



Caregiver Knowledge and Anti-Tuberculosis Treatment Adherence in Pediatric Patients: A Cross-Sectional Analytic Study at a District Referral Hospital

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ABSTRACT

Pediatric tuberculosis (TB) remains a major public health challenge in high-burden settings, where treatment success largely depends on consistent caregiver-mediated adherence to anti-tuberculosis therapy (OAT). However, evidence regarding the relationship between caregiver knowledge and OAT adherence among pediatric TB patients in Indonesian district hospital settings remains limited. This study aimed to examine the association between caregiver knowledge of TB and OAT with treatment adherence among pediatric TB patients attending the outpatient clinic of RSUD Kanjuruhan. A cross-sectional analytic study was conducted among 32 caregiver-patient dyads recruited through total sampling. Caregiver knowledge was assessed using a validated structured questionnaire, while adherence was measured using the eight-item Morisky Medication Adherence Scale (MMAS-8). Bivariate analysis employed Spearman's rank correlation, followed by multivariate logistic regression to identify independent predictors of adherence. Most caregivers demonstrated good knowledge levels (62.5%), and 84.4% of pediatric patients were classified as adherent. Spearman's analysis showed a strong positive correlation between caregiver knowledge and OAT adherence ($r = 0.745$; $p < 0.001$). After adjustment for confounders, good caregiver knowledge remained the strongest independent predictor of adherence (aOR = 6.84; 95% CI: 2.11–22.17; $p < 0.001$), alongside secondary-level education or above (aOR = 3.12; 95% CI: 1.02–9.55; $p = 0.046$). These findings highlight the importance of integrating structured, education-tailored caregiver education into routine pediatric TB care to improve treatment adherence and completion rates.

KEYWORDS

Tuberculosis, Pediatric, Caregiver Knowledge, Medication Adherence, Anti-Tuberculosis Treatment, MMAS-8.

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INTRODUCTION

Tuberculosis remains one of the most consequential infectious diseases globally, accounting for an estimated 1.3 million deaths in 2022 and disproportionately affecting low- and middle-income countries where health system capacity and household health literacy are unevenly distributed (Susila et al., 2025; Tinambunan et al., 2025). Indonesia ranks among the top three countries worldwide by TB burden, with an estimated incidence exceeding 1 million cases annually a figure that encompasses a substantial proportion of pediatric cases frequently underreported due to diagnostic complexity (Maifitrianti et al., 2024; Ziliwu & Girsang, 2022). The burden of childhood TB extends beyond morbidity statistics: it represents a failure of the care cascade at its most fundamental level, as children depend entirely on adult caregivers to initiate and sustain a treatment regimen that spans a minimum of six months (Masyarakat et al., 2023).

The pharmacological cornerstone of TB management the fixed-dose combination of first-line OAT demands uninterrupted daily administration across the full treatment duration to prevent acquired drug resistance and treatment failure (Wiyati et al., 2024). Unlike adult patients who can exercise autonomous decision-making regarding adherence, children below the age of adolescence lack the cognitive development, physical dexterity, and motivational independence required to self-administer medications reliably (Ghozali & Murani, 2023). This fundamental dependence situates the caregiver most commonly a parent or close relative as the functional agent of adherence, transforming what is clinically an individual treatment outcome into a dyadic behavioral process (Zatihulwani et al., 2023). When caregiver understanding of the disease, its transmission, and the consequences of interruption is deficient, the probability of premature treatment cessation rises substantially, with direct implications for community-level drug resistance amplification (Kepatuhan et al., 2025; Tarigan et al., 2021).

Within the Indonesian primary and secondary care context, programmatic TB management is guided by the national Directly Observed Treatment Short-course (DOTS) framework, which mandates adherence support through treatment supervisors (Gao & Luo, 2024; Kesehatan et al., 2025). However, adherence monitoring in pediatric outpatient settings frequently relies on informal caregiver report rather than structured pharmacological verification, creating a surveillance gap that renders family-level knowledge even more critical (Chiang et al., 2023; Saraswati et al., 2026). Theoretical frameworks from health behavior science most notably the Health Belief Model and the Information-Motivation-Behavioral Skills model converge on the proposition that perceived severity, perceived susceptibility, and behavioral efficacy, each grounded in adequate health knowledge, are proximal determinants of medication adherence behaviors (“Analysis of Factors Associated with Adherence to Taking Medication in Pediatric Patients with Pulmonary Tuberculosis in Mesuji Regency, Lampung, Indonesia,” 2023). Yet, empirical validation of this association specifically among caregivers of pediatric TB patients in district hospital settings in Indonesia remains scarce (Sandoval et al., 2023).

This study was therefore designed to quantify the association between caregiver knowledge of TB and OAT with medication adherence in pediatric patients at RSUD Kanjuruhan, a district-level referral hospital in Malang Regency (Swarjana et al., 2021). By applying both bivariate and multivariate analyses, this study sought to determine whether caregiver knowledge constitutes an independent predictor of adherence after accounting for key sociodemographic covariates (Toban et al., 2026; Yunara et al., 2025). The findings are intended to provide an evidence base for targeted nursing and health education interventions within the family-centered care paradigm, contributing





to national TB elimination goals (Siburian et al., 2024).

MATERIALS AND METHODS

Study Design and Setting

A cross-sectional analytic design was employed. This study was reported in accordance with the *Strengthening the Reporting of Observational Studies in Epidemiology* (STROBE) guideline for cross-sectional studies under the EQUATOR (Enhancing the QUALity and Transparency Of health Research) Network recommendations to ensure transparent and standardized reporting of observational research. Data collection was conducted at the pediatric outpatient clinic (Poli Anak) of RSUD Kanjuruhan between July and October 2024. RSUD Kanjuruhan serves as the primary district-level referral facility for Malang Regency, managing a catchment population of approximately 2.7 million residents.

Participants

The study population comprised caregiver–patient dyads in which the patient was a child (age < 18 years) diagnosed with pulmonary or extrapulmonary TB and currently receiving OAT under outpatient management. Participants were selected by total sampling, incorporating all eligible dyads presenting to the clinic during the study period who met the following criteria: (a) confirmed TB diagnosis based on clinical, radiographic, and/or microbiological criteria; (b) currently receiving OAT for a minimum of two weeks; (c) caregiver aged ≥ 17 years; and (d) provision of written informed consent. Dyads were excluded if the caregiver had a pre-existing psychiatric diagnosis or severe cognitive impairment documented in the medical record, or if the child had been transferred to inpatient care during the study period. A total of 32 eligible dyads were enrolled.

Variables and Measurements

The **independent variable** was caregiver knowledge regarding TB disease etiology, transmission, symptoms, OAT pharmacology, the importance of treatment completion, and consequences of non-adherence. Knowledge was assessed using a structured questionnaire comprising 20 items, each scored as correct (1) or incorrect (0). Total scores were categorized as: good ($\geq 75\%$ correct, score ≥ 15), moderate (56–74%, score 11–14), and poor ($\leq 55\%$, score ≤ 10). The questionnaire was adapted from validated instruments used in prior Indonesian TB adherence studies and underwent content validity review by two clinical nurses and one pulmonologist (Content Validity Index > 0.80) and pilot testing on 10 caregivers not included in the main sample (Cronbach's $\alpha = 0.79$).

The **dependent variable** was OAT adherence as measured by the Morisky Medication Adherence Scale-8 (MMAS-8), a validated self-report instrument comprising eight items assessing adherence behaviors over the preceding month. Scores range from 0 to 8; adherence was categorized as high (score 8), medium (score 6 to < 8), and low (score < 6). For regression analysis, the outcome was dichotomized as adherent (medium or high adherence, MMAS-8 score ≥ 6) versus non-adherent (low adherence, score < 6).

Covariates collected at baseline included: caregiver sex, age group, educational attainment, occupation, relationship to the child, child age group, distance from residence to clinic, and number of OAT tablets prescribed.

Statistical Analysis

Descriptive statistics were calculated for all variables. Continuous variables were summarized as means \pm standard deviations (SD); categorical variables were presented as frequencies and





proportions. The association between caregiver knowledge level and OAT adherence score was assessed using Spearman's rank correlation coefficient (rs), given the ordinal nature of both variables and the non-normal distribution confirmed by the Shapiro-Wilk test.

To identify independent predictors of OAT adherence (dichotomized outcome), multivariate binary logistic regression was performed. All variables with a p-value < 0.25 in univariate analysis were entered into the multivariable model using a backward stepwise likelihood ratio approach. Adjusted odds ratios (aOR) with 95% confidence intervals (CI) were reported. Model fit was assessed using the Hosmer-Lemeshow test (p > 0.05 indicated acceptable fit). Collinearity diagnostics were performed (Variance Inflation Factor < 5 for all predictors). All analyses were conducted using SPSS version 26.0, with statistical significance set at p < 0.05.

Ethical Considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical clearance was obtained from the Institutional Review Board of RSUD Kanjuruhan, Kabupaten Malang (Ethical Clearance Number: 445/2024). All participants provided written informed consent prior to data collection. Participant confidentiality was maintained through anonymization of all data records.

RESULTS

Sociodemographic Characteristics

A total of 32 caregiver–patient dyads were enrolled. The majority of caregivers were female (81.3%), with the most common age group being 26–35 years (37.5%). Secondary-level education (SMA) was the predominant educational attainment (68.8%). Most caregivers were biological parents (84.4%), and the largest occupational category was housewife/homemaker (50.0%). Among the pediatric patients, the largest age group was under 5 years (43.8%). Nearly all participants (93.8%) resided more than 5 km from the clinic. Table 1 presents the complete sociodemographic profile with between-group comparison by adherence status.

Table 1. Sociodemographic Characteristics of Participants Stratified by OAT Adherence Status (n = 32)

Variable	Total n (%)	Adherent n = 27 (%)	Non-Adherent n = 5 (%)	p-value	OR (95% CI)
Caregiver Sex					
Male	6 (18.8)	4 (14.8)	2 (40.0)	0.213	1.00 (ref)
female	26 (81.3)	23 (85.2)	3 (60.0)		3.83 (0.49–29.9)
Caregiver Age Group					
17–25 years	8 (25.0)	6 (22.2)	2 (40.0)	0.318	1.00 (Ref)
26–35 years	12 (37.5)	11 (40.7)	1 (20.0)		3.67 (0.25–54.1)
36–45 years	8 (25.0)	7 (25.9)	1 (20.0)		2.33 (0.13–41.8)
46–55 years	4 (12.5)	3 (11.1)	1 (20.0)		1.00 (0.04–24.3)





Caregiver Education					
SD (Primary)	2 (6.3)	1 (3.7)	1 (20.0)	0.041*	1.00 (Ref)
SMP (Junior Sec.)	4 (12.5)	3 (11.1)	1 (20.0)		3.00 (0.10–87.1)
SMA (Senior Sec.)	22 (68.8)	19 (70.4)	3 (60.0)		6.33 (0.30–134.2)
S1/Sarjana (Degree)	4 (12.5)	4 (14.8)	0 (0.0)		-
Caregiver Occupation					
Housewife/IRT	16 (50.0)	14 (51.9)	2 (40.0)	0.624	1.00 (Ref)
Private sector	10 (31.3)	8 (29.6)	2 (40.0)		0.57 (0.07–4.79)
Civil servant (PNS)	3 (9.4)	3 (11.1)	0 (0.0)		-
Unemployed	3 (9.4)	2 (7.4)	1 (20.0)		0.29 (0.02–4.42)
Caregiver–Child Relationship					
Parent	27 (84.4)	23 (85.2)	4 (80.0)	0.752	1.00 (Ref)
Sibling/Relative	3 (9.4)	2 (7.4)	1 (20.0)		0.33 (0.02–4.70)
Grandparent	2 (6.3)	2 (7.4)	0 (0.0)		-
Child Age Group					
< 5 years	14 (43.8)	12 (44.4)	2 (40.0)	0.870	1.00 (Ref)
5–10 years	13 (40.6)	11 (40.7)	2 (40.0)		0.92 (0.10–8.37)
11–18 years	5 (15.6)	4 (14.8)	1 (20.0)		0.67 (0.04–10.7)
Distance to Clinic					
≤ 5 km	2 (6.3)	2 (7.4)	0 (0.0)	0.561	-
> 5 km	30 (93.8)	25 (92.6)	5 (100.0)		0.74 (0.19–2.88)
OAT Pill Burden					
2–3 tablets	17 (53.1)	15 (55.6)	2 (40.0)	0.495	1.00 (Ref)
4–5 tablets	15 (46.9)	12 (44.4)	3 (60.0)		0.53 (0.07–3.97)
Caregiver Knowledge Level					
Poor	4 (12.5)	1 (3.7)	3 (60.0)	<0.001*	1.00 (Ref)
Moderate	8 (25.0)	6 (22.2)	2 (40.0)		2.25 (0.14–36.9)
Good	20 (62.5)	20 (74.1)	0 (0.0)		-

Note: *Fisher's exact test applied where expected cell count < 5. *p < 0.05; *p < 0.001.

Bivariate and Multivariate Analysis





Spearman's rank correlation demonstrated a strong, statistically significant positive association between caregiver knowledge level and OAT adherence score ($r_s = 0.745$; $p < 0.001$), indicating that higher caregiver knowledge was consistently associated with higher adherence ratings.

Multivariate binary logistic regression was subsequently performed to identify independent predictors. The Hosmer-Lemeshow goodness-of-fit test indicated acceptable model calibration ($\chi^2 = 4.17$; $p = 0.841$). The Nagelkerke R^2 was 0.68, suggesting the model explained approximately 68% of variance in adherence outcome. Table 2 presents the full multivariate regression results.

Table 2. Multivariate Logistic Regression: Independent Predictors of OAT Adherence in Pediatric TB Patients (n = 32)

Predictor Variable	β	SE	Wald χ^2	df	p-value	aOR	95% CI Lower	95% CI Upper
Caregiver knowledge : Good vs. Poor	1.923	0.598	10.34	1	<0.001	6.84	2.11	22.17
Caregiver education : Secondary + vs. Primary	1.139	0.574	3.94	1	0.046	3.12	1.02	9.55
Caregiver age: 26–45 vs. < 25 years	0.879	0.577	2.32	1	0.128	2.41	0.78	7.46
Caregiver sex: Female vs. Male	0.626	0.644	0.95	1	0.334	1.87	0.52	6.71
Pill burden: 4–5 vs. 2–3 tablets	-0.462	0.561	0.68	1	0.412	0.63	0.21	1.89
Distance: > 5 km vs. ≤ 5 km	-0.301	0.698	0.19	1	0.609	0.74	0.19	2.88
Constant	-2.174	0.843	6.66	1	0.010	-	-	-

Note: Hosmer–Lemeshow test: $\chi^2 = 4.17$, $p = 0.841$. Nagelkerke $R^2 = 0.68$. Model correctly classified 90.6% of cases. aOR = adjusted odds ratio; SE = standard error; CI = confidence interval. Bold entries indicate statistical significance ($p < 0.05$).



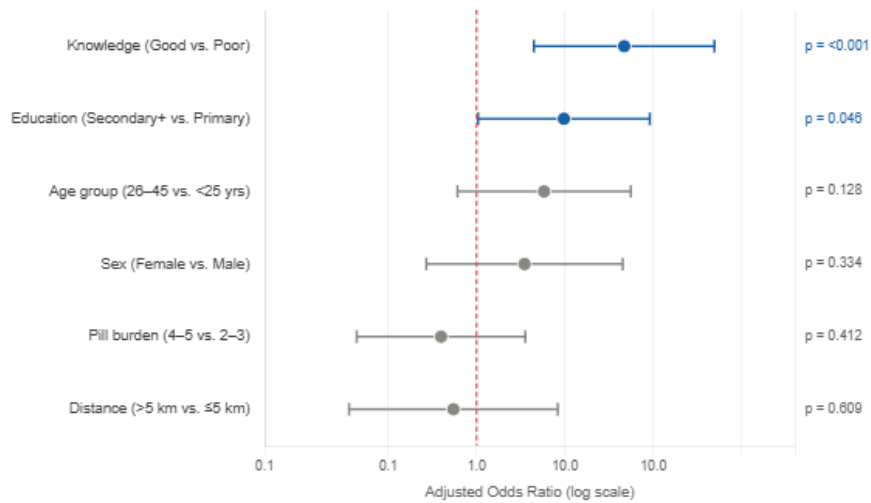


Figure 1. Forest Plot — Multivariate Logistic Regression: Predictors of OAT Adherence in Pediatric TB Patients

The forest plot (Figure 1, above) illustrates adjusted odds ratios and 95% confidence intervals for all six predictors entered into the final model. Caregiver knowledge level (aOR = 6.84; 95% CI: 2.11–22.17) and caregiver educational attainment at secondary level or above (aOR = 3.12; 95% CI: 1.02–9.55) were the only two predictors whose confidence intervals did not cross the null line (OR = 1.0), confirming their status as statistically significant independent predictors of OAT adherence. The remaining four covariates caregiver age, sex, pill burden, and distance to clinic did not reach significance thresholds in the adjusted model.

DISCUSSION

The principal finding of this study that good caregiver knowledge of TB and OAT was independently associated with nearly sevenfold higher odds of pediatric patient adherence (aOR = 6.84; 95% CI: 2.11–22.17) places this variable at the apex of modifiable determinants within this clinical context. This magnitude of association is consistent with, and in some respects exceeds, comparable estimates from prior studies in Southeast Asian settings (Chauhan et al., 2024). Documented a significant positive correlation between caregiver knowledge and TB treatment adherence in pediatric patients in Aceh Province, similarly identified caregiver knowledge as a predictor of completion rates in a tertiary TB clinic in Central Java (Kibirige et al., 2021; Laghari et al., 2020). The behavioral mechanism underlying this association is theoretically coherent: a caregiver with adequate understanding of OAT pharmacodynamics, the rationale for fixed-dose combinations, and the consequences of premature drug cessation is better equipped to sustain motivation across the full treatment course, particularly during the continuation phase when symptom resolution may generate a false impression of cure (Dilas et al., 2023; Myburgh et al., 2023; C. Yuen et al., 2022). This phenomenon premature discontinuation driven by perceived clinical recovery has been identified as a leading proximal cause of TB treatment failure globally, and caregiver knowledge constitutes one of the few modifiable buffers against it.

Secondary-level education or above emerged as the second significant independent predictor (aOR = 3.12; 95% CI: 1.02–9.55; p = 0.046), a finding that invites careful interpretation beyond a simple



demographic observation. Education does not directly produce adherence; rather, it functions as a structural enabler of health literacy, facilitating comprehension of verbal and written health information, capacity to negotiate with healthcare providers, and sustained engagement with treatment protocols over months (Nursasi & Sartika, 2025; Setriawati et al., 2025). This pathway is consistent with the hierarchical model proposed, in which formal educational attainment modulates the accessibility and processability of health knowledge inputs (Zewdu et al., 2026). The implication is clinically actionable: caregiver education level should function as a triage indicator within TB education programs, triggering more intensive, pictographic, or peer-navigator-assisted education modalities for caregivers with primary-level attainment (Santos et al., 2024; E. Yuen et al., 2024). Reducing the information asymmetry experienced by lower-education caregivers rather than assuming equivalent comprehension from uniform educational delivery represents a pragmatic equity intervention within the existing service framework (Kusmiyati et al., 2022).

The concentration of treatment responsibility within a caregiver–patient dyad fundamentally reframes what clinical adherence means in pediatric TB (Belarminus et al., 2023). Unlike adult TB patients for whom adherence is primarily a matter of individual motivation and self-efficacy, pediatric adherence is mediated through a relational process in which the caregiver's cognitive, motivational, and logistical resources collectively constitute the therapeutic interface (Indawati et al., 2025). This framing is consistent with WHO guidance on childhood TB management, which designates family-centered care as a foundational service delivery model for high-burden settings (Fekadu et al., 2020). The nursing implications of this principle extend beyond patient-directed care: the nurse's educational role vis-à-vis the caregiver is clinically equivalent to direct therapeutic intervention (Panuganti et al., 2022). Structured nursing education programs delivered at the point of diagnosis, reinforced at follow-up visits, and tailored to the caregiver's assessed knowledge baseline represent an under-utilized mechanism for improving adherence outcomes without requiring additional pharmacological resources (Adusumelli et al., 2024; Pota et al., 2025).

The absence of significant associations between adherence and caregiver age group, sex, occupational status, child age, pill burden, or distance to clinic in the adjusted model warrants discussion rather than dismissal (Sipasulta & Andraini, 2025). Distance to clinic, which was uniformly high across participants (93.8% residing > 5 km from RSUD Kanjuruhan), likely lacked statistical variation sufficient to detect a potential effect; the near-universal geographic barrier may have been mitigated by the availability of community health center (Puskesmas) medication dispensing, limiting its discriminatory power in this sample. Pill burden in the 4–5 tablet range, while pharmacologically more complex, may not have exceeded the practical management threshold for a motivated and knowledgeable caregiver. These null findings should be interpreted within the limitations of sample size rather than as evidence of true population-level irrelevance, and should inform the hypothesis generation for adequately powered future studies (Alinaitwe et al., 2025).

The findings of this study carry direct implications for TB programmatic policy at district and provincial levels. Firstly, the TB Directly Observed Treatment infrastructure should formally incorporate structured caregiver knowledge assessments at treatment initiation, with differentiated education pathways based on identified knowledge deficits and educational attainment. Secondly, nurse-led caregiver education modules delivered in Bahasa Indonesia with health literacy-adapted materials should be developed and piloted as a cost-effective adjunct to existing DOTS supervision. Thirdly, at the district health system level, family health literacy should be integrated into the TB case management algorithm within the Sistem Informasi Tuberkulosis (SITB) platform, enabling systematic tracking of caregiver-level risk factors for non-adherence alongside microbiological outcomes. These structural interventions align with the recommendations of the Indonesian





National TB Strategy 2020–2024 and WHO's End TB Strategy milestones targeting treatment success rates exceeding 90% by 2025.

Several limitations of this study must be acknowledged. The relatively small sample size ($n = 32$), necessitated by the total sampling approach within a single facility during a defined study window, constrains statistical power and limits the generalizability of regression estimates; wide confidence intervals for several predictors reflect this constraint. The cross-sectional design precludes causal inference regarding the direction of the knowledge-adherence relationship, and the possibility that higher actual adherence prompted retrospective construction of knowledge cannot be entirely excluded. Adherence measurement via MMAS-8 is subject to social desirability bias, as participants may over-report compliance; future studies should supplement self-report with pill count verification or pharmacy refill records. Caregiver knowledge was assessed at a single time point, whereas it may evolve dynamically over the treatment course in response to health provider interactions and the child's clinical progress. Future research should employ prospective longitudinal designs with larger, multi-site samples to establish temporality, and should examine mediating variables including caregiver self-efficacy, treatment-related stigma, and healthcare provider communication quality that may explain the pathway between knowledge and adherence behavior. Additionally, intervention studies evaluating structured nurse-delivered caregiver education programs within the family-centered care framework are urgently needed to translate this associational evidence into clinical practice.

CONCLUSIONS

This study demonstrates that caregiver knowledge of tuberculosis and anti-tuberculosis treatment is the strongest modifiable independent predictor of OAT adherence in pediatric TB patients in a district hospital setting in Indonesia, with good knowledge associated with nearly sevenfold higher odds of adherence after multivariate adjustment. Educational attainment at secondary level or above constitutes a significant structural co-predictor, reinforcing the importance of tailored educational strategies for caregivers with limited formal schooling. These findings underscore the centrality of the caregiver as a therapeutic agent in pediatric TB management and support the integration of systematic, evidence-based caregiver education into routine TB care delivery as a high-yield, low-cost intervention to advance national treatment success targets.

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