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ORIGINAL RESEARCH ARTICLE

Knowledge, Attitude, Access to Health Services, Social Support and Tuberculosis in a Peri-Urban Indonesian Community: A Case-Control Study in Driyorejo, Gresik

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ABSTRACT

Tuberculosis (TB) remains a major public health problem in Indonesia, and behavioral and service-related conditions may influence exposure, care-seeking and prevention in communities. This study examined the associations of knowledge, attitude, access to health services and social support with pulmonary TB in the working area of Driyorejo Community Health Center, Gresik Regency. A community-based case-control study included 56 people with pulmonary TB registered in 2025 and 56 neighborhood controls pair-matched by residence. Scores were analyzed as dichotomous categories (poor ≤ 60% of the maximum score) and as continuous scores using conditional logistic regression adjusted for age, sex and education. Poor knowledge (14.3% vs 7.1%), attitude (19.6% vs 8.9%), access (23.2% vs 10.7%) and social support (21.4% vs 12.5%) were more frequent among cases, but the matched odds ratios (ORs) for these categories were imprecise and not statistically significant. Continuous scores were markedly lower among cases (medians 75.0–80.0% vs 95.0%; all $p < 0.001$). Each 10-point lower score was associated with higher adjusted odds of TB for knowledge (OR 7.12, 95% CI 2.53–20.00), attitude (3.63, 1.94–6.80), access to health services (2.48, 1.56–3.94) and social support (2.65, 1.62–4.35), and the results were robust in sensitivity analyses. Because exposures were measured after diagnosis and socioeconomic, clinical and household factors were not measured, these associations should not be interpreted as causal. TB prevention in this community should strengthen health literacy, accessible services and family support alongside active case finding and attention to structural risk factors.

Introduction

Tuberculosis (TB), caused by *Mycobacterium tuberculosis*, remains one of the leading infectious causes of death worldwide. In 2024, an estimated 10.7 million people fell ill with TB and more than 1.2 million died, and progress toward the End TB Strategy milestones remains far off track [1]. Indonesia carries about 10% of the global burden, the second-largest national share, and a substantial share of its incident cases is still not diagnosed or notified [1]. The problem is also evident at the local level. Data from Driyorejo Community Health Center show that reported TB cases in Gresik Regency rose from 2,755 in 2022 to 3,388 in 2023 and 3,404 in 2024, and that cases in the health center's own working area increased from 98 in 2024 to 123 in 2025 [2]. Driyorejo is a peri-urban subdistrict with substantial industrial activity, a mobile working-age population and dense settlements, conditions that favor sustained household and community transmission. An earlier study in the same area linked pulmonary TB to household sanitation [3], but the behavioral and health-service conditions of the community have

not been examined. Without such evidence, local programs cannot judge whether health education and service improvement are likely to reduce TB, or whether resources should be directed elsewhere.

Current evidence shows that TB occurrence is shaped by interacting biological, structural and behavioral determinants. Undernutrition, HIV infection, diabetes, smoking, alcohol use, poverty, close contact with an infectious case and crowded or poorly ventilated housing are well-established risk factors, and the burden is concentrated among socially disadvantaged groups [1], [4]. A recent meta-analysis of Indonesian studies reported the largest pooled odds ratios for household contact, malnutrition, inadequate ventilation, diabetes and smoking [5]. Intervention research has confirmed the importance of these structural factors: nutritional supplementation of household contacts reduced TB incidence in a cluster-randomized trial [6], and close exposure carries a high risk of disease, particularly among young children [7].

Behavioral and health-system determinants are thought to act mainly by influencing how long an infectious person remains undiagnosed in the household and community. A systematic review of high-burden countries found that delayed diagnosis was associated with poor TB knowledge, perceived stigma, financial insecurity, long care-seeking pathways and poor access to services [8]. In Indonesia, patients often consult several providers before diagnosis and incur substantial costs despite universal health coverage [9], [10], and population surveys have documented gaps in TB knowledge, negative attitudes and stigma [11], [12], [13]. Studies in Indonesian families and communities have linked knowledge, attitude and family support to TB prevention behavior [14], [15], [16], [17], while health-service organization and family support have been linked to early detection and treatment adherence among people already diagnosed with TB [18], [19], [20], [21]. TB-related stigma further discourages care-seeking and disclosure [22], [23]. Lawrence Green's PRECEDE–PROCEED model provides a coherent framework for these determinants, classifying knowledge and attitude as predisposing factors, access to health services as an enabling factor and social support as a reinforcing factor [24]. Within this framework, the determinants are expected to affect TB occurrence indirectly, through earlier symptom recognition and care-seeking that shorten the infectious period, household prevention practices that reduce exposure, and support for completing evaluation and treatment.

Three gaps remain in this body of evidence. First, most Indonesian studies have used prevention behavior or treatment adherence, rather than TB occurrence, as the outcome, or have included only people already diagnosed with TB [18], [25], [26]; their findings therefore do not show whether the same determinants distinguish people with TB from people without TB in the community. Second, the four Green-framework determinants have usually been examined separately, so their relative contribution within one population is unknown. Third, many local studies report the direction of associations without their precision, which makes it difficult to judge how much confidence program planners can place in them. To our knowledge, no community-based case-control study has addressed these questions in a peri-urban industrial setting such as Driyorejo.

Therefore, this study aimed to determine whether poor knowledge, attitude, access to health services and social support were associated with pulmonary TB among residents of the working area of Driyorejo Community Health Center, Gresik Regency, Indonesia, and to estimate the magnitude and precision of these associations using a community-based case-control design. We hypothesized that each of these determinants would be associated with higher odds of pulmonary TB.

Materials and Methods

Study design and setting: This community-based, pair-matched case-control study was conducted in the ten villages of the working area of Driyorejo Community Health Center, Gresik Regency, East Java, Indonesia, in 2026. The study is reported in accordance with the STROBE guidelines for case-control studies [27].

Cases: Cases were residents of the working area recorded in the health center TB register (Sistem Informasi Tuberkulosis, SITB) as having pulmonary TB notified in 2025. Diagnosis followed the Indonesian national TB guidelines [28]: pulmonary TB was either bacteriologically confirmed by a rapid molecular test (Xpert MTB/RIF) or sputum smear microscopy, or clinically diagnosed by a physician on the basis of symptoms and chest radiography when bacteriological results were negative or unavailable. People with extrapulmonary TB only, those who had moved out of the area and those not found after three home visits were excluded. Cases of all ages were eligible; for the four cases aged under 15 years (3–13 years), the questionnaire was answered by a parent or primary caregiver. Because the register included people on treatment and people who had completed treatment, cases were prevalent rather than newly diagnosed.

Controls: For each case, one control was selected from the same neighborhood unit (rukun tetangga, RT). Households in the RT other than the case's household were listed, one household was selected at random, and one adult (aged 18 years or older) in that household was selected at random. Controls had no record of TB in the health center register and reported no history of TB diagnosis or treatment. At interview, they were screened for TB symptoms (cough for two weeks or longer, hemoptysis, fever, night sweats or unexplained weight loss); people reporting symptoms were not enrolled and were referred to the health center for examination. If the selected person was ineligible or declined, the procedure was repeated in another randomly selected household in the same RT. Cases and controls were therefore drawn from the same source population and were pair-matched on neighborhood of residence only; they were not matched on age, sex or other characteristics.

Sampling: Of the 123 TB cases registered in 2025, 56 were selected by proportionate stratified random sampling, with the number in each of the ten villages proportional to the number of registered cases there, and individual cases drawn at random from the register list of each village. With one matched control per case, the study included 56 matched pairs (112 participants). All participants completed the interview, and no data were missing. One data-entry error (a social-support total recorded as 118 instead of 18) was corrected against the recorded percentage score before analysis.

Variables and measurement: The outcome was TB case status (case or control). The exposures were knowledge and attitude (predisposing factors), access to health services (enabling factor) and social support (reinforcing factor) [24]. Knowledge was measured with 10 statements on the cause, transmission and symptoms of TB, cough etiquette, hand hygiene, ventilation, examination and treatment, and attitude, access to health services and social support were each measured with five statements. All items were answered on a four-point scale (1 = strongly disagree to 4 = strongly agree), and negatively worded or incorrect statements were reverse-scored, giving possible totals of 10–40 for knowledge and 5–20 for the other scales. Each total was expressed as a percentage of the maximum possible score. For the categorical analysis, scores were dichotomized with a cut-off set before data collection: good if the score exceeded 60% of the maximum and poor if it was 60% or lower (knowledge ≤ 24 of 40; attitude, access and social support ≤ 12 of 20). This threshold classifies as poor any respondent who did not give favorable responses to most items. Because any such threshold is arbitrary and dichotomization discards information [29], the scores were also analyzed as continuous variables. All items are listed in Supplementary Table S1. Respondents answered with reference to their situation at the time of interview, that is, after diagnosis for cases. Age, sex, education and occupation were also recorded.

Validity and reliability: The questionnaire was pilot-tested on 25 respondents with similar characteristics outside the study sample. Item validity was assessed with Pearson product-moment correlation between each item and the total score, and an item was considered valid when r exceeded the critical value of 0.396 (df = 23, $\alpha = 0.05$). Internal consistency was assessed with Cronbach's α, with $\alpha > 0.60$ considered acceptable. All items used in the final questionnaire met the validity criterion, and all four scales met the reliability criterion.

Data collection: The questionnaire was administered face-to-face in respondents' homes by the research team. Because cases were identified from the TB register, the interviewer was aware of each respondent's case or control status. Information on the diagnosis and treatment status of cases was taken from the register.

Statistical analysis: Characteristics of cases and controls were compared using the Mann–Whitney U test for age and the chi-square test with Monte Carlo permutation p-values (20,000 permutations) for categorical variables. For the dichotomized exposures, crude ORs were calculated with 95% CIs using Woolf's logit method and tested with two-sided Fisher's exact test; because of the pair-matched design, matched ORs were also estimated from discordant pairs, with exact 95% CIs and the exact McNemar test [30]. Continuous scores were summarized as medians and interquartile ranges (IQRs) and compared within pairs using the Wilcoxon signed-rank test. Conditional logistic regression was used to estimate the OR of TB per 10-percentage-point lower score, without adjustment and with adjustment for age (years), sex and education (elementary school or less, junior high school, senior high school or higher). Each exposure was modelled separately because the four scores were strongly correlated (Spearman $\rho = 0.68–0.87$). Two sensitivity analyses were performed: excluding the four pairs whose case was a child under 15 years, and excluding the six pairs whose control was a health worker. Data on household TB contact, income, nutritional status, smoking, diabetes and housing conditions were not collected, so these factors could not be included. Analyses were performed in Python 3 with the NumPy and SciPy libraries; $p < 0.05$ was considered statistically significant.

Ethical considerations: The study protocol was reviewed by the Health Research Ethics Committee (KEPK) of Poltekkes Kemenkes Surabaya and declared ethically appropriate in accordance with the WHO 2011 standards and the CIOMS 2016 guidelines (No. EA/4828/KEPK-Poltekkes_Sby/V/2026, 26 July 2026). Participants received an explanation of the study purpose, procedures, risks and their right to withdraw, and adult participants gave written informed consent before the interview; for participants under 18 years, consent was obtained from a parent or guardian. Data were anonymized using numeric codes, stored securely, accessible only to the research team and reported only in aggregate.

Results

All 56 matched pairs (112 participants) were included in the analysis. Their characteristics are shown in Table 1. The sex distribution was identical in the two groups, and mean age was similar, but cases covered a wider age range: four cases (7.1%) were children under 15 years and 11 (19.6%) were older than 55 years, compared with none and two (3.6%) of the controls. Education and occupation also differed. No case had higher education, compared with 10 controls (17.9%); controls included 10 professionals or civil servants, six of whom were health workers, whereas 13 cases (23.2%) were students and five (8.9%) were not working.

Table 1. Characteristics of TB Cases and Controls

Characteristic	Cases (n = 56)	Controls (n = 56)	p	Characteristic	Cases (n = 56)	Controls (n = 56)	p
Age (years), mean ± SD	37.8 ± 19.2	38.9 ± 9.0	0.656	**Sex**			**1.000**
Age group (years)			**0.003**	Male	27 (48.2)	27 (48.2)	
< 15	4 (7.1)	0 (0.0)		Female	29 (51.8)	29 (51.8)	
15–35	21 (37.5)	23 (41.1)		**Occupation**			**< 0.001**
36–55	20 (35.7)	31 (55.4)		Private/factory worker	13 (23.2)	12 (21.4)	
> 55	11 (19.6)	2 (3.6)		Farmer/driver/laborer	11 (19.6)	16 (28.6)	
Education			**0.002**	Trader/self-employed	3 (5.4)	9 (16.1)	
None/not yet in school	4 (7.1)	0 (0.0)		Professional/civil servant	0 (0.0)	10 (17.9)	
Elementary school	8 (14.3)	10 (17.9)		Housewife	11 (19.6)	9 (16.1)	
Junior high school	14 (25.0)	14 (25.0)		Student	13 (23.2)	0 (0.0)	
Senior high school	30 (53.6)	22 (39.3)		Not working	5 (8.9)	0 (0.0)	
Higher education	0 (0.0)	10 (17.9)					

Values are n (%) unless otherwise indicated. p: Mann–Whitney U test for age; chi-square test with Monte Carlo permutation p-values (20,000 permutations) for categorical variables.

When scores were dichotomized, most participants in both groups were classified in the good category: 89.3% for knowledge, 85.7% for attitude, and 83.0% for access to health services and for social support. The poor category was more frequent among cases than controls for knowledge (14.3% vs 7.1%), attitude (19.6% vs 8.9%), access to health services (23.2% vs 10.7%) and social support (21.4% vs 12.5%) (Table 2). The crude ORs ranged from 1.91 to 2.52 and the matched ORs from 1.83 to 3.00, but all CIs included 1, and none of the associations was statistically significant.

Table 2. Poor Knowledge, Attitude, Access to Health Services and Social Support among TB Cases and Controls (Dichotomized Scores)

Variable (poor category)	Cases, n (%)	Controls, n (%)	Crude OR (95% CI)	p	Matched OR (95% CI)	p
Knowledge	8 (14.3)	4 (7.1)	2.17 (0.61–7.66)	0.360	3.00 (0.54–30.39)	0.289
Attitude	11 (19.6)	5 (8.9)	2.49 (0.80–7.72)	0.176	2.50 (0.72–10.92)	0.180
Access to health services	13 (23.2)	6 (10.7)	2.52 (0.88–7.20)	0.129	2.40 (0.79–8.70)	0.143
Social support	12 (21.4)	7 (12.5)	1.91 (0.69–5.28)	0.314	1.83 (0.62–6.04)	0.332

Poor: score ≤ 60% of the maximum (good category is the reference). Crude OR with 95% CI by Woolf's method and two-sided Fisher's exact test. Matched OR = ratio of discordant pairs, with exact 95% CI and exact McNemar test. Discordant pairs (case poor/control good vs case good/control poor): knowledge 6 vs 2; attitude 10 vs 4; access 12 vs 5; social support 11 vs 6.

Analysis of the continuous scores showed a different picture (Table 3). Median scores were lower among cases than controls for all four domains, at 77.5% vs 95.0% for knowledge, 75.0% vs 95.0% for attitude, 80.0% vs 95.0% for access to health services and 75.0% vs 95.0% for social support (all $p < 0.001$). In conditional logistic regression, each 10-point lower score was associated with higher odds of TB. After adjustment for age, sex and education, the ORs were 7.12 (95% CI 2.53–20.00) for knowledge, 3.63 (1.94–6.80) for attitude, 2.48 (1.56–3.94) for access to health services and 2.65 (1.62–4.35) for social support (all $p < 0.001$).

Table 3. Continuous Scores and Odds of TB per 10-Percentage-Point Lower Score (Conditional Logistic Regression)

Domain	Cases, median (IQR)	Controls, median (IQR)	Crude matched OR (95% CI)	Adjusted matched OR (95% CI)
Knowledge	77.5 (71.9–85.0)	95.0 (90.0–97.5)	4.01 (2.05–7.86)	7.12 (2.53–20.00)
Attitude	75.0 (68.8–80.0)	95.0 (90.0–95.0)	2.47 (1.61–3.78)	3.63 (1.94–6.80)
Access to health services	80.0 (70.0–85.0)	95.0 (90.0–100.0)	1.96 (1.36–2.82)	2.48 (1.56–3.94)
Social support	75.0 (65.0–80.0)	95.0 (90.0–95.0)	2.03 (1.44–2.85)	2.65 (1.62–4.35)

Scores are percentages of the maximum possible score, shown as median (interquartile range). p for the difference in scores: Wilcoxon signed-rank test (all p < 0.001). ORs from conditional logistic regression per 10-percentage-point lower score; adjusted for age, sex and education (three categories); p < 0.001 for all crude and adjusted ORs.

The associations were robust in sensitivity analyses. After exclusion of the four pairs with child cases, the adjusted ORs per 10-point lower score were 6.42 (2.39–17.22) for knowledge, 3.39 (1.83–6.29) for attitude, 2.56 (1.57–4.16) for access and 2.56 (1.57–4.17) for social support. After exclusion of the six pairs with health-worker controls, they were 6.59 (2.33–18.58), 3.44 (1.84–6.44), 2.35 (1.49–3.71) and 2.46 (1.52–4.01), respectively. All CIs excluded 1.

Discussion

This pair-matched case-control study found that people with pulmonary TB in Driyorejo had lower knowledge, attitude, perceived access to health services and social support scores than their neighbors without TB. When the scores were dichotomized at 60% of the maximum, the differences were modest and statistically imprecise, with all CIs including 1. When the full information in the scores was used, however, every 10-point lower score was associated with two- to sevenfold higher odds of TB, and these associations remained after adjustment for age, sex and education and after exclusion of child cases or health-worker controls. The hypothesis that poorer status on each determinant would be associated with higher odds of TB was therefore supported for the continuous scores, but not for the predefined categories.

The contrast between the two analyses is mainly methodological. Controls clustered near the top of every scale, with medians of 95%, and cases mostly scored between 65% and 85%, so a cut-off at 60% placed more than 80% of both groups in the good category and concentrated the real difference between groups within that category. With 9–13% of controls classified as poor, the dichotomous analysis also had low power: detecting an OR of 2.5 with 80% power would have required roughly 150 cases and 150 controls rather than 56 of each. Dichotomizing continuous measures is known to discard information, reduce power and make results depend on the chosen threshold [29]. The continuous analysis is therefore the more informative, although the size of its estimates should be interpreted with caution, because ceiling effects among controls and the wide CI for knowledge indicate that the magnitude is uncertain. Using validated instruments that discriminate across the full range of scores would strengthen future studies [31].

The lower knowledge and attitude scores among cases are consistent with Indonesian population surveys that found persistent misconceptions and stigma alongside general awareness of TB [11], [12], [13], and with studies linking knowledge and attitude to TB prevention behavior in families and communities [14], [15], [16], [17]. Those studies, however, used behavior rather than TB occurrence as the outcome. The most plausible pathway from knowledge to TB occurrence operates through care-seeking and household practices: in high-burden countries, poor knowledge has been associated with patient delay [8], which prolongs the infectious period and exposure of household and community contacts. A person's own knowledge is less likely to influence his or her own susceptibility once exposure has occurred, so the association observed here probably reflects a combination of household-level prevention, care-seeking and the broader health literacy and social position that knowledge represents.

Measuring the exposures after diagnosis is a central limitation. In Indonesia, people starting TB treatment receive counselling on transmission, cough etiquette, ventilation and adherence, which would be expected to raise cases' knowledge and attitude scores and bias the ORs toward 1. That cases nevertheless scored lower suggests that this bias did not create the associations, and that the true pre-diagnosis differences may have been at least as large. Other biases may act in the opposite direction. The experience of illness, stigma and treatment may lead cases to report more negative attitudes, poorer access and weaker support; the interviewer was aware of case status; and controls may have given

socially desirable answers, which could partly explain their ceiling scores. Because these biases can act in different directions, the associations cannot be taken to describe conditions before the onset of disease.

Access to health services showed a consistent association, although its effect per 10 points was smaller than that of knowledge. Health-system barriers are well documented. A systematic review of high-burden countries identified distance, costs, complex procedures and care-seeking through multiple providers as causes of diagnostic delay [8], and Indonesian studies have shown that patients often pass through several providers and incur substantial costs despite universal health coverage [9], [10]. Because cases and controls lived in the same neighborhoods, geographic distance was largely held constant by design. The remaining difference therefore probably reflects individual barriers, such as working hours, transport costs, familiarity with procedures and experiences with services, rather than physical distance. At the same time, cases rated access on the basis of their actual experience of diagnosis and treatment, whereas controls who had not needed TB services may have rated it hypothetically, which may have produced differential misclassification.

Most evidence on social support in TB concerns outcomes after diagnosis. Indonesian and international studies have linked family support and motivation to treatment adherence and self-management [18], [19], [20], [26], and the study by Juliasih et al. examined transmission-prevention behavior among people already diagnosed with TB in Surabaya [25]. These findings address a different question from the present study. Social support is also particularly susceptible to reverse causation, because a TB diagnosis can change it: families may mobilize practical and emotional help, but stigma can lead to social withdrawal or discrimination [22], [23]. The lower support scores among cases may therefore partly reflect consequences of the disease rather than conditions that preceded it.

Confounding must also be considered. Controls had more education and included professionals and health workers, whereas cases included children, older adults, students and people not working. Adjustment for age, sex and education and exclusion of health-worker controls changed the estimates little, but socioeconomic status was captured only partly by education, and household TB contact, nutritional status, smoking, diabetes and housing conditions were not measured. These factors are among the strongest determinants of TB [1], [4], [5], [7] and are likely to be correlated with health literacy, attitudes, access and support. The strong correlations among the four scores (ρ = 0.68–0.87) suggest that they reflect a common underlying dimension, such as general health literacy or social position, so their separate contributions cannot be distinguished and they should not be ranked. Evidence that nutritional support [6] and social protection [32] can reduce the TB burden is a reminder that behavioral determinants operate within, and may partly mark, structural conditions.

The findings nevertheless have practical implications for TB control in Driyorejo. People with TB and their households appear to have lower health literacy, less favorable attitudes, more perceived barriers to services and weaker social support than their neighbors, which identifies them as a priority group for community action. Health education on cough etiquette, hand hygiene, ventilation and early examination, delivered through cadres and the health center, is reasonable, but it is more likely to reduce transmission when it is combined with interventions supported by stronger evidence: active case finding and systematic contact investigation, TB preventive treatment for eligible contacts, nutritional support for affected households, reduction of stigma and out-of-pocket costs, and improvement of housing ventilation [1], [6], [23], [32]. In a peri-urban industrial setting, flexible service hours and collaboration with employers may help working adults to obtain examination and complete treatment.

The study has several strengths. Cases and controls were pair-matched by neighborhood, cases were sampled proportionately across all ten villages, diagnoses were verified in the TB register, controls were screened for TB symptoms, and the analysis accounted for matching, used the full information in the scores and was tested in two sensitivity analyses. Its limitations include the small

sample; the use of prevalent cases interviewed after diagnosis, which precludes establishing temporality; possible reverse causation, recall bias and social desirability bias; the lack of interviewer blinding; ceiling effects among controls; proxy responses for child cases; and residual confounding by unmeasured socioeconomic, clinical, household-contact and housing factors. Future studies should enroll newly diagnosed cases and interview them at diagnosis, use blinded interviewers and validated instruments analyzed as continuous scores, and include these additional determinants in multivariable models.

Conclusions

In the Driyorejo community, people with pulmonary TB had lower knowledge, attitude, perceived access to health services and social support scores than their neighbors without TB. These associations were strong and robust when the scores were analyzed as continuous variables, but imprecise when they were dichotomized. Because the exposures were measured after diagnosis and important socioeconomic, clinical and household factors were not measured, the associations cannot be interpreted as causal. Community TB prevention should strengthen health literacy, accessible services and family support, in combination with active case finding, contact investigation and attention to nutritional, socioeconomic and housing determinants. Prospective studies with incident cases are needed to establish the direction of these associations.

Declarations

Author Contributions: Conceptualization, N.N.I., I.T. and R.; methodology, N.N.I., I.T. and R.; data collection, N.N.I.; formal analysis, N.N.I.; writing—original draft preparation, N.N.I.; writing—review and editing, I.T. and R.; supervision, I.T. and R. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and was reviewed by the Health Research Ethics Committee of Poltekkes Kemenkes Surabaya, which declared it ethically appropriate (No. EA/4828/KEPK-Poltekkes_Sby/V/2026, 26 July 2026).

Informed Consent Statement: Written informed consent was obtained from all adult participants before data collection; for participants under 18 years, consent was obtained from a parent or guardian. Participants were informed of the study purpose, procedures, voluntary participation and their right to withdraw at any time without consequences for their health care. Personal identifiers were replaced by codes, and data were kept confidential.

Data Availability Statement: The anonymized data supporting the findings of this study are available from the corresponding author on reasonable request. The data are not publicly available because they contain information that could compromise participant privacy.

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Conflicts of Interest: The authors declare no conflict of interest.

References

[1] World Health Organization, *Global Tuberculosis Report 2025*. Geneva, Switzerland: WHO, 2025. [Publisher]

[2] Puskesmas Driyorejo, *Laporan Program Penanggulangan Tuberkulosis Tahun 2022–2025 [Tuberculosis Control Program Report 2022–2025]*, unpublished internal report. Gresik, Indonesia: Driyorejo Community Health Center, 2025.

[3] M. N. Fitri, P. Hermiyanti, Khambali, S. Setiawan, and M. Marlik, "Kejadian tuberkulosis paru di wilayah kerja Puskesmas Driyorejo dipengaruhi oleh sanitasi rumah," *J. Penelit. Kesehat. Suara Forikes*, vol. 13, no. 3, pp. 861–864, Jul. 2022. [Crossref]

[4] S. Litvinjenko, O. Magwood, S. Wu, and X. Wei, "Burden of tuberculosis among vulnerable populations worldwide: An overview of systematic reviews," *Lancet Infect. Dis.*, vol. 23, no. 12, pp. 1395–1407, Dec. 2023. [Crossref]

[5] R. D. Nindrea *et al.*, "Modifiable and non-modifiable risk factors for tuberculosis among adults in Indonesia: A systematic review and meta-analysis," *Afr. J. Infect. Dis.*, vol. 18, no. 2, pp. 19–28, Mar. 2024. [Crossref]

[6] A. Bhargava *et al.*, "Nutritional supplementation to prevent tuberculosis incidence in household contacts of patients with pulmonary tuberculosis in India (RATIONS): A field-based, open-label, cluster-randomised, controlled trial," *Lancet*, vol. 402, no. 10402, pp. 627–640, Aug. 2023. [Crossref]

[7] L. Martinez *et al.*, "The risk of tuberculosis in children after close exposure: A systematic review and individual-participant meta-analysis," *Lancet*, vol. 395, no. 10228, pp. 973–984, Mar. 2020. [Crossref]

[8] A. K. J. Teo, S. R. Singh, K. Prem, L. Y. Hsu, and S. Yi, "Duration and determinants of delayed tuberculosis diagnosis and treatment in high-burden countries: A mixed-methods systematic review and meta-analysis," *Respir. Res.*, vol. 22, p. 251, Sep. 2021. [Crossref]

[9] B. W. Lestari *et al.*, "Patient pathways and delays to diagnosis and treatment of tuberculosis in an urban setting in Indonesia," *Lancet Reg. Health West. Pac.*, vol. 5, p. 100059, Nov. 2020. [Crossref]

[10] A. Fuady *et al.*, "Cost of seeking care for tuberculosis since the implementation of universal health coverage in Indonesia," *BMC Health Serv. Res.*, vol. 20, p. 502, Jun. 2020. [Crossref]

[11] S. Kaaffah, I. Y. Kusuma, F. S. Renaldi, Y. E. Lestari, A. D. E. Pratiwi, and M. A. Bahar, "Knowledge, attitudes, and perceptions of tuberculosis in Indonesia: A multi-center cross-sectional study," *Infect. Drug Resist.*, vol. 16, pp. 1787–1800, Mar. 2023. [Crossref]

[12] I. M. Puspitasari, R. K. Sinuraya, A. N. Aminudin, and R. R. Kamilah, "Knowledge, attitudes, and preventative behavior toward tuberculosis in university students in Indonesia," *Infect. Drug Resist.*, vol. 15, pp. 4721–4733, Aug. 2022. [Crossref]

[13] I. M. Zulfa and F. D. Yunitasari, "Public knowledge, attitude and stigma towards tuberculosis in Surabaya, Indonesia: Determining associated factors for poor attitude," *Int. J. Health Pharm.*, vol. 5, no. 1, pp. 56–62, Feb. 2025. [Crossref]

[14] A. Amallia, A. Kusumawati, and P. N. Prabamurti, "Perilaku masyarakat dalam pencegahan tuberkulosis di wilayah kerja Puskesmas Manyaran Kota Semarang," *Media Kesehat. Masy. Indones.*, vol. 20, no. 5, pp. 317–326, Oct. 2021. [Crossref]

[15] E. I. Sa'diyah and S. Indarjo, "Perilaku pencegahan penularan tuberkulosis pada keluarga penderita tuberkulosis," *J. Kesehat. Masy. Indones.*, vol. 16, no. 2, pp. 98–107, Jun. 2021. [Crossref]

[16] L. Yunita, R. Rahagia, F. H. Tambuala, A. S. Musrah, A. A. Sainal, and Suprapto, "Effective knowledge and community attitudes in tuberculosis prevention efforts," *J. Health*, vol. 10, no. 2, pp. 186–193, 2023. [Crossref]

[17] L. Nafisah, W. Lestari, and B. Hariyadi, "Determinants of family behavior in tuberculosis prevention: A cross-sectional study in Baturraden II Health Center, Indonesia," *J. Public Health Trop. Coastal Reg.*, vol. 8, no. 1, pp. 40–50, Apr. 2025. [Crossref]

[18] P. P. Siregar, A. Erlangga, A. Andini, A. M. N. Siregar, R. A. M. Lubis, and A. Petri, "Akses pelayanan kesehatan berhubungan terhadap tingkat kepatuhan minum obat pada pasien tuberkulosis di Puskesmas Tuntungan," *J. Pandu Husada*, vol. 7, no. 4, 2026. [Crossref]

[19] R. D. Nindrea, L. C. Ming, and D. R. Agustian, "Family support, motivation, and patient adherence to tuberculosis treatment: Insights from Indonesia," *Afr. J. Infect. Dis.*, vol. 19, no. 2, pp. 43–49, Apr. 2025. [Crossref]

[20] R. Wulandari, A. Kusumawati, and P. N. Prabamurti, "Dukungan sosial keluarga pada pasien TB MDR di Kota Semarang," *Media Kesehat. Masy. Indones.*, vol. 20, no. 1, pp. 41–49, Feb. 2021. [Crossref]

[21] Z. Inayah, M. S. Agustin, A. L. L. Muflihah, R. A. Safitri, and M. P. D. Putra, "Peran Puskesmas dalam peningkatan deteksi dini dan penanganan tuberkulosis di Puskesmas Kebomas Kabupaten Gresik," *J. Dunia Kesmas*, vol. 13, no. 3, pp. 236–241, Jul. 2024. [Crossref]

[22] A. Nasir *et al.*, "Coping efforts made: Psychological burden of people living with tuberculosis due to social stigma in society. A qualitative phenomenology study," *PLoS ONE*, vol. 19, no. 7, p. e0303331, Jul. 2024. [Crossref]

[23] I. Foster *et al.*, "Analysing interventions designed to reduce tuberculosis-related stigma: A scoping review," *PLOS Glob. Public Health*, vol. 2, no. 10, p. e0000989, Oct. 2022. [Crossref]

[24] L. W. Green and M. W. Kreuter, *Health Program Planning: An Educational and Ecological Approach*, 4th ed. New York, NY, USA: McGraw-Hill, 2005.

[25] N. N. Juliasih, L. F. Sakinah, R. M. Sari, and H. Winarso, "Determinants of transmission prevention behavior among tuberculosis patients in Surabaya, Indonesia," *Infect. Prev. Pract.*, vol. 6, no. 4, p. 100404, Dec. 2024. [Crossref]

[26] J. Li *et al.*, "Determinants of self-management behaviors among pulmonary tuberculosis patients: A path analysis," *Infect. Dis. Poverty*, vol. 10, p. 103, Jul. 2021. [Crossref]

[27] E. von Elm *et al.*, "The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies," *Lancet*, vol. 370, no. 9596, pp. 1453–1457, Oct. 2007. [Crossref]

[28] Kementerian Kesehatan Republik Indonesia, *Keputusan Menteri Kesehatan Republik Indonesia Nomor HK.01.07/MENKES/755/2019 tentang Pedoman Nasional Pelayanan Kedokteran Tata Laksana Tuberkulosis*. Jakarta, Indonesia: Kemenkes RI, 2019.

[29] D. G. Altman and P. Royston, "The cost of dichotomising continuous variables," *BMJ*, vol. 332, no. 7549, p. 1080, May 2006. [Crossref]

[30] N. Pearce, "Analysis of matched case-control studies," *BMJ*, vol. 352, p. i969, Feb. 2016. [Crossref]

[31] D. A. E. Pitaloka, I. Y. Kusuma, H. Pratiwi, and I. S. Pradipta, "Development and validation of assessment instrument for the perception and attitude toward tuberculosis among the general population in Indonesia: A Rasch analysis of psychometric properties," *Front. Public Health*, vol. 11, p. 1143120, Sep. 2023. [Crossref]

[32] H. Todd *et al.*, "Social protection interventions for TB-affected households: A scoping review," *Am. J. Trop. Med. Hyg.*, vol. 108, no. 4, pp. 650–659, Apr. 2023. [Crossref]



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