

Healthy Living Practices and Housing Quality as Risk Factors for Tuberculosis in Toddlers

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ABSTRACT

Tuberculosis in young children is influenced by environmental conditions and household hygiene practices, as this age group has an underdeveloped immune system. This study aims to examine the association between housing conditions such as lighting, ventilation, and housing density and hygiene practices and healthy lifestyles with the incidence of tuberculosis in toddlers. A case-control study was conducted involving 42 participants (21 cases and 21 controls) in the service area of the Martapura 2 Community Health Center. Data were collected through home observations, interviews with parents, and direct measurements, and analyzed using chi-square or Fisher's exact tests and logistic regression. The results showed that poor hygiene and healthy lifestyle practices ($p = 0.026$; $OR = 5.667$) and inadequate lighting ($p = 0.045$; $OR = 5.455$) were significantly associated with tuberculosis incidence among toddlers. Multivariate analysis identified hygiene and healthy living practices as the most dominant factor ($p = 0.031$; $Exp(B) = 4.978$), while lighting showed a near-significant association ($p = 0.055$; $Exp(B) = 4.692$). Housing density and ventilation were not significantly associated with tuberculosis incidence. These findings highlight the importance of improving household hygiene practices and ensuring adequate lighting as key strategies to reduce the risk of tuberculosis in toddlers.

Keywords: *Tuberculosis, toddlers, Hygiene and healthy living practices, House Lighting, Home Environmental Factors*

INTRODUCTION

Toddlers spend most of their time indoors, making the home environment a critical determinant of their health status. Although the home is expected to provide a safe space for growth and development, inadequate environmental conditions may increase the risk of infectious diseases, including tuberculosis.¹ Tuberculosis (TB) remains a major public health problem in Indonesia and globally. Toddlers are a highly vulnerable group because their immune systems are still developing, which limits their ability to control infection caused by *Mycobacterium tuberculosis*.^{2,3} In addition, children aged 0–5 years are more susceptible to infection and progression to active disease due to

immature innate and cellular immune responses.⁴

Tuberculosis is primarily transmitted through airborne droplets released when an infected individual coughs, sneezes, or speaks. In enclosed environments with poor air circulation and limited sunlight exposure, these droplets can remain suspended in the air for extended periods, increasing the likelihood of transmission. Toddlers who spend most of their time indoors are therefore at a higher risk of exposure, especially when living in households with inadequate environmental conditions.⁵

The Global Tuberculosis Report 2025 shows that TB continues to pose a significant global

burden, with an estimated 10.7 million cases and 1.23 million deaths annually. Children account for approximately 11% of all cases, or around 1.2 million cases, highlighting the substantial impact of TB on this age group. Indonesia ranks third among countries with the highest number of TB cases, contributing approximately 10% of global cases, or about 1.1 million cases.⁶

The South Kalimantan Provincial Health Office reported a total of 12,702 TB cases at the regional level, of which 2,412 occurred in children. This indicates that nearly one-fifth (19%) of TB cases affect the pediatric population, highlighting the vulnerability of this group. Banjar District recorded the second-highest number of TB cases, with 1,316 cases.⁷ At the primary health care level, the Martapura 2 Community Health Center (Puskesmas) experienced a significant increase in TB cases among children under five. The number of cases rose by 28.1% from 2022 to 2023, reaching 41 cases, and surged sharply by 129% in 2024 to a total of 94 cases.⁸

Tuberculosis in toddlers requires serious attention because diagnosis is often more complex and the risk of complications is higher than in adults. The immature immune system increases susceptibility to infection and accelerates progression to severe disease. Without proper treatment, TB can lead to permanent damage to vital organs, including the lungs, meninges, and spine.⁹

Given the high burden of tuberculosis and the vulnerability of young children, it is essential to identify modifiable risk factors within the household environment. Understanding the combined role of housing conditions and hygiene practices is particularly important in high-burden areas, where both environmental and behavioral factors may interact to influence disease transmission. This highlights the need for integrated prevention strategies that address both physical and behavioral determinants of tuberculosis.^{6,9}

According to Gordon's epidemiological triangle, the occurrence of tuberculosis is influenced by the interaction between agent, host, and environment.¹⁰ The agent, *Mycobacterium tuberculosis*, causes disease when it infects a susceptible host. In toddlers, susceptibility is higher due to their underdeveloped immunity and dependence on caregivers for maintaining hygiene and healthy living practices. Environmental factors, particularly housing conditions, also play an important role in facilitating TB transmission. Overcrowding, poor ventilation, and inadequate lighting can increase the spread of airborne droplets containing TB bacteria in enclosed spaces.¹¹

Housing conditions that fail to meet health standards may increase the risk of disease transmission. Poor air circulation, insufficient lighting, and substandard building conditions can create environments that support the survival and transmission of *Mycobacterium tuberculosis*. Therefore, both environmental factors and household hygiene practices are important determinants of TB incidence in toddlers.^{5,12}

In addition to environmental factors, household hygiene and healthy living practices play a crucial role in tuberculosis prevention. Behaviors such as proper cough etiquette, the use of masks by infected individuals, maintaining household cleanliness, and ensuring adequate sanitation can significantly reduce the risk of transmission. Conversely, poor hygiene practices may facilitate the spread of infection within the household, particularly among vulnerable groups such as toddlers.¹³

Previous studies have demonstrated that both environmental and behavioral factors are associated with tuberculosis incidence in children. A study by Fahdhienie et al. found that poor housing conditions, including inadequate ventilation and lighting, significantly increase the risk of pulmonary tuberculosis in high-burden areas. Similarly, Syahputri et al. reported that inadequate household hygiene practices, such as poor cough etiquette and sanitation, contribute to higher transmission of tuberculosis among family members.^{14,15}

However, most previous studies have examined environmental and behavioral factors separately, and limited research has explored their combined influence on tuberculosis incidence among toddlers, particularly in high-burden areas such as South Kalimantan. Therefore, this study aims to analyze the association between housing conditions (housing density, ventilation, and lighting) and hygiene and healthy living practices with the incidence of tuberculosis among toddlers in the working area of the Martapura 2 Community Health Center.

METHOD

This study employed a quantitative approach using a case-control design to analyze the relationship between housing conditions, hygiene practices, and healthy lifestyle behaviors, and the incidence of tuberculosis among toddlers. The case-control design was chosen because it is suitable for identifying risk factors and allows for comparison between groups of toddlers with and without tuberculosis. The study was conducted in the service area of the Martapura 2 Community Health Center, South Kalimantan, in July 2025. This

location was chosen because there has been an increase in tuberculosis cases among toddlers over the past three years, making it a high-burden area requiring further investigation. This study adhered to research ethics principles by obtaining informed consent from participants prior to data collection. All data collected is kept confidential and used solely for research purposes.

The study population consisted of all toddlers diagnosed with tuberculosis in the study area. The sample size was 42 participants, comprising 21 cases and 21 controls. The case group was selected using total sampling, while the control group consisted of healthy toddlers matched by age and sex to minimize bias.

The independent variables in this study include housing density, home ventilation, home lighting, as well as hygiene practices and healthy lifestyle behaviors. The selection of variables was based on Gordon's epidemiological triangle theory, which emphasizes the interaction between environmental factors and host factors in the onset of disease. Housing conditions represent environmental factors, while hygiene practices reflect individual/family behavioral factors.

Data collection was conducted through direct observation of housing conditions, interviews with parents or caregivers of toddlers, and measurements using tools such as tape measures and lux meters. Housing density was measured

based on floor area per occupant, ventilation was calculated based on the ratio of ventilation area to floor area, and lighting was measured in lux.

Data analysis was performed using bivariate analysis with the chi-square test or Fisher's exact test to determine the relationship between independent variables and the incidence of tuberculosis. Subsequently, multivariate analysis using logistic regression was performed to identify the most influential factors. This analytical method was chosen because it is suitable for categorical data and capable of estimating the magnitude of risk through the odds ratio.

RESULT AND DISCUSSION

The results of the research include the distribution of physical characteristics of houses, bivariate relationships between independent variables and TB cases in toddlers, and multivariate analysis to identify the most influential factors in the emergence of TB in toddlers.

Univariate analysis was conducted to describe the distribution of variables related to housing conditions and household hygiene and healthy living practices among respondents in the working area of Martapura 2 Community Health Center. The variables analyzed included hygiene and healthy living practices, housing density, ventilation, and lighting.

Tabel 1. Distribution Frequency Variable

Variable	Category	n	%
Hygiene and healthy lifestyle practices	Less Optimal	16	38,1
	Good	26	61,9
Housing Density	Not Meeting Standard	9	21,4
	Meeting Standard	33	78,6
House Ventilation	Inadequate	14	33,3
	Adequate	28	66,7
House Lighting	Inadequate	13	31,0
	Adequate	29	69,0

The results showed that 38.1% of respondents had less optimal hygiene and healthy living practices, while 61.9% were categorized as having good practices. In terms of housing density, most households (78.6%) met the minimum standard, while 21.4% did not meet the required standard.

Regarding housing conditions, 33.3% of houses had inadequate ventilation, whereas 66.7% had adequate ventilation. Similarly, 31.0% of

houses had inadequate lighting, while the majority (69.0%) met the recommended lighting standards. These findings indicate that although most respondents lived in relatively adequate housing conditions, a considerable proportion still experienced substandard environmental conditions and inadequate hygiene practices, which may contribute to an increased risk of tuberculosis transmission among toddlers.¹⁶

Table 2. Bivariate Analysis

Variable	Category	Tuberculosis				p-value	OR (95% CI)
		Yes		No			
		n	%	n	%		
Hygiene and healthy living practices	Less Optimal	12	57,1	4	19,0	0,026*	5,667 (1,411–22,761)
	Good	9	42,9	17	81,0		
Housing Density	Not Meeting Standard	5	23,8	4	19,0	1,000	1,328 (0,302-5,843)
	Meeting Standard	16	16,5	17	81,0		
House	Inadequate	6	28,6	8	38,1	0,743	0,650 (0,178-2,369)
Ventilation	Adequate	15	53,6	13	61,9		
House	Inadequate	10	47,6	3	14,3	0,045*	5,455 (1,226–24,261)
Lighting	Adequate	11	52,4	18	85,7		

*Significant

Table 2 shows that a higher proportion of toddlers with tuberculosis lived in households with poor hygiene and healthy living practices (57.1%) compared to the control group (19.0%). Bivariate analysis indicated a significant association between hygiene and healthy living practices and tuberculosis incidence ($p = 0.026$). Toddlers living in households with poor hygiene and healthy living practices had a 5.667 times higher risk of developing tuberculosis compared to those living in households with good practices (OR = 5.667; 95% CI: 1.411–22.761).

This finding indicates that inadequate household hygiene practices play an important role in facilitating tuberculosis transmission among toddlers. Good hygiene practices, such as covering the mouth when coughing or sneezing, using masks for TB patients, and maintaining household cleanliness, can reduce the spread of *Mycobacterium tuberculosis*. Conversely, poor practices such as not covering the mouth when coughing (71%) and indiscriminate sputum disposal (86%) can increase the risk of transmission within the household.¹⁷

These results are consistent with previous studies in Indonesia, which have shown that poor hygiene behavior is a significant risk factor for tuberculosis transmission. A study by Syahputri et al. reported that household contact with TB patients who do not practice proper hygiene increases the likelihood of infection. Other studies have also emphasized the importance of hygiene and healthy living practices in reducing the risk of tuberculosis, particularly among children.^{17,18} Therefore, improving household hygiene practices is essential as part of tuberculosis prevention strategies, especially for vulnerable groups such as toddlers, alongside improvements in housing conditions.

The physical quality of the home, housing density, ventilation, and lighting play an important role in determining the risk of tuberculosis in toddlers. Homes with poor lighting, cramped spaces, and limited ventilation tend to create a damp environment with poor air circulation, facilitating the spread of TB bacteria among toddlers. Research shows that housing density is not related to the incidence of TB in toddlers with $p = 1,000$ (OR: 1,328; 95% CI: 0,302-5,843). Housing density within a home affects the health of its occupants. Homes that are not large enough for the number of occupants can cause overcrowding, which risks reducing air quality and oxygen consumption. In addition, if one family member has pulmonary tuberculosis, transmission to other members becomes easier, given that one patient has the potential to transmit the disease to two to three people in the same home.^{19,20}

The results of the study indicate that the majority of respondents (78.6%) had adequate living space, with an average living area of approximately 16 m² per occupant. This suggests that housing density in this study was relatively homogeneous, which may explain the absence of a statistically significant association with tuberculosis incidence. This finding may also be influenced by the limited variation in housing density among respondents, reducing the ability of statistical analysis to detect differences.

Consistent with previous research, Suma et al. reported that housing density was not significantly associated with pulmonary tuberculosis ($p = 0.136$). Similarly, other studies have found that although housing density is theoretically linked to disease transmission, its effect may be less evident when most households meet minimum health standards and environmental conditions are

relatively uniform. These results suggest that while housing density remains an important environmental factor, other variables such as lighting and hygiene practices may play a more dominant role in influencing tuberculosis transmission among household members.^{21,22}

The results of this study indicate that home ventilation was not significantly associated with the incidence of tuberculosis among toddlers ($p = 0.743$; $OR = 0.650$; $95\% CI: 0.178-2.369$). Although ventilation plays an important role in maintaining indoor air quality and reducing humidity, inadequate ventilation can lead to increased humidity levels, thereby creating conditions that support the survival of *Mycobacterium tuberculosis*, which thrives in dark and damp environments.

In this study, the majority of homes (66.7%) had inadequate ventilation, which may explain the lack of a significant association due to the relatively homogeneous distribution of ventilation conditions among respondents. These findings are consistent with previous studies by Suma et al. ($p = 0.297$) and Marni et al. (2024), which also reported no significant association between ventilation and tuberculosis incidence. This suggests that although ventilation is an important environmental factor, its impact may be less evident when other factors, such as hygiene practices and lighting, play a more dominant role in influencing tuberculosis transmission.^{21,23}

The results of this study indicate that home lighting is significantly associated with the incidence of tuberculosis among toddlers ($p = 0.045$; $OR = 5.455$; $95\% CI: 1.226-24.261$). Toddlers living in homes with inadequate lighting have a 5.455 times higher risk of contracting tuberculosis compared to those living in homes with adequate lighting.

Adequate lighting plays a crucial role in maintaining a healthy indoor environment. Dark and damp conditions can support the survival of *Mycobacterium tuberculosis*, as this bacterium is known to persist longer in environments with limited sunlight exposure. Conversely, natural sunlight, particularly ultraviolet (UV) radiation, has a bactericidal effect that can reduce the viability of airborne pathogens.²⁴

These findings align with previous studies highlighting the protective role of adequate natural lighting against tuberculosis transmission, particularly among children who spend most of their time indoors. Therefore, improving home lighting through proper window design, increased sunlight exposure, or structural modifications could be an effective strategy for reducing the risk of tuberculosis transmission among vulnerable populations such as toddlers.^{1,19}

The results of the study show that the average lighting in the homes of respondents with TB cases is still below 60 lux. This finding is in line with research conducted by Syukur, which shows that home lighting is associated with tuberculosis incidence, with a $p = 0.041$ and $OR = 3.024$. These results confirm that poor lighting increases the risk of TB transmission within the home, making lighting improvements an important strategy in TB control among toddlers.¹⁹

In addition, the findings of this study highlight the importance of an integrated approach in preventing tuberculosis among toddlers. The interaction between environmental factors and household hygiene practices suggests that improving only one aspect may not be sufficient to effectively reduce transmission. For example, adequate housing conditions without proper hygiene behavior may still allow the spread of infection, while good hygiene practices in a poor physical environment may not fully prevent bacterial survival.

Therefore, tuberculosis prevention strategies should be implemented comprehensively, combining improvements in housing quality such as adequate lighting and ventilation with consistent promotion of hygiene and healthy living practices at the household level. Public health interventions, including health education, community-based programs, and environmental improvements, are essential to create a supportive environment for reducing tuberculosis transmission, particularly among vulnerable groups such as toddlers.

Multivariate analysis

The results of multivariate analysis (Table 3) indicate that hygiene and healthy living practices are the most dominant factor associated with tuberculosis incidence among toddlers. Toddlers living in households with less optimal hygiene and healthy living practices had a 4.978 times higher risk of developing tuberculosis compared to those living in households with good practices ($p = 0.031$; $95\% CI: 1.158-21.406$).

These findings suggest that household hygiene behavior plays a crucial role in influencing tuberculosis transmission, even after controlling for other environmental factors. This highlights the importance of promoting consistent hygiene practices as a key strategy in preventing tuberculosis among vulnerable groups such as toddlers.

Table 3. Multivariate Analysis

	Variable	B	p-value	Exp(B)	95% CI for Exp(B)
Model	Hygiene and healthy living practices	1.605	0.031	4.978	1.158 – 21.406
	House Lighting	1.546	0.055	4.692	0.966 – 22.782
	Constant	-5.268	0.006	0.001	–

Multivariate analysis results indicate that hygiene and healthy living practices are the most dominant factor associated with tuberculosis incidence among toddlers, as evidenced by a $p=0.031$ and $\text{Exp}(B) = 4.978$ (95% CI: 1.158–21.406). Toddlers living in households with poor hygiene and healthy living practices had a substantially higher risk of developing tuberculosis compared to those living in households with good practices. This finding highlights the critical role of household hygiene behavior in influencing tuberculosis transmission, even after controlling for environmental factors. Practices such as covering the mouth when coughing, proper sputum disposal, maintaining household cleanliness, and implementing basic sanitation are essential in reducing the spread of *Mycobacterium tuberculosis*.^{25,26}

Home lighting also showed a tendency to influence tuberculosis incidence ($p = 0.055$; $\text{Exp}(B) = 4.692$; 95% CI: 0.966–22.782), although it did not reach statistical significance. This finding suggests that environmental factors, particularly lighting, may still contribute to tuberculosis risk when combined with behavioral factors.

Previous studies have reported that inadequate lighting and poor housing conditions can increase the risk of tuberculosis transmission by creating environments that support bacterial survival. Limited exposure to natural sunlight reduces the bactericidal effect of ultraviolet (UV) radiation, allowing *Mycobacterium tuberculosis* to persist longer in indoor environments. This indicates that although lighting was not statistically significant in the multivariate analysis, it remains an important environmental factor in tuberculosis prevention.^{25,27}

Theoretically, these findings support Gordon's epidemiological triangle, which emphasizes the interaction between the agent, the host, and the environment in the onset of disease. In this study, hygiene and healthy living practices represent behavioral factors related to the host, while housing conditions reflect environmental factors that facilitate the transmission of *Mycobacterium tuberculosis*. The results indicate that behavioral factors may have a more dominant influence, although their interaction with environmental conditions remains important in

determining the risk of tuberculosis in infants.

These findings also highlight important implications for public health policies and practices. Tuberculosis prevention efforts must adopt an integrated approach that combines improvements in household hygiene practices with enhancements to housing conditions, including adequate lighting and ventilation. Strengthening community-based tuberculosis prevention programs is crucial, particularly through health education that promotes proper hygiene behaviors and awareness of healthy housing conditions.

Additionally, collaboration between the health sector and local governments is necessary to support housing improvements and ensure compliance with minimum health standards. Community-based interventions, such as home visits by health workers and targeted education for families with young children, can further enhance the effectiveness of tuberculosis prevention efforts.

CONCLUSION

The research found that hygiene and healthy living practices and household lighting were associated with the incidence of tuberculosis among toddlers. Multivariate analysis confirmed that hygiene and healthy living practices were the most influential factor in determining tuberculosis risk, while household lighting also showed a meaningful contribution. Although housing density and ventilation were not significantly associated, both remain important factors in maintaining indoor air quality and overall living conditions.

These findings highlight that both household hygiene practices and adequate natural lighting play a critical role in reducing tuberculosis risk among toddlers. Therefore, tuberculosis prevention strategies should focus on improving household hygiene practices and ensuring adequate lighting, so that the home environment can better support child health and prevent disease transmission.

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