastra et al., 2026). It is important to note that these caregiving functions are drawn from family nursing theory and the broader caregiving literature; the present study does not directly observe or measure these specific behaviors. As described in the Methods, the proxy indicators used to operationalize the care-pattern construct in this study capture only a narrow, administratively recorded subset of this broader theoretical construct and should not be equated with a direct assessment of family caregiving.

Social support has consistently been recognized as an important correlate of chronic disease management and treatment adherence (Wilder et al., 2021). House conceptualized social support as comprising emotional, instrumental, informational, and appraisal support, each of which contributes to an individual's capacity to cope with illness and maintain health-related behaviors (Drageset, 2021). Within the Papuan context, social support extends beyond the nuclear family to include extended family members, clan (marga) networks, church communities, neighborhood relationships, community health volunteers, and primary healthcare providers. These communal structures represent distinctive sociocultural characteristics that may strengthen caregiving capacity and facilitate successful TB treatment. Consequently, caregiving behavior and social support should be viewed as complementary dimensions: caregiving patterns reflect the family's capacity to provide day-to-day care, whereas social support represents the broader

network of resources that enables caregivers to sustain those responsibilities throughout treatment. These sociocultural structures are presented here as contextual background that motivates the study's theoretical framing. None of these specific relationships — clan affiliation, church involvement, or the identity of accompanying persons — were directly recorded in the TBC.03 SO register used in this study, and any inferences about their role in caregiving capacity remain hypotheses for future research rather than findings of the present study.

Previous studies have demonstrated that family support, caregiver involvement, and PMO supervision are positively associated with medication adherence and TB treatment outcomes (Agus & Rosmiati, 2025; Priyanto & Rossana Rhisky Ambardewi, 2025; Syamsir et al., 2024). However, most existing studies have evaluated these constructs independently using primary caregiver questionnaires or patient-reported measures (Boele et al., 2022). Limited evidence is available regarding how caregiving patterns and social support can be integrated into a comprehensive caregiver classification that reflects the diversity of family caregiving contexts. Moreover, empirical evidence from Papua remains scarce despite its unique sociocultural characteristics, and few studies have explored whether routinely collected TB surveillance data can be utilized to characterize caregiver-related factors. Routine service registers such as the TBC.03 SO Health Facility Register primarily document clinical and programmatic information and were not originally designed to directly measure caregiver behaviors or social support. Nevertheless, several variables contained within these records may serve as proxy indicators that reflect underlying caregiving characteristics and household support systems.

Therefore, this study addresses an important gap by developing proxy measures of care patterns and social support from routinely collected TBC.03 SO data and integrating these proxies into a two-by-two typology. Unlike previous studies that primarily relied on primary survey instruments, the present study explores the feasibility of using secondary routine surveillance data to construct a proxy-based typology of care patterns and social support drawn from routine surveillance data rather than direct caregiver assessment, and to examine its relationship with TB treatment outcomes within a primary healthcare setting in Papua. This proof-of-concept approach provides preliminary empirical evidence that may inform the future development of a standardized caregiver assessment framework, which would need to be validated through primary caregiver surveys. Accordingly, this study aims to describe the distribution of care-pattern and social-support proxies among TB patients treated at Puskesmas Waibhu between 2023 and 2025, construct a proxy-based care-pattern/social-support typology from these indicators, and examine the association between this typology and TB treatment outcomes.

2. METHODS

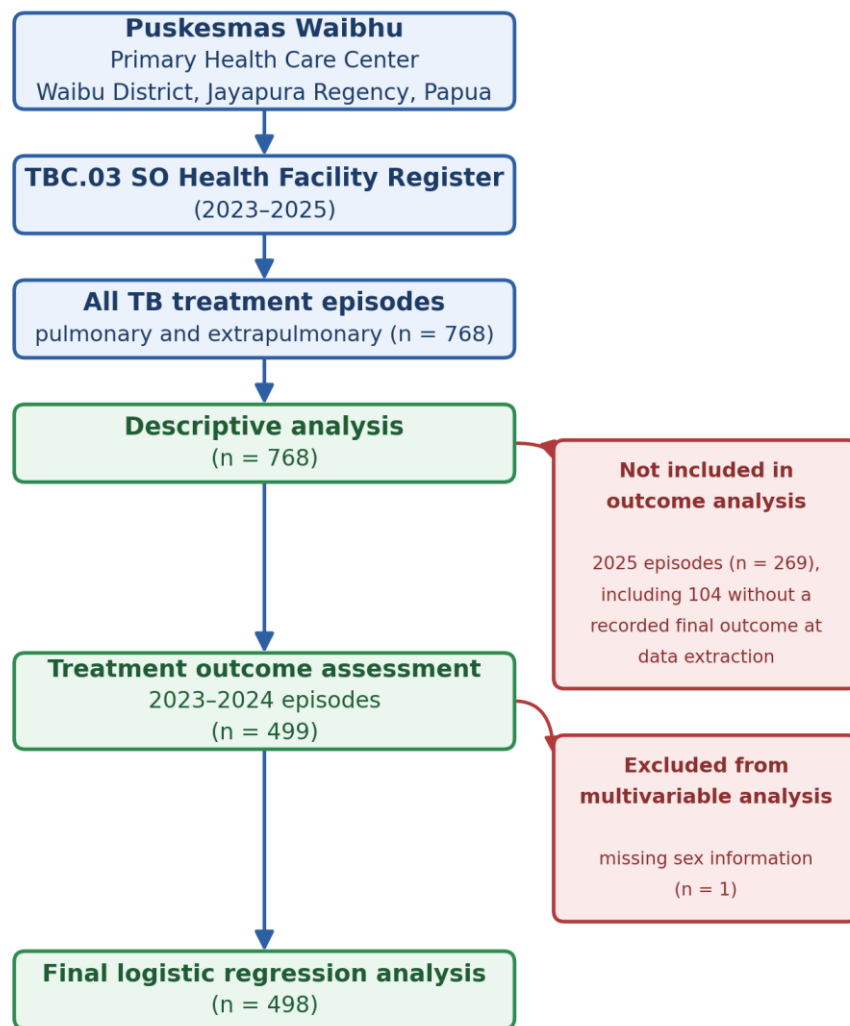
This study employed a descriptive-analytic observational design using routinely collected secondary data. Because the analysis draws on baseline register characteristics recorded at or near treatment initiation and follows each treatment episode forward to its recorded treatment outcome, the temporal structure corresponds more closely to a retrospective (historical) cohort design than to a cross-sectional design, in which exposure and outcome are typically measured at approximately the same point in time; this study is therefore described as a retrospective cohort study using routinely collected surveillance data. The design was selected to explore the association between proxy measures of family caregiving characteristics and tuberculosis (TB) treatment outcomes using existing programmatic records without intervening in patient management.

The study was conducted at Puskesmas Waibhu, Waibu District, Jayapura Regency, Papua Province, Indonesia. Data were obtained from TB treatment episodes

recorded between January 2023 and December 2025 in the TBC.03 SO Health Facility Register of the Indonesian National Tuberculosis Information System. The study population consisted of all TB treatment episodes registered during the study period, encompassing both pulmonary and extrapulmonary disease sites. A total sampling approach was employed, whereby all eligible treatment episodes recorded in the register were included.

The final dataset comprised 768 treatment episodes originating from 729 unique patients identified through the National Identity Number (Nomor Induk Kependudukan, NIK). The difference between treatment episodes and unique individuals reflected patients who underwent retreatment or experienced relapse during different reporting years. Consequently, the unit of analysis in this study was the treatment episode rather than the individual patient. For analyses examining treatment outcomes, only treatment episodes from 2023 and 2024 were included because a substantial proportion of patients registered in 2025 had not yet completed treatment at the time of data extraction. Accordingly, 499 treatment episodes were eligible for bivariate analysis, while one additional episode with incomplete sex information was excluded from multivariable analysis, yielding a final analytical sample of 498 episodes. Each of the 768 records in the merged register corresponds to a distinct, individually registered treatment episode; no duplicate episode records were identified or removed, and the difference between the number of episodes (768) and the number of unique patients (729) reflects genuine repeated treatment episodes (retreatment or relapse) rather than duplicate data entry. Because 768 treatment episodes originated from only 729 unique patients, a small number of patients contributed more than one episode to the analysis, which may violate the independence assumption underlying conventional chi-square tests and logistic regression; this is addressed further below and in the Limitations.

Eligible treatment episodes included all TB cases recorded in the TBC.03 SO Health Facility Register of Puskesmas Waibhu between January 2023 and December 2025, including both pulmonary and extrapulmonary disease sites. "Sufficient information to derive the study variables" specifically required a recorded value for sex, age, TB diagnosis type, anatomical disease classification, HIV status, diabetes mellitus history, household contact-investigation status, and new/previously-treated classification; a treatment episode missing any of these core register fields could not be assigned a Care Pattern, Social Support, or covariate value and was not analyzable for the corresponding table. For analyses examining treatment outcomes, treatment episodes recorded as transferred out, not evaluated, or still on treatment at the time of data extraction were excluded because definitive treatment outcomes were unavailable. In addition, treatment episodes with incomplete information on variables required for multivariable analysis were excluded only from the corresponding regression model (only the single episode with missing sex information described above), while remaining eligible for descriptive analyses where appropriate.



TBC.03 SO = Tuberculosis Register (Sistem Informasi Tuberkulosis)

Note: no duplicate treatment-episode records were identified in the merged register; each of the 768 records corresponds to a distinct registered treatment episode. "TB treatment episodes" includes both pulmonary and extrapulmonary anatomical sites (see Table 5 for the anatomical-site breakdown).

Figure 1. Flow diagram of TB treatment episodes included in the study.

Data were extracted from three annual TBC.03 SO Health Facility Registers (2023–2025) and merged into a single structured database consisting of 768 treatment episodes with 86 original variables and one reporting-year identifier. The primary independent variables were Care Pattern and Social Support, both operationalized as proxy measures derived from routinely collected surveillance data. Care Pattern was constructed using two indicators available within the register: (1) whether household contact investigation had been performed (Yes = 1, No = 0), and (2) whether the patient was classified as a new TB case rather than previously treated (New = 1, Previously treated = 0). The combined score ranged from 0 to 2 and was subsequently categorized into low and high care-pattern groups for caregiver typology analysis. Social Support was operationalized using the patient's referral or accompaniment source. Patients presenting independently were

classified as having low social support, whereas referrals originating from another health facility, community health cadre, or household contact investigation were categorized as high social support. The two Care Pattern indicators were combined into an unweighted sum reflecting registration-level engagement with TB surveillance procedures rather than a validated multidimensional caregiving construct; because household contact investigation is primarily a case-finding/surveillance activity and new-versus-previously-treated status is a disease-history characteristic rather than a caregiver behavior, this score should be interpreted as a proxy for administrative engagement with the TB program rather than as a direct measure of family caregiving capacity, and its construct validity has not been independently established. Similarly, the Social Support indicator, based solely on referral or accompaniment pathway, captures only the healthcare-access dimension of social support and does not directly measure the emotional, instrumental, informational, or appraisal support that patients may or may not have received; a patient presenting independently may nonetheless have substantial family support, while a patient referred through a programmatic pathway may not. This terminology limitation is discussed further in the Discussion and Limitations.

The primary outcome variable was treatment outcome, classified as 'Successful' (cured or treatment completed) and 'Not Successful' (treatment failure, loss to follow-up, or death). A caregiver typology was subsequently derived by combining Care Pattern (Low/High) and Social Support (Low/High), producing four mutually exclusive caregiver categories. To control for potential confounding, six additional covariates available in the register were included: sex, age group (<15 years, 15–59 years, and ≥60 years), TB diagnosis type (bacteriologically confirmed or clinically diagnosed), anatomical disease classification (pulmonary or extrapulmonary), HIV status, and history of diabetes mellitus.

Data management and statistical analyses were performed using Python (pandas, scipy.stats, and statsmodels libraries). Descriptive statistics were used to summarize patient characteristics, caregiver proxy variables, and treatment outcomes. Categorical variables were presented as frequencies and percentages. Associations between caregiver typology, Care Pattern, Social Support, additional covariates, and treatment outcomes were evaluated using Pearson's Chi-square test. Fisher's exact test was applied whenever expected cell frequencies were fewer than five. Variables considered clinically relevant were subsequently entered simultaneously into a binary logistic regression model to estimate adjusted odds ratios (aORs) and 95% confidence intervals. Treatment outcome (Successful = 1; Not Successful = 0) served as the dependent variable. Independent variables included Care Pattern, Social Support, sex, age group, TB diagnosis type, HIV status, and diabetes mellitus history. Anatomical disease classification was excluded from the multivariable model because all extrapulmonary TB cases experienced successful treatment outcomes, resulting in quasi-complete separation and unstable regression coefficient estimates. All statistical tests were two-tailed, and statistical significance was established at $p < 0.05$. Because 768 treatment episodes originated from only 729 unique patients (see above), observations from the same patient may not be fully independent, which could cause conventional chi-square tests and the standard errors from the logistic regression model to be understated.

This study utilized routinely collected secondary program data obtained from the TBC.03 SO Health Facility Register. Personal identifiers, including patient names, national identification numbers, and residential addresses, were removed before analysis to ensure confidentiality. Study findings are presented only in aggregate form, and no individual participant can be identified from the published results. This study used anonymized secondary data routinely collected for tuberculosis surveillance and program monitoring at Puskesmas Waibhu. As the study did not involve direct interaction with

human participants and no personally identifiable information was accessed or reported, formal ethical approval was not required according to the applicable institutional policy. Permission to access and use the data for research purposes was obtained from the Jayapura Regency Health Office and Puskesmas Waibhu as the authorized data custodians. All data were analyzed in aggregate form, and confidentiality was maintained throughout the study.

3. RESULTS AND DISCUSSION

Table 1. Characteristics of TB treatment episodes at Puskesmas Waibhu (n = 768).

Characteristic	n	%
Reporting year		
2023	230	29.9
2024	269	35.0
2025	269	35.0
Sex		
Male	426	55.5
Female	341	44.4
Age group		
<15 years	222	28.9
15–59 years	511	66.5
≥60 years	35	4.6
TB diagnosis		
Clinically diagnosed	454	59.1
Bacteriologically confirmed	314	40.9
Treatment history		
New	647	84.2
Relapse	53	6.9
Treatment after loss to follow-up	25	3.3
Other retreatment	43	5.6

Note: Mean age = 25.5 ± 17.3 years (median = 25 years; range = 0–81 years).

The 768 TB treatment episodes were roughly evenly distributed across the three reporting years, with a somewhat lower share in 2023 (29.9%) than in 2024 and 2025 (35.0% each). Slightly more episodes involved male patients (55.5%) than female patients (44.4%). Mean patient age was 25.5 years (SD 17.3; median 25; range 0–81 years); the age distribution was concentrated in the working-age group (15–59 years, 66.5%), but children under 15 years also made up a substantial share (28.9%), reflecting a considerable pediatric TB burden within the Puskesmas Waibhu catchment area, while older adults (≥60 years) were comparatively few (4.6%). Clinically diagnosed cases outnumbered bacteriologically confirmed cases (59.1% vs. 40.9%), consistent with the more limited availability of bacteriological confirmation (microscopy or molecular testing) at the primary-care level. The large majority of episodes involved newly diagnosed patients (84.2%), with relapse (6.9%), treatment after loss to follow-up (3.3%), and other retreatment (5.6%) together accounting for the remaining episodes.

Table 2. Distribution of care pattern and social support proxies (n = 768)

Variable	Category	n	%
Care Pattern	Low	90	11.7
	Moderate	523	68.1
	High	155	20.2
Social Support	Low (self-presented)	476	62.0
	High (referred/accompanied)	292	38.0

Regarding the two proxy indicators, most treatment episodes fell into the Moderate Care Pattern category (68.1%), meeting only one of the two component criteria (contact investigation performed or new-case status), while the Low (11.7%) and High (20.2%) categories were comparatively smaller; as noted under Table 3, the Moderate category was subsequently merged with Low to construct the two-by-two typology used in the association analyses. For Social Support, most episodes were classified as Low/self-presented (62.0%), with the remaining 38.0% classified as High/referred or accompanied. The joint distribution of the two individual Care Pattern component indicators (contact investigation and new-case status) against one another is not reported separately in this table and would require access to the underlying episode-level dataset to construct; we recommend the authors report this component-level crosstabulation, together with the sensitivity analysis noted under Table 3, before the manuscript is finalized.

Table 3. Distribution of caregiver typology (n = 768)

Caregiver Typology	n	%
Low Care – Low Support	372	48.4
Low Care – High Support	241	31.4
High Care – Low Support	104	13.5
High Care – High Support	51	6.6

Note: The moderate Care Pattern category (contact investigation performed OR new-case status, but not both; combined score = 1) was merged with the low category (combined score = 0) to construct the 2 × 2 caregiver typology, on the rationale that only episodes meeting both component criteria (combined score = 2) were classified as “High” care pattern, so as to define a conservative, high-specificity High Care group; episodes meeting only one criterion were grouped with those meeting neither.

The Low Care–Low Support group was the largest of the four caregiver-typology categories, accounting for nearly half of all treatment episodes (48.4%), followed by Low Care High Support (31.4%). The two High Care categories were considerably smaller, together comprising one-fifth of episodes (High Care–Low Support, 13.5%; High Care High Support, 6.6%), which, as discussed below, limits the statistical power available to detect differences involving these subgroups.

Table 4. Association between caregiver typology, care pattern, social support, and treatment outcome (n = 499).

Variable	Successful n (%)	Not Successful n (%)	p-value
Caregiver typology			0.066
Low Care – Low Support	204 (79.4)	53 (20.6)	
Low Care – High Support	156 (88.1)	21 (11.9)	
High Care – Low Support	33 (80.5)	8 (19.5)	
High Care – High Support	22 (91.7)	2 (8.3)	
Care Pattern			0.875
Low	351 (82.9)	72 (17.1)	
High	64 (84.6)	12 (15.4)	

Social Support		0.012*
Low	257 (79.5)	66 (20.5)
High	156 (88.6)	20 (11.4)

Table 4 shows that treatment success was numerically highest in the High Care High Support group (91.7%) and lowest in the Low Care–Low Support group (79.4%), but this four-category gradient did not reach conventional statistical significance ($p = 0.066$). Considered separately, Care Pattern showed almost no association with treatment outcome (82.9% success for Low vs. 84.6% for High; $p = 0.875$), whereas Social Support showed a clear and statistically significant association, with treatment success considerably higher among episodes classified as High Social Support than Low Social Support (88.6% vs. 79.5%; $p = 0.012$). This pattern a significant marginal association for Social Support alongside a null association for Care Pattern, foreshadows the multivariable results in Table 6, where Social Support, but not Care Pattern, remained independently associated with treatment success.

Table 5. Bivariate analysis of patient characteristics associated with treatment outcome ($n = 499$).

Variable	Successful (%)	Not Successful (%)	Statistical test
Sex			$\chi^2 = 0.05$; $p = 0.823$
Male	82.6	17.4	
Female	83.8	16.2	
Age group			$\chi^2 = 1.83$; $p = 0.401$
<15 years	85.7	14.3	
15–59 years	81.7	18.3	
≥60 years	90.0	10.0	
Diagnosis type			$\chi^2 = 6.33$; $p = 0.012^*$
Clinical	86.8	13.2	
Bacteriological	77.8	22.2	
Anatomical site			Fisher's exact $p = 0.013^*$
Pulmonary	82.3	17.7	
Extrapulmonary	100.0	0.0	
HIV status			$\chi^2 = 4.00$; $p = 0.136$
Negative	84.6	15.4	
Positive	72.9	27.1	
Unknown	84.2	15.8	
Diabetes mellitus			$\chi^2 = 4.17$; $p = 0.125$
No	86.4	13.6	
Yes	72.7	27.3	
Unknown	80.3	19.7	

Note: *Significant at $\alpha=0.05$. A “Not Successful” cell of 0 in the Extrapulmonary TB category caused some expected cell frequencies to fall below 5, so Fisher's exact test was used; this finding is also why the anatomical-site variable was excluded from the multivariate model (see 4.6 and the Limitations section).

None of sex, age group, HIV status, or diabetes mellitus history was significantly associated with treatment outcome in bivariate analysis (all $p > 0.10$), although both HIV-positive status and confirmed diabetes mellitus were associated with numerically lower treatment success (72.9% and 72.7%, respectively) than their reference categories. Diagnosis type and anatomical site were the two variables significantly associated with treatment outcome: clinically diagnosed episodes had higher treatment success than bacteriologically confirmed episodes (86.8% vs. 77.8%; $p = 0.012$), and pulmonary

episodes had lower treatment success than extrapulmonary episodes (82.3% vs. 100.0%; $p = 0.013$); as discussed further below, the extrapulmonary comparison reflects complete separation driven by the small number of extrapulmonary episodes ($n = 25$) with zero unsuccessful outcomes, rather than a stable estimate of a true difference in prognosis.

Table 6. Multivariable logistic regression analysis of factors associated with treatment success ($n = 498$).

Variable	Adjusted OR	95% CI	p-value
High Care Pattern (ref: Low)	1.17	0.55–2.48	0.680
High Social Support (ref: Low)	2.22	1.24–3.99	0.007*
Female (ref: Male)	1.29	0.78–2.15	0.323
Child <15 years (ref: Adult)	0.90	0.46–1.77	0.761
Elderly ≥ 60 years (ref: Adult)	1.57	0.34–7.31	0.562
Bacteriologically confirmed (ref: Clinical)	0.43	0.25–0.76	0.004*
HIV-positive (ref: Negative)	0.53	0.21–1.34	0.182
HIV status unknown (ref: Negative)	1.77	0.82–3.81	0.143
DM history: Yes (ref: No)	0.32	0.07–1.39	0.128
DM history: Unknown (ref: No)	0.53	0.30–0.93	0.027*
Reporting year 2024 (ref: 2023)	0.68	0.40–1.15	0.149

Model fit: Likelihood Ratio $\chi^2 = 30.4$; $df = 11$; $p = 0.0014$; Pseudo- $R^2 = 0.067$.

Note: Adjusted OR = adjusted odds ratio; CI = confidence interval. Variables with $p < 0.05$ are shown in bold.

A binary logistic regression model with treatment outcome (Successful=1) as the dependent variable and all independent variables entered simultaneously produced an overall significant model (LLR $\chi^2=30.4$; $df=11$; $p=0.0014$; Pseudo $R^2=0.067$). The following table presents adjusted Odds Ratios (OR), controlling for all other covariates in the model. After adjusting for all covariates, high Social Support remained significantly associated with treatment success, with its OR actually strengthening relative to the bivariate result (adjusted OR=2.22 vs. the bivariate ratio of 88.6%:11.4% against 79.5%:20.5%). Care Pattern remained non-significant ($p=0.680$), consistent with the bivariate finding. Two new covariates emerged as significant: bacteriologically confirmed diagnosis was associated with lower odds of success (adjusted OR=0.43; $p=0.004$), and unknown DM history status was associated with lower odds of success compared with a recorded “No” (adjusted OR=0.53; $p=0.027$).

DISCUSSION

The present study provides preliminary evidence that social support, rather than the care-pattern proxy, was associated with TB treatment success among patients treated at Puskesmas Waibhu. The main finding was that patients with high social support had significantly higher treatment success compared with those with low social support ($p = 0.012$), and this association remained significant after adjustment for demographic and clinical characteristics (adjusted OR = 2.22; 95% CI: 1.24–3.99; $p = 0.007$). In contrast, the care-pattern proxy was not significantly associated with treatment outcome in either bivariate or multivariable analysis. These findings suggest that the availability of supportive pathways facilitating access to care may play a more measurable role in TB treatment completion than the currently available indicators representing household caregiving processes.

The association between social support and treatment success is consistent with established social support theories. Social support has been described as including emotional, instrumental, informational, and appraisal components, each of which can

influence health behavior and disease management (Wen et al., 2020). In the context of TB care, referral or accompaniment by health facilities, community health cadres, or through contact investigation may represent instrumental and informational support that facilitates timely diagnosis, treatment initiation, follow-up attendance, and adherence throughout the treatment period (Thakur et al., 2025). Patients who enter the healthcare system through an established support pathway may have greater opportunities to receive continuous monitoring and encouragement compared with patients who seek care independently (Divala et al., 2022).

The lack of association between the care-pattern proxy and treatment outcome requires careful interpretation. The indicators used to construct the care-pattern proxy in this study, namely contact investigation status and new-case classification, were derived from routinely collected TB surveillance data and may not adequately represent the multidimensional nature of family caregiving. According to family nursing theory, caregiving involves daily behaviors such as medication supervision, nutritional support, symptom monitoring, infection prevention practices, and assistance in accessing healthcare services (Busebaia et al., 2023). However, these dimensions are not captured in the TBC.03 SO register. One plausible interpretation is that this non-significant finding reflects limitations in proxy measurement rather than a true absence of association between family caregiving and TB outcomes (Lutfian et al., 2025); however, a non-significant association may equally result from limited statistical power, misclassification of the proxy indicators, residual confounding, or a genuinely weak underlying association, and the present data cannot distinguish among these explanations. Future studies using direct caregiver assessment instruments are needed to validate and refine this classification framework.

The four-category caregiver typology was not statistically significantly associated with treatment outcome at the conventional $\alpha = 0.05$ threshold ($p = 0.066$); consistent with the reviewers' guidance, this result is interpreted here as no statistically significant association detected, rather than as a near-significant finding, a trend toward significance, or evidence of an effect. Descriptively, the High Care–High Support group had the highest observed treatment success rate (91.7%), whereas the Low Care–Low Support group had the lowest (79.4%), an absolute difference of approximately 12 percentage points; because this comparison did not reach statistical significance, it should be read as a descriptive, hypothesis-generating pattern rather than as evidence supporting the validity of the four-category typology. The absence of statistical significance may partly reflect the limited sample sizes within the high-care categories, particularly High Care–High Support ($n = 24$) and High Care–Low Support ($n = 41$), which limit statistical power to detect a difference of this magnitude even if a true association exists. This descriptive gradient is hypothesis-generating and warrants evaluation in larger studies with adequate statistical power (Song et al., 2017); it should not, on the basis of the present data, be treated as confirmatory evidence for a multidimensional caregiver classification (Pamungkas et al., 2017).

The interpretation of social support within Papua requires consideration of the local sociocultural context. Papuan communities commonly maintain strong extended-family, clan (*marga*), and church-based networks that may influence pathways to healthcare access and treatment support. It is plausible that patients embedded within stronger community networks are more likely to be accompanied or referred through supportive mechanisms. However, this interpretation remains hypothetical because the current register does not document specific social relationships, clan affiliation, church involvement, or the identity of accompanying persons (Alkhaldi et al., 2025). Future qualitative and quantitative studies involving caregivers and community members are

required to explore how these sociocultural resources influence TB care practices in Papua. The multivariable analysis provides additional evidence that social support represents an important independent factor associated with treatment success: after controlling for sex, age group, diagnosis type, HIV status, diabetes history, and reporting year, high social support remained significantly associated with successful treatment outcomes. Conversely, Care Pattern remained statistically non-significant (adjusted OR = 1.17; $p = 0.680$), further suggesting that the available register-based indicators do not adequately capture actual caregiving behaviors at the household level.

Several clinical characteristics also demonstrated important associations with treatment outcomes. Patients with bacteriologically confirmed TB had significantly lower odds of treatment success compared with clinically diagnosed cases (adjusted OR = 0.43; $p = 0.004$). This finding is consistent with previous TB research suggesting a possible link between bacteriologically confirmed status and higher bacillary burden or more clinically apparent disease; however, disease severity was not directly measured in this study, so this explanation should be treated as one plausible interpretation rather than a demonstrated mechanism, and other factors associated with diagnostic classification (such as differences in case-finding pathway or health-seeking behavior) may also contribute to the observed association. Similarly, unknown diabetes mellitus status was associated with lower odds of treatment success (adjusted OR = 0.53; $p = 0.027$). This finding should not be interpreted as a direct biological effect of unknown DM status but may reflect gaps in screening, documentation, and comprehensive clinical monitoring. Patients without documented DM assessment may also experience less complete evaluation of comorbid conditions during TB management (Boadu et al., 2024; Cáceres et al., 2022; Starshinova et al., 2023). HIV-positive status and confirmed DM history were associated with numerically lower treatment success in descriptive comparisons, but these associations did not reach statistical significance, likely due to limited subgroup sizes; consistent with the interpretive standard applied elsewhere in this manuscript, these non-significant findings are not described as trends toward an effect (Abbas et al., 2022).

The association between anatomical site classification and treatment outcome should be interpreted cautiously. Although extrapulmonary TB was significantly associated with successful treatment in bivariate analysis (Fisher's exact $p = 0.013$), all 25 extrapulmonary TB cases achieved successful treatment outcomes, resulting in complete separation when included in logistic regression. Under such conditions, odds ratio estimates become unstable and cannot be reliably interpreted. This statistical separation reflects a limitation of the available sample size and event distribution, not evidence that anatomical disease classification is clinically unimportant; the fact that all extrapulmonary cases in this dataset happened to achieve successful treatment does not mean that site of disease has no bearing on outcomes, only that the current sample cannot support a stable regression estimate for this variable. Therefore, this variable was excluded from the multivariable model, and the observed association should be considered a descriptive finding requiring confirmation in larger datasets. This study contributes a novel approach by demonstrating the feasibility of using routinely collected TB surveillance data to develop a preliminary caregiver classification framework. Although the current proxy measures cannot replace direct caregiver assessment, the findings highlight the potential value of integrating social-support dimensions into TB program monitoring. Strengthening family and community-based support mechanisms may represent a promising strategy for improving success, particularly in culturally diverse settings such as Papua.

This study has several limitations. First, the care-pattern and social-support variables were derived from indirect proxy indicators available in the TBC.03 SO register, which was designed for TB program reporting rather than direct assessment of caregiver

behaviors; therefore, important dimensions such as medication supervision, emotional support, appraisal support, and family or community affiliation could not be captured, and the resulting typology should be regarded as an exploratory, proxy-based classification rather than a validated measure of family caregiving. Second, the study was conducted in a single primary healthcare facility, limiting the generalizability of findings to other settings in Papua. Third, 269 treatment episodes registered in 2025 (including 104 without a recorded final treatment outcome at the time of data extraction) were excluded from outcome analysis, which may introduce selection bias; Figure 1 has been revised to show this step explicitly. Fourth, because 768 treatment episodes originated from only 729 unique patients, the use of treatment episodes rather than unique individuals as the unit of analysis may introduce non-independence among repeated treatment records from the same patient, which could cause conventional chi-square tests and the logistic regression model's standard errors to be understated; we were not able to re-run the analysis using cluster-robust standard errors, a generalized estimating equation, or a sensitivity analysis restricted to one episode per patient for this revision, because we did not have renewed access to the underlying episode-level dataset, and we recommend the authors conduct this check, as requested by the reviewers, before the manuscript is finalized. Fifth, the decision to merge the moderate Care Pattern category with the low category, and the underlying joint distribution of the two Care Pattern component indicators, both warrant further transparency; as detailed in the notes to Tables 2 and 3, we recommend the authors report the component-level crosstabulation and a sensitivity analysis using an alternative categorization strategy. Sixth, the retrospective secondary-data design limits causal interpretation, and the observed associations should be considered correlational; some caution is also warranted regarding the temporal and causal ordering of the Care Pattern proxy relative to the outcome, since household contact investigation may itself be triggered by index-case characteristics. High proportions of unknown categories for HIV status and diabetes history indicate incomplete comorbidity recording, potentially reducing statistical power and complicating interpretation.

Anatomical site classification was excluded from the multivariable model due to complete separation caused by the absence of unsuccessful outcomes among extrapulmonary TB cases in this sample; as noted above, this reflects a limitation of the available data rather than evidence that anatomical classification is clinically unimportant. Finally, the relatively low pseudo- R^2 of the multivariable model (0.067) indicates that important determinants of treatment success, such as medication adherence, drug-related factors, healthcare accessibility, psychosocial factors (Maynard et al., 2023), and household economic support, were not captured in the available register data. Therefore, these findings should be interpreted as an exploratory proof-of-concept demonstrating the feasibility of constructing a proxy-based care-pattern/social-support typology from routine surveillance data, rather than as a definitive evaluation of caregiver effects. Future studies should validate this framework using prospective designs and caregiver-specific instruments measuring direct caregiving behaviors and multidimensional social support.

4. CONCLUSION

This study demonstrates the feasibility of constructing a preliminary, proxy-based typology of care patterns and social support from routine TB surveillance data in a primary healthcare setting in Papua; it does not demonstrate that this typology accurately classifies actual family caregivers, since family caregivers themselves were not directly identified or assessed. Most TB treatment episodes involved newly diagnosed patients and were characterized by moderate care-pattern indicators with limited social-support pathways,

while the proposed typology identified patients with low levels of both proxies as the largest group. Social support was consistently associated with treatment success, underscoring the importance of referral and accompaniment pathways in maintaining continuity of care, whereas the care-pattern proxy showed no statistically significant relationship with treatment outcomes, possibly because it could not adequately capture actual household caregiving practices, though limited statistical power and other explanations cannot be ruled out. Diagnosis type and completeness of comorbidity assessment were also associated with treatment outcomes. These preliminary findings support further evaluation of social-support measures within routine TB program monitoring and, as a future programmatic implication rather than a direct consequence proven by this study, consideration of ways to strengthen family- and community-based support networks, including church and referral pathways, and to incorporate caregiver or treatment-supervisor information into TB registers. They also provide a foundation for developing and validating direct caregiver-specific instruments and for further evaluating the proposed classification framework, including its Care Pattern component and categorization thresholds, across diverse TB care settings using prospective, adequately powered designs.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Agustina Regina Yufuai contributed to the study conceptualization, methodology, data collection, formal analysis, and manuscript drafting. Dolfinus Yufu Bouway and Katarina Lodia Tururop contributed to data interpretation, supervision, and critical revision of the manuscript. Inriyanti Assa and Lenny Lea Pangkali contributed to data validation, manuscript review, and editing. All authors reviewed and approved the final version of the manuscript.

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DECLARATION OF ARTIFICIAL INTELLIGENCE USE

During the preparation of this manuscript, the authors used generative artificial intelligence (AI)-assisted technology to improve the language, grammar, readability, and overall organization of the manuscript. The AI tool was used solely as a writing support tool and was not involved in the study design, data collection, data analysis, interpretation of findings, or the generation of scientific conclusions. All scientific content, methodological decisions, interpretation of results, and final revisions were reviewed and approved by the authors, who take full responsibility for the accuracy, originality, and integrity of the manuscript.

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