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THE INFLUENCE OF HOUSEHOLD ENVIRONMENTAL FACTORS ON PULMONARY TUBERCULOSIS IN INDONESIA (Literature Review)

Alif Rizkyansyah [1], Onny Setiani[2], Nikie Astorina YD[2]
1Environmental Health Concentration, Faculty of Public Health, Diponegoro University
[2]Department of Environmental Health, Faculty of Public Health, Diponegoro University, Semarang, Indonesia
Jl. Prof. Soedarto, S.H., Tembalang, Semarang, 50275
E-mail: alifrizky9915@gmail.com

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ABSTRACT

The Influence Of Household Environmental Factors On Pulmonary Tuberculosis In Indonesia (Literature Review). *Indonesia was the 3rd country with the highest number of tuberkulosis sufferers in the world. The high number of tuberkulosis (TB) in Indonesia was related to various factors in the home environment. Population density, poor housing conditions, limited access to health services, low nutritional status, social and economic factors, high population mobility, and inappropriate treatment patterns were some of the main causes. A study was conducted to investigate the relationship between the home environment and the occurrence of pulmonary tuberkulosis in Indonesia. A systematic review was employed in this study, utilizing a sample of 15 pertinent journal articles. The data collection approach encompassed the exploration of articles aligned with the research objectives in designated databases, namely Google Scholar, Portal Garuda, Science Direct, ProQuest, and Springer Link, following defined inclusion and exclusion criteria. The Gathered data were organized into tables, and a table for data extraction was formulated. The identification of home environmental risk factors and data analysis were conducted using meta-synthesis (qualitative). The results of the research indicated that out of the 15 articles obtained in the final databases, factors such as ventilation, humidity, temperature, lighting, income , diabetes mellitus, and a history of household contacs were established as correlated with prevalence of pulmonary tuberkulosis in Indonesia. Home environmental factors, including ventilation, humidity, temperature, lighting, income, diabetes mellitus, and history of household contacts, influenced pulmonary tuberkulosis in Indonesia.*

INTRODUCTION

Tuberculosis (TB) is a communicable disease that has become a major concern in global health discourse. TB is ranked among the top ten causes of death worldwide and is classified as the leading infectious cause of death after HIV/AIDS. The infection is caused by *Mycobacterium tuberculosis* and is primarily transmitted through the air when an infected individual coughs, classifying it as an airborne disease. Although it predominantly affects the lungs (commonly referred to as pulmonary TB), tuberculosis may also infect other parts of the body (known as extrapulmonary TB). Nearly one-quarter of the global population is estimated to be infected with *M. tuberculosis*[1].

TB remains a significant health challenge in many countries and continues to rank tenth among the world's most fatal diseases. According to the *Global Tuberculosis Report 2021* by the World Health Organization (WHO), the global prevalence of TB reached 10 million people. The distribution of TB cases varies among countries, with India accounting for 27% of the global burden, followed by China (9%), Indonesia (8%), the Philippines (6%), Pakistan (5%), Nigeria (4%), Bangladesh (4%), and South Africa (3%). These statistics place Indonesia as the country with the third-highest number of TB cases globally. [23]

In 2021, there was a significant increase in the number of TB cases identified in Indonesia, reaching 397,377 cases, compared to 351,936 cases in the previous year. Provinces with large populations—specifically Central Java, West Java, and East Java—reported the highest TB incidence rates. Combined, these three provinces contributed to approximately 44% of the total TB cases reported across Indonesia. [26]

Several factors are associated with the occurrence of pulmonary TB, including age, gender, employment status, income level, educational attainment, household environmental conditions, smoking habits, and history of contact with infected individuals[4,5,6]. When categorized by age group, TB prevalence in 2021 showed the highest incidence in individuals aged 45–54 years (17.5%), followed by the 25–34 age group (17.1%) and the 15–24 age group (16.9%). [26]

Housing conditions play a crucial role in determining the health and well-being of a population. A dwelling that meets the standards of a healthy home can contribute to reducing the risk of disease transmission and improving public health. In contrast, poor residential environmental conditions can increase the risk of disease spread, including the transmission of TB. [7]

Other contributing factors, such as educational level, community knowledge and attitudes, employment status, history of diabetes mellitus, and history of contact with TB patients, have also been associated with the high incidence of tuberculosis in Indonesia.[8] [9][10]

Numerous studies have been conducted, both domestically and internationally, to investigate the association between residential environmental factors and the incidence of pulmonary TB. These studies have yielded diverse results and conclusions. Therefore, a systematic literature review was conducted with the aim of identifying and analyzing environmental factors in the home that are associated with pulmonary TB incidence.

In light of these issues, a literature review was carried out using various credible sources and previous research to explore which specific residential environmental factors are associated with the incidence of pulmonary tuberculosis in Indonesia.

MATERIALS AND RESEARCH METHODS

This study adopted a systematic review approach with the aim of identifying and analyzing the relationship between residential environmental factors and the incidence of pulmonary tuberculosis in Indonesia. The data utilized in this study consisted of secondary data, specifically journal articles published in national journals with a minimum accreditation level of Sinta 4, and reputable international journals. The keywords employed in this study included: "pulmonary tuberculosis AND household environmental factors AND Indonesia" and "TB AND household environment." For international journal searches, the keywords used were "pulmonary tuberculosis AND the physical environment of the house AND Indonesia." Databases such as Google Scholar, Portal Garuda, ScienceDirect, ProQuest, and SpringerLink were utilized to access articles online.

The inclusion criteria applied in this study were: publication within the last ten years (2013–2023), research conducted in Indonesia, use of a case-control study design, articles written in either Bahasa Indonesia or English, pulmonary tuberculosis patients as the population and sample, inclusion of research findings, and availability of full-text open access articles.

The article selection process began by entering the keywords into the respective databases, identifying a total of 1,400 articles at this stage. All identified articles were then checked for

duplication. After removing duplicates, 1,390 articles proceeded to the screening stage. Out of these, 1,260 articles were excluded due to titles and abstracts that were irrelevant to the research topic and/or inaccessible full texts, resulting in 130 articles progressing to the next stage. Upon a comprehensive assessment of these 130 articles, it was found that 115 articles did not meet the predefined inclusion and exclusion criteria. Therefore, only 15 scientific articles were eligible for quality evaluation. To assess the quality of the selected articles, the Critical Appraisal Checklist for Case-Control Studies developed by the Joanna Briggs Institute (JBI) was employed. Articles that passed the quality assessment were included in this study, and data analysis was conducted using a meta-synthesis approach.

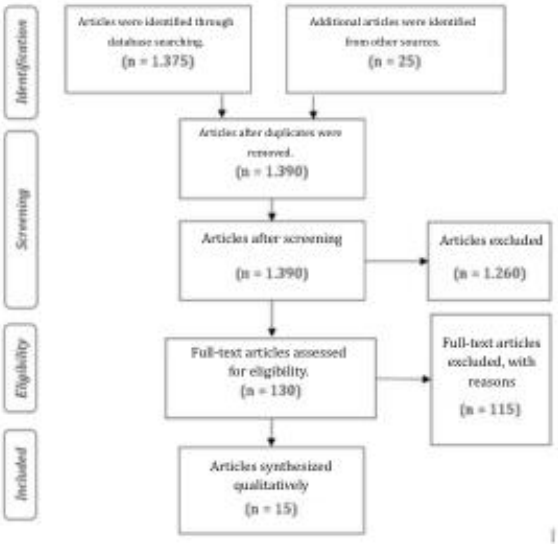

Figure 1. Flow Diagram of Article Selection

RESEARCH RESULTS AND DISCUSSION

After reviewing all selected articles, 15 different research locations were identified, namely Pekalongan, Denpasar, Bima (West Nusa Tenggara), Kebumen, Bandar Lampung City, Semarang, Bulukumba (South Sulawesi), Surabaya, Asahan (North Sumatra), North Lampung, Merangin (Jambi), Purwokerto, Sragen (Central Java), Kendari, and Kupang — each accounting for 6.7% of the total studies.

Table 1. Identification of Household Environmental Factors

Article	Household Environmental Factors										
	Ventilation	Humidity	Temperature	Lighting	**Occupancy density**	**Educational level**	Income level	Occupation	Knowledge	Diabetes Mellitus	History of Household Contact
Mudiyono, et al. (2015)[1]	√	√	√	√	√				√		
Karminiasih, et al. (2016)[2]	√			√						√	√
Bachmida, et al. (2016)[3]	√	√		√	√	√					
Yuniar, et al. (2017)[4]							√				
Perdana, and Putra (2018)[5]	√	√		√	√						
Zulaikhah, et al. (2019)[6]	√	√	√	√	√						
Dani, et al. (2020)[7]	√				√						
Muhammad, et al. (2020)[8]	√	√	√	√	√						
]Gultom, et al. (2022)[9]				√							
Derny, et al. (2022)[10]	√	√	√	√	√						
Miharti (2022)[11]		√							√		
Nur'aini, et al. (2022)[12]	√	√	√	√	√				√		
Wulandari, et al. (2022)[13]		√		√	√						
Hasan, et al. (2023)[14]	√				√						
Baun, et al. (2023) [15]		√		√							

Based on Table 1, the household environmental factors that showed a significant association with the incidence of pulmonary tuberculosis according to the reviewed articles include ventilation (9 out of 10 articles), humidity (7 out of 10 articles), temperature (4 out of 5 articles), lighting (9 out of 11 articles), income (1 article), diabetes mellitus (1 article), and history of household contact (1 article).
Meanwhile, the factors that did not show a significant association with pulmonary tuberculosis incidence include occupancy density (5 out of 10 articles showed no significant relationship), education (1 article), knowledge (2 out of 3 articles), and occupation (0 articles).

Association between Ventilation and the Incidence of Pulmonary Tuberculosis
Findings from studies on ventilation as a household environmental risk factor show that nearly all (90% of the reviewed articles) concluded a significant association between ventilation conditions and the incidence of pulmonary tuberculosis. Therefore, it can be concluded that ventilation is a proven risk factor related to pulmonary tuberculosis incidence in Indonesia.
Inadequate home ventilation has been identified as a risk factor associated with increased incidence of pulmonary tuberculosis in Indonesia[1,3,5,16–18] [1] [3] [5] [16-18]. The standard requirement for healthy ventilation is at least 10% of the floor area. Ventilation that does not meet this standard (<10%) can decrease oxygen levels while increasing carbon dioxide levels, temperature, and humidity. Ventilation functions to maintain fresh air and provide sufficient oxygen in the room.
Homes with inadequate ventilation prevent natural light from entering, resulting in increased humidity and temperature indoors, which creates a favorable environment for the tuberculosis bacteria to survive and infect residents. Factors affecting indoor ventilation include outdoor temperature and the condition of windows or doors. Mycobacterium tuberculosis bacteria may linger in the air if the air circulation is poor, and TB transmission is more likely in spaces with inadequate ventilation. [6]
Evidence was found in a study conducted in Dusun Sembung, Margopatut Village, Sawahan Subdistrict, Nganjuk Regency, by Mayasari et al., involving 212 respondents selected through simple random sampling. The study found that home sanitation—including ventilation, floor type, ceiling, occupancy density, and lighting—was associated with the incidence of pulmonary TB[19]. Nurany et al. (2022) also found consistent evidence that ventilation is a risk factor for pulmonary TB [20-22]

Association between Humidity and the Incidence of Pulmonary Tuberculosis
Based on the results of the article analysis regarding humidity as an environmental risk factor in the household setting, nearly all of the reviewed articles (8 out of 10) reported significance values of less than 0.05. This indicates a statistically significant association between indoor humidity and the incidence of pulmonary tuberculosis (TB). Humidity has been confirmed as a risk factor associated with pulmonary TB incidence in Indonesia. [1,3,17,18,23,24]
Both excessively high and low humidity levels can promote the proliferation of microorganisms. The recommended humidity level is between 40% and 60%. Poor housing construction—such as leaky roofs, and non-water-resistant floors and walls—can increase indoor humidity levels. If the indoor humidity falls below 40%, several public health interventions can be implemented, including: (a) using devices to increase humidity, such as humidifiers, (b) opening house windows, (c) increasing the number and size of windows, and (d) modifying the physical structure of the building to enhance lighting and air circulation. Conversely, if the humidity exceeds 60%, interventions may include: (a) installing glass roof tiles and (b) using devices to reduce humidity, such as dehumidifiers. [6]
These findings are consistent with the study conducted by Nurany et al. (2022), which reported that humidity can exacerbate the incidence of pulmonary tuberculosis. [20]

Association between Temperature and the Incidence of Pulmonary Tuberculosis

The analysis of articles regarding temperature as a household environmental risk factor found that all of them (100% of the 4 reviewed articles) concluded a significant association between indoor temperature and the incidence of pulmonary tuberculosis. Therefore, temperature is a proven risk factor associated with the incidence of pulmonary tuberculosis in Indonesia [8-10, 18,22,24]

Indoor air temperatures above 30ºC can be reduced by improving air circulation through the addition of mechanical or artificial ventilation. Conversely, if the temperature falls below 18ºC, room heating should be used with energy sources that are safe for both the environment and human health. Variations in indoor air temperature are influenced by several factors, including: (1) the use of biomass fuels, (2) inadequate ventilation, (3) housing density, (4) building materials and structure, (5) geographical conditions, and (6) topographical characteristics.

According to the indoor air health guidelines for residential housing, the recommended room temperature is between 18–30ºC. Temperature is one of the risk factors for pulmonary tuberculosis. *Mycobacterium tuberculosis* cannot survive in hot environments or under direct sunlight. [6]

Association between Lighting and the Incidence of Pulmonary Tuberculosis

Based on the analysis of articles regarding lighting as a household environmental risk factor, nearly all (9 out of 11 reviewed articles) confirmed a significant association between lighting and the incidence of pulmonary tuberculosis. Thus, lighting is a proven risk factor correlated with the incidence of pulmonary tuberculosis in Indonesia. [1,8,9,15,17,18,23,24,26,]

Insufficient lighting (< 60 lux) affects the eye's accommodation process, which can lead to retinal damage. Excessive lighting (> 120 lux), on the other hand, can increase indoor temperatures. Indoor lighting should be adjusted to meet the minimum requirement of 60 lux, sufficient for seeing surrounding objects and reading comfortably. Lighting is also associated with indoor temperature and humidity, both of which influence the growth of microorganisms. [6]

The study by Mayasari et al. (2022) in Dusun Sembung, Margopatut Village, Sawahan Subdistrict, Nganjuk Regency, involving 212 respondents, provided evidence that lighting is associated with the incidence of pulmonary tuberculosis. [19,20]

Association between Residential Crowding and the Incidence of Pulmonary Tuberculosis

Based on the results of article analysis concerning residential density as a household environmental risk factor, 5 out of 10 reviewed articles indicated no association between residential density and the incidence of pulmonary tuberculosis. Therefore, it can be concluded that higher housing density does not correlate with the occurrence of pulmonary tuberculosis. Thus, residential density is not considered a risk factor associated with the incidence of pulmonary tuberculosis in Indonesia.

Although some environmental factors have been shown to be associated with pulmonary tuberculosis incidence in Indonesia, residential density is not regarded as one of them. The article analysis revealed no consistent link between residential overcrowding and increased risk of pulmonary tuberculosis. While high occupancy density may contribute to the transmission of infectious diseases, the findings suggest that other factors such as ventilation, humidity, and temperature may have a more significant impact in the Indonesian context. Hence, greater emphasis should be placed on these environmental factors in efforts to prevent and control pulmonary tuberculosis in Indonesia.[1,5,18]

These findings contrast with a study by Mayasari et al. (2022), conducted in Dusun Sembung, Margopatut Village, Sawahan Subdistrict, which reported that housing density was significantly correlated with the incidence of pulmonary tuberculosis.[19]

Association between Education and the Incidence of Tuberculosis

The analysis of articles regarding education as a household environmental risk factor concluded that there is no significant association between education level and the incidence of pulmonary tuberculosis. Consequently, it can be inferred that education is not considered a risk factor associated with the incidence of pulmonary tuberculosis in Indonesia.

Although education plays an important role in shaping health behavior and public knowledge, the analysis results indicate that it does not serve as a risk factor for pulmonary tuberculosis incidence in the country. This may be due to the complex variability in how education influences tuberculosis risk, with other factors—such as environmental conditions and access to healthcare—potentially playing a more substantial role. Therefore, while education remains a critical component in disease prevention efforts, this analysis highlights the need to focus more on environmental and healthcare-related factors in addressing pulmonary tuberculosis in Indonesia.[3]

These findings contradict the study by Darmin et al. (2022), which reported that education level plays a significant role in the increased incidence of pulmonary tuberculosis. [27]

Association between Income and the Incidence of Pulmonary Tuberculosis

The analysis of income as a household environmental risk factor indicates a significant association between income levels and the incidence of pulmonary tuberculosis. Thus, income is considered a proven risk factor associated with the incidence of pulmonary tuberculosis in Indonesia.

Income is deemed a relevant risk factor through its relationship with access to healthcare services and the overall living environment. Low-income individuals often reside in substandard living conditions and have limited access to healthcare facilities. These conditions—such as overcrowded housing and poor ventilation—can increase susceptibility to pulmonary tuberculosis transmission. Therefore, addressing income disparities and improving healthcare access are critical strategies in controlling pulmonary tuberculosis in Indonesia, particularly among low-income populations. [4]

The Relationship between Occupation and Pulmonary Tuberculosis Incidence

Based on the analysis of the reviewed articles, no significant association was found between occupational status and the incidence of pulmonary tuberculosis in Indonesia. Although occupational exposure may influence certain health risks, its relationship with pulmonary tuberculosis appears to be inconsistent within the broader population context. The variability in job types, access to healthcare, and environmental conditions at workplaces may represent complex factors that obscure a clear link between occupation and tuberculosis incidence.

Therefore, while occupation remains an important aspect of public health consideration, these findings highlight the need to understand and assess a wide range of risk factors comprehensively in efforts to control pulmonary tuberculosis in Indonesia.[1,14,29,35]

The relationship of knowledge with the incidence of pulmonary tuberculosis

Based on the analysis of reviewed articles, only 1 out of 3 studies examined reported a significant association between knowledge and the incidence of pulmonary tuberculosis. This indicates that the majority of findings did not support a significant relationship, suggesting that knowledge is not considered a key risk factor associated with pulmonary tuberculosis in Indonesia.

Although good knowledge can play an important role in disease prevention efforts, the findings imply that in the context of pulmonary tuberculosis, other environmental and health-related factors may have a more substantial impact. The lack of association between knowledge and tuberculosis incidence may be influenced by various variables, including

access to healthcare services, environmental conditions, and other socioeconomic determinants. Therefore, tuberculosis prevention and control efforts in Indonesia should incorporate a comprehensive approach that takes into account these multifaceted factors to achieve more effective outcomes. [1,13,26]

The Association of Diabetes Mellitus with Pulmonary Tuberculosis Incidence

Based on the analysis of the reviewed article, there is a demonstrated association between diabetes mellitus (DM) and the incidence of pulmonary tuberculosis. Thus, diabetes mellitus is recognized as a risk factor associated with pulmonary tuberculosis in Indonesia.

Diabetes mellitus is considered a proven risk factor for pulmonary tuberculosis due to its detrimental effects on the immune system. Individuals with diabetes may have impaired immune responses to *Mycobacterium tuberculosis*, increasing their susceptibility to infection and progression of pulmonary tuberculosis. Given the rising prevalence of diabetes mellitus in Indonesia, this association becomes increasingly significant and demands focused attention in tuberculosis prevention, diagnosis, and management strategies.

Therefore, holistic health monitoring and management approaches are necessary to reduce the risk of pulmonary tuberculosis among individuals with diabetes mellitus in Indonesia.[2]

The Association of Household Contact History with the Incidence of Pulmonary Tuberculosis

Findings from the analysis in this study indicate a significant association between household contact history and the incidence of pulmonary tuberculosis. Thus, household contact history is recognized as a risk factor associated with the incidence of pulmonary tuberculosis in Indonesia.

Household contact is considered a proven risk factor for pulmonary tuberculosis due to the close physical proximity and frequent interactions with individuals already infected by *Mycobacterium tuberculosis*. Households serve as environments where transmission can occur more efficiently due to prolonged and repeated exposure. Therefore, identifying and managing individuals with a history of household contact plays a crucial role in the prevention and control of pulmonary tuberculosis in Indonesia. Measures such as tuberculin testing and prophylactic treatment for high-risk individuals can help reduce disease incidence among populations with potential exposure.

This study supports the findings of Darmin et al. (2022), who reported that having contact with TB patients significantly increases the risk of developing pulmonary tuberculosis. [16-25]

CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis of 15 reviewed articles, it was found that residential environmental factors can increase the risk of pulmonary tuberculosis (TB). Several factors associated with TB incidence—including humidity, ventilation, lighting, temperature, income level, diabetes mellitus (DM), and household contact history—have been confirmed as risk factors for pulmonary TB in Indonesia. These risk factors influence the incidence of pulmonary TB by facilitating the growth of Mycobacterium tuberculosis, worsening the health condition of susceptible individuals, and increasing the likelihood of infection.

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