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Original Article

Analysis of risk factors for the incidence of pulmonary tuberculosis in Tebing Tinggi Community Health Center: A cross-sectional study

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Abstract

Background
Pulmonary tuberculosis (TB) remains a persistent public health concern in Indonesia, driven by a complex interplay of individual and environmental risk factors. Understanding these determinants is crucial to enhance disease control strategies at the community level.

Objective
This study aimed to analyze the risk factors associated with the incidence of pulmonary tuberculosis in the working area of Tebing Tinggi Public Health Center, Empat Lawang.

Methods
A quantitative cross-sectional study was conducted involving 76 respondents selected from 321 suspected TB patients using purposive sampling. Data were collected using structured questionnaires. Bivariate analysis was performed using the Chi-Square test, and multivariate analysis was conducted using logistic regression to determine the dominant risk factors.

Results
Bivariate analysis showed that age ($p = 0.04$) and household contact ($p = 0.00$) were significantly associated with the incidence of pulmonary TB, while gender, knowledge, housing density, and ventilation were not ($p > 0.05$). Multivariate analysis revealed that household contact was the most dominant factor influencing TB incidence.

Conclusion
Household contact and older age were significantly associated with pulmonary tuberculosis incidence. Targeted interventions such as household contact tracing and focused health education for older populations are essential to reduce transmission and improve TB control at the community level.

Background

Pulmonary tuberculosis (TB) remains a major public health issue and continues to pose a global challenge, particularly in developing countries such as Indonesia (Ministry of Health, Republic of Indonesia, 2024). According to the Global TB Report 2023, Indonesia ranks second in the world for the highest number of TB cases after India, with an estimated 1,060,000 new cases each year (WHO, 2024). TB not only affects the physical condition of patients but also imposes significant economic, social, and psychological burdens due to the persistent stigma within society (Dam et al., 2022).

At the local level, TB continues to show a relatively high incidence, especially in densely populated areas with poor environmental sanitation (Kk et al., 2025). These conditions indicate that despite the implementation of various national TB control programs, the risk factors associated with TB incidence must continuously be evaluated within the context of each region (Suryani, Ekawati, & Zaman, 2025).

In the working area of the Tebing Tinggi Primary Health Center, data indicate that the incidence of pulmonary TB has remained relatively stable from year to year, with a slight decline. According to health center records, there were 64 cases in 2022, which decreased to 62 in 2023, and further declined to 57 in 2024. In 2024, there were 321 individuals suspected of having TB, of whom 110 were officially notified as TB cases, and 100 patients underwent treatment. Although the number of cases appears to be declining, the notification and treatment rates remain relatively high, suggesting the continued presence of active transmission within the community (Tebing Tinggi Health Center, 2024).

Various risk factors have been identified as contributing to the incidence of pulmonary TB, including age, gender, history of household contact with TB patients, public knowledge about TB, housing density, and ventilation

conditions (V. K. Putri, Zaman, Priyanto, & Ekawati, 2025; Ramayanti, Marita, Yansyah, & Varge, 2024). A previous study by Razak, Rahmadina, and Santiyah (2025) in Central Java revealed that high housing density and poor ventilation significantly contributed to increased TB risk. Additionally, research by Sari and Setyawati (2022) found that household contact with TB patients and low public knowledge levels were significantly associated with TB infection. However, differences in social and environmental contexts across regions necessitate localized analyses of these risk factors.

Age has also been identified as a crucial factor in TB incidence, as immunity tends to decline with age, increasing vulnerability to infection (Fuady et al., 2024). Gender has similarly been linked to differences in risk exposure and access to healthcare services. Men, for example, have been reported to have higher TB incidence rates compared to women, possibly due to behavioral factors such as smoking, greater mobility, and social activity (Fuady et al., 2023).

Public knowledge of TB, including transmission and prevention methods, is a key indicator in controlling disease spread (Dam et al., 2022). A lack of information and health education can delay diagnosis and treatment, worsening the chain of transmission. A study by Huddart et al. (2018) found that individuals with low knowledge levels had twice the risk of contracting TB compared to those with good understanding.

Housing density and ventilation are directly related to the airborne transmission of TB. Overcrowded living conditions and inadequate ventilation systems increase the likelihood of droplet-borne TB transmission (WHO, 2024). The risk of TB infection is substantially higher in enclosed environments with poor air circulation. In many urban and peri-urban areas, this phenomenon is commonly observed due to land scarcity and limited economic resources (Alotaibi et al., 2019).

Despite the abundance of research on TB risk factors, there remains a gap in data coverage at the primary healthcare level, particularly in the Tebing Tinggi region. Few studies have simultaneously explored the relationships among individual factors (age, gender, knowledge), environmental factors (housing density and ventilation), and exposure history (household contact) in relation to pulmonary TB incidence at the local level. Yet, understanding local determinants is essential for designing context-specific and effective intervention strategies. This study aims to address this gap by providing an up-to-date analysis of relevant risk factors.

The objective of this study is to analyze the associations between age, gender, knowledge, household contact history, housing density, and ventilation conditions with the incidence of pulmonary tuberculosis in the working area of the Tebing Tinggi Primary Health Center.

Methods

Study Design

This study employed a quantitative research design with a cross-sectional approach. The approach aimed to identify the relationship between independent and dependent variables by collecting data at a single point in time. The study focused on analyzing the risk factors associated with the incidence of pulmonary tuberculosis within the working area of the Tebing Tinggi Primary Health Center, located in Empat Lawang Regency. The research was conducted from April to May 2025.

Sampling

The population of this study comprised all suspected pulmonary tuberculosis patients recorded at Tebing Tinggi Primary Health Center in 2024, totaling 321 individuals. The sample size was determined using the Slovin formula with a 10% margin of error, resulting in 76 respondents. A purposive sampling technique was employed with the following inclusion criteria: (1) individuals suspected of having pulmonary TB, (2) residents within the working area of Tebing Tinggi Primary Health Center, and (3) able to communicate effectively. The exclusion criteria included patients who were severely ill during the data collection period.

Instruments

The instrument used in this study was a structured questionnaire that had undergone validity and reliability testing. The questionnaire consisted of items assessing the independent variables, including age, gender, knowledge, household contact history, housing

density, and ventilation. The dependent variable was the incidence of pulmonary tuberculosis.

Data Collection

Data were collected through direct interviews using the structured questionnaire with respondents who met the inclusion criteria. In addition, secondary data were obtained from reports provided by Tebing Tinggi Primary Health Center. The data collection process was carried out by the researcher with the assistance of trained enumerators to ensure the quality and ethical standards of the interviews.

Data Analysis

The collected data were analyzed through three statistical stages. First, univariate analysis was conducted to describe the distribution, frequencies, and proportions of each variable, providing an overview of respondents' characteristics. Second, bivariate analysis was performed using the Chi-Square test to examine the association between each independent variable—such as age, gender, knowledge, household contact, housing density, and ventilation—and the dependent variable, which was the incidence of pulmonary tuberculosis. Variables that demonstrated a p-value of less than 0.25 in the bivariate analysis were subsequently included in the multivariate analysis. Finally, multivariate analysis using multiple logistic regression was employed to identify the most dominant factor influencing pulmonary TB incidence. The results of the multivariate model were interpreted based on the Odds Ratio (OR) and 95% Confidence Interval (CI), enabling the determination of the strength and direction of associations between variables.

Ethical Consideration

This study received approval from the Tebing Tinggi Primary Health Center and the Ethics Committee of Bina Husada College of Health Sciences, Palembang. All participants were given a clear explanation of the study objectives and were asked to sign an informed consent form. The researcher ensured the confidentiality of respondents' identities and personal data, which were used solely for academic purposes.

Results

The characteristics of respondents in this study include information on tuberculosis status, age, gender, level of knowledge, history of household contact, housing density, and home ventilation conditions.

Table 1. Frequency Distribution of Respondents

Variables	Frequency (n)	Percentage (%)
Pulmonary Tuberculosis Incidence		
Not TB	41	53,9
Diagnosed with TB	35	46,1
Age		
Late adulthood	31	40,8
Early adulthood	45	59,2
Gender		
Male	42	55,3
Female	34	44,7
Knowledge		
Good	44	57,9
Moderate	32	42,1
Household Contact		
No	33	43,4
Yes	43	56,6
Housing Density		
Meets the standard	63	82,9
Does not meet the standard	13	17,1
Ventilation		
Meets the standard	24	31,6
Does not meet the standard	52	68,4

This descriptive overview aims to present the frequency distribution of each variable studied, serving as a foundation for analyzing the factors associated with the incidence of pulmonary tuberculosis in the working area of Tebing Tinggi Primary Health Center, Empat Lawang Regency.

Table 1 presents an analysis of 76 respondents. It shows that 53.9% of participants were not diagnosed with pulmonary tuberculosis, while 46.1% were diagnosed with pulmonary tuberculosis. The majority of respondents were in the early adulthood age group (59.2%), with the remaining 40.8% categorized as late adulthood. Respondents were predominantly male (55.3%), while female respondents accounted for 44.7%.

Most respondents demonstrated a good level of knowledge about tuberculosis (57.9%), whereas 42.1% had a moderate level of knowledge. Additionally, 56.6% of respondents reported a history of household contact with TB patients, while 43.4% had no such contact.

Regarding housing conditions, the majority of respondents lived in dwellings with acceptable housing density (82.9%), whereas 17.1% lived in homes that did not meet density standards. However, most of the respondents' homes did not meet ventilation standards (68.4%), and only 31.6% had adequate ventilation.

Table 2. Analysis of risk factors for the incidence of tuberculosis

Variabel	Pulmonary Tuberculosis Incidence				Total		*pValue*	*OR (95% CI)*
	Not TB		Diagnosed with TB					
	n	%	n	%	n	%		
Age								
Late adulthood	12	38,7	19	61,3	31	100	0,04	0,34 (0,13-0,89)
Early adulthood	29	64,4	16	35,6	45	100		
Gender								
Male	21	50	21	50	42	100	0,59	-
Female	20	58,8	14	41,2	34	100		
Knowledge								
Good	23	52,3	21	47,7	44	100	0,91	-
Moderate	18	56,2	14	43,8	31	100		
Household Contact								
No	31	93,9	2	6,1	33	100	0,00	51,15 (10,37-25,21)
Yes	10	23,3	33	76,7	43	100		
Housing Density								
Meets the standard	36	57,1	27	42,9	63	100	0,35	-
Does not meet the standard	5	38,5	8	61,5	13	100		
Ventilation								
Meets the standard	13	54,2	11	45,8	24	100	1,00	
Does not meet the standard	28	53,8	24	46,2	52	100		

Based on the bivariate analysis presented in Table 2, age and household contact were found to have a significant association with the incidence of pulmonary tuberculosis at Tebing Tinggi Primary Health Center in 2025. The variable age showed a p-value of 0.04 and an Odds Ratio (OR) of 0.34, indicating that respondents in the late adulthood group were 0.34 times less likely to develop pulmonary tuberculosis compared to those in the early adulthood group. Meanwhile, the household contact variable demonstrated a very strong association, with a p-value of 0.00 and an OR of 51.15, suggesting that respondents without a history of household contact were 51.15 times less likely to develop pulmonary tuberculosis compared to those with such a history.

In contrast, the variables gender (p = 0.59), knowledge (p = 0.91), housing density (p = 0.35), and home ventilation (p = 1.00) did not show a statistically significant relationship with the incidence of tuberculosis in this study.

Table 3. Results of multivariate analysis of all independent variables

		pValue	*OR*	95,0% *C.I.for EXP*(B)	
				Lower	*Upper*
Step 1[a]	Household Contact	0,00	0,20	0,004	0,096
	Constant	1,19			

The final result of the multivariate analysis indicated that the most dominant variable associated with the incidence of pulmonary tuberculosis at Tebing Tinggi Primary Health Center in 2025 was household contact (p-value = 0.00). When all independent variables were tested simultaneously, household contact was found to have the strongest influence on the occurrence of tuberculosis compared to the other variables.

Discussion

The results of the bivariate analysis revealed a significant association between age and the incidence of pulmonary tuberculosis, with a p-value of 0.04. This indicates that age serves as one of the risk factors for pulmonary TB in the working area of Tebing Tinggi Primary Health Center. A person's age is closely linked to the immune system's ability to combat infection. Older adults typically experience a decline in immune function and pulmonary tissue elasticity, which facilitates the invasion of Mycobacterium tuberculosis (Mgode et al., 2021). This finding is supported by studies conducted by Sikumbang, Eyanoer, and Siregar (2022) and Ekawati (2022), which found that older adults are more vulnerable to pulmonary TB. According to the researchers' assumption, as individuals age, their natural resistance to infectious agents weakens, making older populations in need of more intensive preventive and early detection interventions. Therefore, the elderly should be prioritized in tuberculosis elimination programs.

In contrast, the relationship between gender and the incidence of TB was not statistically significant (p = 0.59), indicating that males and females are at equal risk of developing pulmonary TB. Gender, defined biologically by differences in reproductive organs and functions (Azisah et al., 2016), is not a primary determinant in TB transmission. Transmission occurs through droplets from coughing, sneezing, or speaking, which can spread in the environment regardless of gender (Samsugito, 2020). This result aligns with findings from Tuntun and Budi (2016) and Lestari, Dedy, Artawan, and Buntoro (2022), who also found no significant differences in TB incidence by gender. Therefore, TB prevention strategies should target the entire population equally, regardless of gender, with more appropriate focus directed toward environmental factors and risky behaviors.

Bivariate analysis of the knowledge variable also showed no significant relationship with TB incidence, with a p-value of 0.91. Although knowledge is often linked to disease prevention behavior, this finding indicates that knowledge alone is insufficient to prevent TB infection. Knowledge forms the foundation for shaping an individual's attitudes and actions (Mei Lestari Ika Widyyati, 2021), but its implementation is influenced by several other factors, such as access to healthcare services and socioeconomic status. This result is supported by studies from Marleni, Syafei, and Saputra (2020) and Sinha, Shenoi, and Friedland (2020), which also found no significant correlation between knowledge and TB incidence. The researchers assume that TB-related information is often available but not necessarily followed by behavioral change. Thus, an educational approach that is interactive and context-specific—rather than merely informative—is needed. This includes using accessible communication media tailored to community characteristics.

Unlike the previous variables, household contact showed a highly significant association with TB incidence, indicated by a p-value of 0.00. Household contact is one of the highest risk factors due to close physical proximity that facilitates airborne transmission. Respondents in this study were found to have a history of living with family members or neighbors with

TB, significantly increasing their exposure to M. tuberculosis (Dewi, Saraswati, & Maywati, 2024). This finding is consistent with the study by Wardani, Dewi, and Suharmanto (2020), which found a strong correlation between household contact and TB incidence. Droplets expelled during coughing or talking by TB patients can remain airborne and be easily inhaled by household members. Therefore, active screening of household contacts is essential to prevent further transmission. The researchers concluded that education and strict monitoring of households with TB cases are critical components of an effective prevention strategy.

Furthermore, the analysis of housing density showed no significant association with pulmonary TB incidence (p = 0.35). Although theoretically housing density can increase the risk of transmission, this was not statistically proven in the present study. Housing density refers to the number of individuals living in a given space and the total living area available. According to the Indonesian Ministry of Health Regulation No. 2 of 2023, the minimum required space is 9 m^2 per person to ensure health and comfort (Pramono, Hendriani, Ardyanti, & Chifdillah, 2023). Similar findings were reported by Ariani, Lapau, Zaman, Mitra, and Rustam (2022), who also found no significant relationship between housing density and pulmonary TB. The researchers assumed that housing density only becomes a risk factor when not accompanied by adequate ventilation or healthy living behaviors. Therefore, fulfilling healthy housing standards should be combined with comprehensive TB prevention education.

Ventilation was also examined as a variable, and the results showed no significant association with pulmonary TB incidence, with a p-value of 1.00. Home ventilation plays an important role in air circulation and reducing humidity, which helps prevent the persistence of TB bacteria in closed environments (A. M. Putri, Thohari, & Sari, 2022). A home is considered adequately ventilated if it has openings covering at least 10% of the floor area. Although most respondents' homes in this study did not meet ventilation standards, this did not correlate directly with higher TB cases (Pramono, 2021). These results are consistent with findings by Maulinda, Hernawati, Marchiant, and Caesarina (2021), who also found no significant link between ventilation and TB. It is likely that other factors, such as environmental hygiene, health education, and early detection, have a more substantial impact. The researchers concluded that while ventilation is an essential element of a healthy home, it does not independently determine TB outcomes.

Multivariate analysis using logistic regression revealed that among all variables tested simultaneously, household contact was the most dominant factor determining the incidence of pulmonary TB. This was evidenced by a p-value of 0.00 and a high Odds Ratio (OR) of 51.15, indicating a very strong association. Even when controlling for other independent variables, household contact remained the strongest predictor of TB incidence. This suggests that individuals living with TB patients have an exceptionally high risk of contracting the disease compared to those without such contact (Faizal & Pangesti, 2021). In the context of prevention, this finding provides a solid basis for strengthening contact tracing programs and household-level surveillance. Active interventions such as sputum screening of household members and targeted education for affected families are highly recommended. Therefore, TB control strategies in the Tebing Tinggi area should prioritize interventions at the household level (Siregar, Yusuf, & Fernaldy, 2022).

Overall, this study shows that not all traditionally assumed risk factors are statistically associated with TB incidence. Only two variables—age and household contact—were significantly related, with the latter being the most dominant factor. Variables such as gender, knowledge, housing density, and ventilation were not significantly associated with TB incidence in this population. These findings highlight the importance of contextual and evidence-based approaches in designing TB control programs. The researchers suggest that field interventions should focus on early detection of household contacts, education for older adults, and strengthening household screening efforts. Although public knowledge is

important, it must be accompanied by concrete preventive behavior and a supportive physical environment. Moving forward, cross-sectoral and community-based efforts will be key to sustainably reducing the incidence of tuberculosis.

Conclusion and Recommendation

Based on the results of this study on the analysis of risk factors for pulmonary tuberculosis in the working area of Tebing Tinggi Primary Health Center, Empat Lawang Regency in 2025, it can be concluded that out of the six variables examined, only two—age and household contact—were found to have a significant association with the incidence of pulmonary tuberculosis. Statistical tests revealed that age was related to TB incidence, with older adults being at higher risk.

Furthermore, household contact emerged as the most dominant factor, demonstrated by a highly significant p-value and a high odds ratio, indicating that living with a TB patient significantly increases the risk of transmission. Meanwhile, gender, knowledge, housing density, and ventilation did not show statistically significant relationships with TB incidence. Therefore, it can be concluded that household contact and age are important indicators in TB prevention and control efforts, particularly in the context of Tebing Tinggi. These findings underscore the importance of household-based and high-risk group approaches in national TB elimination strategies.

Based on these findings, it is recommended that Tebing Tinggi Primary Health Center strengthen the implementation of active contact tracing among the families of TB patients, including providing education and routine screening for household members. Healthcare workers should also enhance practical health education, which not only increases knowledge but also encourages preventive behavior changes, such as proper cough etiquette, mask usage, and maintaining good air circulation in homes.

Although ventilation and housing density were not found to be statistically significant in this study, interventions targeting home conditions remain important as part of the healthy housing framework. Local governments are encouraged to support TB elimination programs through regulations that promote healthy residential environments and empower community health workers. Future researchers are advised to explore additional factors such as nutritional status, smoking habits, and comorbidities that may contribute to TB incidence, as well as to conduct longitudinal studies to gain a more comprehensive understanding of risk factors over time.

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The authors declare no competing interests.

Declaration on the Use of AI
No AI tools were used in the preparation of this manuscript.

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