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Physical environment increase the transmission of tuberculosis

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Abstract

Background: The physical environment is a contributing factor to tuberculosis cases in several developing countries. Indonesia ranks third in the world for tuberculosis cases. According to the World Health Organization (WHO) the increase in cases was attributed to problems with sanitation and poor living conditions. The appropriate method to prevent transmission is to interrupt transmission from three factors: the host, the agent, and the environment to children. The source of tuberculosis (TB) transmission in children is adult patients with smear-positive TB.

Purpose: To prevent transmission of pulmonary TB to children, which is related to the physical environment.

Method: A descriptive correlational, specially focusing on cross-sectional method. The study took place from August 2025 in Community Health Center, Kotabumi. The independent variable was physical environment, meanwhile the dependent variable included tuberculosis transmission. Using random sampling and slovin formula 38 respondents were selected who meet specific inclusion and exclusion criteria. The analysis proceeded with a univariate test to determine the frequency distribution of respondent's characteristics, followed by bivariate analysis using chi square test and multivariate with logistic regression.

Results: Analysis multivariate shows that home lighting and home cleanliness are significantly associated with TB prevention, with OR 8.370 ($p = 0.001$) and OR 4.825 ($p = 0.016$). Ventilation (OR 2.091; $p = 0.238$) and air humidity (OR 2.959; $p = 0.060$) did not show a significant relationship.

Conclusion: Home lighting and home cleanliness was identified as the most influential factor in preventing pulmonary TB transmission.

Keywords: Environmental; Physical; Prevention; Tuberculosis.

INTRODUCTION

Tuberculosis (TB) remains a public health problem and a global challenge. This disease is caused by the bacterium *Mycobacterium tuberculosis*. Globally, in 2019, 7.1 million people were diagnosed with TB (both new and recurrent cases). The TB incidence rate decreased by 9% (from 142 to 130 per 100,000 population), but this achievement falls short of the target of reducing TB incidence by 20% (Sutriyawan, Nofianti, & Halim, 2022).

Indonesia ranks third (8%) in the world in TB incidence after India (27%) and China (9%). Indonesia still faces challenges that require attention, namely the increasing number of TB cases in vulnerable

communities. Confirmed TB cases in 2019 totaled 543,874 cases, a decrease compared to the number of confirmed cases in 2018 of 566,623 cases. The Case Notification Rate (CNR) in 2018 was 214 per 100,000 population, then experienced an insignificant decrease in 2019 to 203 per 100,000. The achievement of treatment success has reached the national target of 86.6% (>85%). There are 28 primary health care facilities in North Lampung. Kotabumi II Community Health Center is one of the primary health care facilities with a high number of pulmonary tuberculosis cases, according to data from the North Lampung Health Office. Data on tuberculosis cases at Kotabumi II

Community Health Center in 2020 showed 12 cases in the first quarter, 15 in the second quarter, 12 in the third quarter, and 10 in the fourth quarter, with a total of 49 cases of pulmonary tuberculosis. Of the 49 cases, most were married and had children (Mahawati, Surjati, Saputra, Sudasman, & Pertiwi, 2023).

One of the activities of the TB control program is preventing TB transmission. TB transmission is influenced by several factors. J. Gordon's epidemiological theory model states that the transmission of infectious diseases is influenced by the interaction of three factors: the host, the agent, and the environment. To prevent transmission, interruption of transmission through these three factors is crucial. Some individuals are at greater risk of contracting TB, including those in close contact with untreated or incompletely treated patients, those with low or weakened immune systems, and those who consume tobacco. Nearly 20 percent of TB cases are caused by smoking (Metri, Andriyani, Febriyanti, & Mulyaningrum, 2023).

Behavior is influenced by 3 main factors, namely predisposing (knowledge, attitudes, traditions, beliefs, education levels, systems and values, socio-economic levels, and so on), enabling factors (availability of facilities and infrastructure or health facilities for the community), and reinforcing factors (attitudes and behavior of community leaders (toma), support from health workers, facilities, including laws and regulations from both the central and regional governments) (Dewi, Rahardjo, & Murti, 2019).

RESEARCH METHOD

A descriptive correlational, specially focusing on cross-sectional method. The study took place from August 2025 in Community Health Center, Kotabumi. The independent variable was physical environment, meanwhile the dependent variable included tuberculosis transmission. Using random sampling and slovin formula 38 respondents were selected who meet specific inclusion and exclusion criteria.

The inclusion criteria included individuals who have lived in the study area for at least 6 months, age ≥ 20 years, living in close contact or in proximity to TB cases, or residing in a high-risk environment and houses located within the study area, actively occupied, and accessible for environmental observation. Exclusion criteria required those with severe illness that prevents participation, individuals who do not reside permanently in the area and houses under renovation,

unoccupied for more than 1 month, or inaccessible for full assessment.

Data obtained from measurement. The Knowledge, Attitude and Practice (KAP) questionnaire for assessing preventive behavior against pulmonary TB consists of three main themes, namely knowledge, attitude, and practice, with a total of 35 questions. Each question uses a Likert scale from 1 to 5, ranging from strongly disagree to strongly agree. The measurement results are then categorized into two levels, namely good knowledge with a score of 35–129 and poor knowledge with a score of 130–175.

The home lighting assessment was conducted using a questionnaire containing 10 questions with "yes" or "no" answers. Each 'yes' answer was given a score of 1 and each "no" answer was given a score of 0, resulting in a total score ranging from 0 to 10. The questions cover natural and artificial lighting, including sunlight exposure, the presence of windows, the absence of obstacles, and the adequacy of lighting. The final results are categorized as good lighting with a score of 7–10 and poor lighting with a score of 0–6.

Household cleanliness was assessed using a questionnaire containing 10 questions with "yes" or "no" answers, where 'yes' was given a score of 1 and "no" was given a score of 0. The questions covered aspects of floor cleanliness, furniture, waste management, kitchen and bathroom cleanliness, and the presence of dust or odors. The results are categorized as good cleanliness score of 7–1 and poor cleanliness score of 0–6.

Home ventilation is assessed using 10 questions about air circulation conditions, such as the presence of windows that can be opened, cross ventilation, and the absence of barriers. Each question is answered with yes or no. The assessment results are categorized as good ventilation if the score is 7–10 and poor ventilation if the score is 0–6.

The assessment of household humidity is conducted using 10 questions with answers of "yes" or "no," where 'yes' is given a score of 1 and "no" is given a score of 0. The total score ranges from 0 to 10, with questions assessing signs of humidity such as musty odors, mold, damp surfaces, poor air circulation, and lack of sunlight. A score of 0–4 is categorized as good humidity, while a score of 5–10 indicates insufficient or excessive humidity.

The analysis proceeded with a univariate test to determine the frequency distribution of respondent's characteristics, followed by bivariate analysis using chi square test and multivariate with logistic regression.

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RESEARCH RESULTS

Table 1. Characteristics of Respondents (N=38)

Variable	Results	OR	p-value
Age (n/%)			
(Mean±SD)(Range)(Year)	(33.42±2.821) (21-65)		
21-35	16/42.11		
36-50	14/36.84		
51-65	6/15.79		
>65	2/5.26		
Gender (n/%)			
Male	20/52.63		
Female	18/47.27		
Occupation (n/%)			
Farmer	8/21.05		
Factory worker	8/21.05		
Self-employed	17/44.74		
Housewife	5/13.16		
Duration of Tuberculosis Treatment (n/%)			
1 month	9/23.68		
2 month	9/23.68		
3 month	8/21.06		
4 month	10/26.32		
5 month	2/5.26		
Prevention TB transmission (n/%)			
Good	26/68.42		
Poor	12/31.58		
Home Lighting (n/%)			
Good	28/73.68	8.370	0.001
Poor	10/26.32		
House Cleanliness (n/%)			
Good	32/84.21	4.825	0.016
Poor	6/15.79		
Ventilation (n/%)			
Good	28/73.68	2.091	0.238
Poor	10/26.32		
Air Humidity (n/%)			
Good	21/55.26	2.959	0.060
Moderate	17/44.74		

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Tabel 1. Characteristics of respondent with a mean age and standard deviation (33.42 ± 2.821) ranging from 21-65 years. The majority of respondents were male, numbering 20 people (52.63%), worked as self-employed, numbering 17 people (44.74%), and some had undergone TB treatment for four months, numbering 10 people (26.31%). Most respondents had good TB prevention behaviors, totaling 26 people (68.42%). The majority had good home lighting (28 people, 73.68%), well-maintained home cleanliness (32 people, 84.21%), good home ventilation (28 people, 73.68%), and good air humidity conditions (21 people, 55.26%).

Analysis multivariate shows that home lighting and home cleanliness are significantly associated with TB prevention, with OR 8.370 ($p = 0.001$) and OR 4.825 ($p = 0.016$). Ventilation (OR 2.091; $p = 0.238$) and air humidity (OR 2.959; $p = 0.060$) did not show a significant relationship.

DISCUSSION

Most respondents showed good preventive behavior toward tuberculosis and lived in homes with adequate lighting, cleanliness, and ventilation, although some still had suboptimal humidity. The study found that patients living in well-lit homes tended to demonstrate better prevention practices. Poor lighting was linked to a higher likelihood of inadequate preventive behavior, indicating that home lighting plays an important role in minimizing TB transmission. This aligns with existing theory that sunlight helps kill TB bacteria, while dark and damp environments allow them to survive and multiply (Rukmini & Chatarina, 2011).

Adequate lighting appears to support healthier behaviors by creating a living environment that discourages bacterial survival and encourages residents to maintain better hygiene and ventilation. Sunlight not only reduces humidity and limits the growth of TB-causing bacteria, but also naturally promotes a more comfortable and less crowded indoor atmosphere, which may motivate families to keep windows open and improve air circulation (Asdie, 2012). Poorly lit homes often feel damp and enclosed, conditions that can foster bacterial persistence and reduce residents' awareness or practice of preventive measures (Fahy & Dickey, 2011).

The study results showed that some respondents had adequate lighting at home but suffered from pulmonary tuberculosis. According to the researchers, individuals with adequate physical home environments are more likely to be in good health. All family members should adopt healthy behaviors, such as not smoking indoors, practicing proper cough etiquette, and consuming a balanced diet to strengthen their immune systems. Observations by the researchers showed that most respondents' homes lacked adequate natural lighting. Other research shows a significant relationship between lighting and the incidence of pulmonary tuberculosis, and that homes with lighting that does not meet requirements have a 3.5 times greater chance of contracting pulmonary tuberculosis (Ruchal, Vale, & Sah, 2014).

Insufficient sunlight also limits the natural disinfection effect that ultraviolet rays provide, allowing pathogens to persist longer in the air and on surfaces. In such poorly lit spaces, residents may be less inclined to open windows or maintain regular airflow, further weakening preventive efforts. This highlights that ensuring adequate natural lighting is not only about comfort but also an important environmental factor that supports healthier behaviors and helps lower the risk of pulmonary TB transmission (Azhar & Perwitasari, 2013).

The study found a clear link between home hygiene and patients' behavior in preventing the spread of pulmonary tuberculosis. Patients living in cleaner homes tend to show better preventive behavior, while those in less clean homes are more likely to behave poorly in preventing transmission. Economic conditions were also noted as an influencing factor, where families with higher incomes are generally more capable of maintaining a clean environment and accessing better health resources. The study also showed a significant relationship between home ventilation and tuberculosis prevention behavior. Patients living in homes with poor ventilation are more likely to show inadequate prevention practices compared to those with well-ventilated homes (Sipayung, Hidayat, & Silitonga, 2023).

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Poor ventilation limits the exchange of indoor and outdoor air, allowing contaminated air to accumulate and creating an environment where TB bacteria can persist longer. When airflow is restricted, homes often feel stuffy and uncomfortable, which may discourage residents from engaging in healthy behaviors such as keeping spaces clean, opening windows, or reducing indoor crowding (Budi, Ardillah, Sari, & Septiawati, 2018).

Well-ventilated homes support better air circulation, lower humidity, and improved comfort, all of which can encourage more consistent preventive practices. Good ventilation also helps disperse airborne particles, reducing the concentration of TB bacteria in the air and supporting overall respiratory health, making it a key element in effective tuberculosis prevention (Mollalo, Mau, Rashidi, & Glass, 2019).

Ventilation plays an important role in reducing the risk of pulmonary tuberculosis. Good air circulation helps fresh air enter, removes polluted indoor air, and supports the dilution of germs in the environment. Homes with poor ventilation tend to become hot, dark, and humid, creating conditions that make disease transmission easier (Thwin & Chapman, 2009). Allowing sunlight and outdoor air to enter especially through windows or cross-ventilation can help naturally expel bacteria from indoor spaces. Adding or improving ventilation, such as creating openings or regularly opening windows and doors, can make the air fresher and reduce the chance of TB spreading (Xu, Li, Yiu, Chen, Sheng, Yan, & Hu, 2021).

Enhancing ventilation not only supports the flow of fresh air but also helps disperse airborne particles that may contain TB bacteria, lowering their concentration indoors. When air can move freely in and out of the house, pollutants, moisture, and pathogens are naturally pushed out and replaced with cleaner outdoor air (Freitas, Popolin, Touse, Yamamura, Rodrigues, Santos, & Arcencio, 2015). This process also reduces humidity, which otherwise creates favorable conditions for bacterial survival and growth. By combining proper ventilation with sunlight exposure, households can create an environment that is far less hospitable to TB transmission (Jahan, Rattanagreethakul, & Toonsiri, 2014).

The study found no significant relationship between home humidity and people's behavior in preventing pulmonary tuberculosis. However, this contrasts with theories suggesting that humidity plays an important role in TB transmission. In general, damp, dark environments allow TB bacteria to survive longer, and many studies indicate that humidity is linked to the incidence of pulmonary tuberculosis (Xiao, He, Chen, Wang, Meng, Chang, & Yu, 2018). High humidity can support bacterial survival, while very low or very high humidity can also create unhealthy indoor conditions. Humidity is also associated with mold growth inside homes. Mold can disrupt breathing, weaken the respiratory immune system, and create lung conditions that allow TB bacteria to thrive (Taylor, Yates, Mthethwa, Tanser, Abubakar, & Altamirano, 2016). Maintaining ideal indoor humidity helps reduce bacterial survival and prevents mold growth. When humidity is too low, improving ventilation is recommended, and when humidity is too high, adjustments such as increasing light exposure or using tools to regulate moisture can help achieve healthier indoor conditions (Romlah, 2015).

Maintaining this balance is essential because both excessively dry and overly damp conditions can weaken the body's natural defenses and create environments where harmful microorganisms thrive. Inadequate humidity may dry out the respiratory tract, making it easier for pathogens to enter the body, while overly humid spaces can support mold and bacterial growth that further compromise respiratory health (Jafta, Jeena, Barregard, & Naidoo, 2019). Ensuring proper airflow, controlling moisture sources, and allowing sufficient sunlight to enter the home help create indoor conditions that limit pathogen survival and support overall well-being (Wikurendra, Herdiani, Tarigan, & Kurnianto, 2021).

Some people in the study had normal home humidity but still developed pulmonary TB. This suggests that a healthy physical environment alone isn't enough health behaviors such as avoiding indoor smoking and maintaining good nutrition are also crucial. Many respondents lived in crowded areas where windows were rarely opened, causing poor air circulation and increased humidity, which can encourage TB bacteria to grow. Research from

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different regions shows mixed findings: some studies link higher humidity to increased TB risk because it creates conditions where bacteria can survive and multiply, while others suggest that very low humidity may also increase vulnerability by weakening the respiratory system's natural defenses (Ukwaja, Alobu, Nweke, & Onyenwe, 2013). Both extremes of humidity can contribute to TB risk in different ways. Overall, humidity influences how easily TB bacteria can survive and how well the human respiratory system can protect itself. Poor ventilation, crowded living conditions, and unhealthy behaviors can further increase the likelihood of TB transmission (Zulaikha, Ratnawati, Sulatsri, Nurkhikmah, & Lestari, 2019).

CONCLUSION

Home lighting, home hygiene, and ventilation were significantly related to prevention behavior, while humidity showed no significant relationship. Among all variables, home lighting was identified as the most influential factor in preventing pulmonary TB transmission.

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