JPPIPA 11(5) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of the Quality of the Physical Environment of the House on the Incidence of Tuberculosis in Tembalang Subdistrict

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Received: February 03, 2025
Revised: April 18, 2025
Accepted: May 25, 2025
Published: May 31, 2025

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DOI: 10.29303/jppipa.v11i5.11393

Abstract: Tuberculosis (TB) remains a major health problem in Indonesia, including in Tembalang Sub-district, Semarang City, which is listed as one of the areas with high cases. Indonesia ranks among the top three countries in the world with the highest number of TB cases exceeding one million cases. This research is an observational analytic study with a case-control study design. The purpose of this study was to assess the risk factors of household physical environment that affect the incidence of Tuberculosis in Tembalang Sub-district. The results showed that most of the houses with tuberculosis patients had unhealthy environmental conditions, such as poor air circulation (37.5%), high occupancy density (35%), improper flooring (57.5%), insufficient ventilation (67.5%), low lighting (85%), and high humidity (87.5%). These factors were found to have a significant association with an increased risk of TB. However, ceiling conditions and room temperature did not show a significant association with increased TB risk. These findings emphasize the importance of improving the living environment through education and community involvement in improving housing quality as a preventive measure to reduce TB transmission.

Keywords: Air Circulation; Environmental quality; House condition; Tuberculosis

Introduction

Tuberculosis (TB) is an infectious disease caused by Mycobacterium tuberculosis, primarily affecting the lungs and spread through droplets when coughing or sneezing. The main symptoms include prolonged cough, chest pain, weight loss, and long-term fever (Farrah et al., 2023). TB is divided into two, namely Drug Sensitive TB (SO) which is easy to treat and Drug Resistant TB (RO) which is more difficult to treat due to resistance to first-line drugs. Drug resistance occurs because TB bacteria mutate, due to inadequate treatment, such as inappropriate doses, incomplete treatment, and inconsistent use of drugs (Kristini & Hamidah, 2020).

In Indonesia, TB cases based on the Global TB Report 2023 show that Indonesia has the second highest number of TB cases in the world, with more than one million cases and 134,000 deaths per year. This number is much higher when compared to pre-pandemic cases which averaged under 600,000 per year. Central Java reported 87,074 cases in 2023 (exceeding the national target), but with low DR-TB case finding coverage (44% of the 80% target). The absolute number of cases found was 1075 out of 2425 cases of DR-TB (Dinas Kesehatan, 2022).

Semarang City, especially Tembalang Sub-district, is an area with high TB cases. From January to October 2024, there were 479 cases with 433 patients starting treatment. The high number of TB cases in Tembalang Subdistrict is thought to be related to the unhealthy physical environment of homes, such as poor ventilation, insufficient lighting, extreme humidity,

How to Cite:
Aditya, V. R., Raharjo, M., & Setiani, O. (2025). Analysis of the Quality of the Physical Environment of the House on the Incidence of Tuberculosis in Tembalang Subdistrict. *Jurnal Penelitian Pendidikan IPA*, *11*(5). https://doi.org/10.29303/jppipa.v11i5.11393

inappropriate temperature, and high residential density. In addition to environmental factors, populations vulnerable to TB include children, the elderly, people with HIV/AIDS, smokers, excessive alcohol consumers, people with diabetes mellitus, close contact with TB patients, and health workers (Devi et al., 2020).

The physical condition of a house that does not meet health standards can increase the number of germs in it. An unhealthy environment plays a role in influencing the incidence of TBC (Arifiati et al., 2024). Several studies have shown that factors such as ventilation, floor and wall types, window opening habits, and smoking behavior influence the incidence of TBC. Environmental health is also an important indicator in the Clean and Healthy Living Behavior (PHBS) program, where research shows that 18.8% of families who do not implement PHBS experience TBC (Kementrian Kesehatan RI, 2020)

The analysis of the quality of the physical environment of houses in Tembalang Sub-district in this study is expected to identify various physical environmental factors that increase the risk factors for TB incidence in Tembalang Sub-district.

Method

This study was an observational analytic study with a case-control study design conducted in Tembalang Subdistrict, Semarang City, in January-February 2025. This study aimed to determine the relationship between home environment risk factors and the incidence of tuberculosis. The sample consisted of 40 BTA positive tuberculosis cases and 40 controls, selected by purposive sampling and matching based on age and gender.

The dependent variable in this study was the incidence of tuberculosis, while the independent variables were air circulation in the house, occupancy density, floor type, wall type, ceiling condition, ventilation area, lighting intensity, humidity level, and room temperature in the house.

Primary data were obtained through interviews, observations, and direct measurements using tools such as thermohygrometer, lux meter, and GPS. Secondary data were obtained from relevant agencies. Data were analyzed univariately, bivariately using the chi-square test and Odds Ratio.

The results of the study are expected to identify significant home environment risk factors for Tuberculosis incidence. These findings will provide a basis for more effective public health interventions.

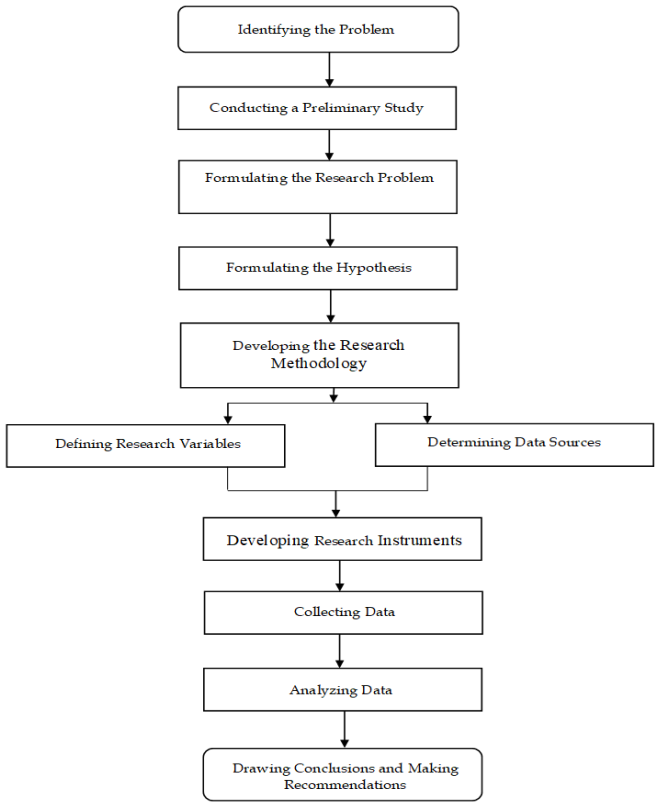

Figure 1. Research Flowchart

Result and Discussion

Results of Data Analysis of Environmental Quality on Tuberculosis Incidence in Tembalang Subdistrict

Table 1. Results of Analysis of Environmental Quality on Tuberculosis Incidence in Tembalang Sub-district

Variable	p Value	OR	95% CI	
			Lower	*Upper*
Air Circulation in the House	0.003	7.400	1.939	28.245
Residential Density	0.001	21.000	2.601	169.539
Floor Type	0.001	5.412	1.998	14.661
Wall Type	0.011	4.667	1.507	14.455
House Ceiling Condition	0.101	3.000	0.945	9.528
Ventilation Area	0.043	2.810	1.129	6.991
Lighting Intensity	0.0001	17.000	5.520	52.359
Humidity Level	0.0001	14.538	4.617	45.782
Indoor Temperature	0.821	1.227	0.505	2.982

Based on the results of the analysis of environmental quality on the incidence of tuberculosis in Tembalang Subdistrict, it is known that there is a significant relationship between several variables of physical environmental conditions of the house and the

incidence of tuberculosis in Tembalang Subdistrict. The results of the bivariate test are described below:

Relationship between Air Circulation in the House with the Incidence of Tuberculosis in Tembalang Subdistrict

Statistical test results showed a p value = 0.003 (p<0.05), indicating a significant relationship between air circulation and the incidence of Tuberculosis in Tembalang Subdistrict. The Odds Ratio (OR) analysis showed an OR = 7.400 (95% CI = 1.939-28.245), which means that dense air circulation increases the possibility of TB transmission with a 7.4 times greater risk. Poor circulation increases the concentration of CO2, toxic substances, and germs including droplets of Mycobacterium tuberculosis bacteria. In addition, through ventilation sunlight can enter the house where sunlight, which is ultraviolet light, has been shown to reduce the concentration of Mycobacterium tuberculosis bacteria in the air (Yunita et al., 2022).

The results of this study are in line with Monintja & Warouw (2020) proving that there is a relationship between air circulation in the house with pulmonary TB with a p value = 0.000 ≤ 0.05. Unqualified air circulation will cause a lot of microorganism growth.

Air circulation is a crucial aspect in assessing the quality of environmental ventilation. Circulation that meets the requirements is more than equal to 12 ACH. The higher the ACH value, the less likely infectious droplets remain in the air and the lower the risk of transmission (Wulandari et al., 2023). Good air circulation can reduce the concentration of CO_2, toxic substances, and germs including *Mycobacterium tuberculosis* bacterial droplets contained in the air in the house. Meanwhile, insufficient air circulation can create an environment that supports the growth of *Mycobacterium tuberculosis* (Monintja & Warouw, 2020).

Relationship between Residential Density and Tuberculosis Incidence in Tembalang Subdistrict

Statistical test results showed a p value = 0.001 (p<0.05), indicating a significant relationship between residential density and the incidence of Tuberculosis in Tembalang Subdistrict. The Odds Ratio (OR) analysis showed an OR = 21,000 (95% CI = 2.601 - 169.539), which means that a dense residential environment increases the likelihood of TB transmission with a 21 times greater risk. This study is in line with that conducted by Ferdiansyah in 2024 individuals who live in houses with unqualified residential density are at 18 times greater risk of developing pulmonary TB compared to those who live in houses with qualified residential density (Ferdiansyah et al., 2024). Then research conducted by Pramono & Wiyadi (2021) stated that there was a significant relationship between occupancy density and the incidence of pulmonary tuberculosis with p=0.018; OR=3.03.

High residential density increases the risk of pulmonary tuberculosis transmission because it reduces oxygen levels and increases humidity and room temperature, which support the growth of Mycobacterium tuberculosis. Dense housing contributes to cross-infection between residents, especially if there are people with TB. Prevention efforts can be done by ensuring the house has good ventilation, sufficient lighting, and the number of occupants according to health standards (≥9 m^2/person) (Yanti, 2017).

Relationship between Floor Type and Tuberculosis Incidence in Tembalang Subdistrict

Statistical test results showed a p value = 0.001 (p<0.05), indicating a significant relationship between floor type and the incidence of Tuberculosis in Tembalang Subdistrict. The result of Odds Ratio (OR) analysis showed OR = 5.412 (95% CI = 21.998-14.661), which means that if the type of floor that does not meet the requirements increases the possibility of TB transmission with a 5.4 times greater risk.

The results of this study are in line with a study conducted that there is a relationship between the type of floor with the incidence of pulmonary TB with the results of the chi square statistical test obtained a value of p = 0.004 <0.05 (Siregar & Lubis, 2022). There is a relationship between the type of floor of the house and the incidence of pulmonary TB in Panekan District, Magetan Regency with a p value = 0.002 and an OR value = 3.551 (95% CI = 1.541 - 8.181), which means that houses with dirt floors can increase the risk of pulmonary TB incidence by 3 times greater than houses with tiled floors.

Floor type is one of the risk factors for pulmonary TB. Floors that do not meet health standards such as floors that are not waterproof, including those made of plaster and soil contribute to pulmonary tuberculosis disease. Impermeable floor types accelerate the process of pulmonary tuberculosis disease, with high indoor humidity. Earthen floors are most likely to have excess moisture, with the floor turning dry during the summer. This condition has the potential to cause dust that is harmful to people living in the house (Kurniasih & Triyantoro, 2017).

According to Permenkes No. 2 of 2023, a good type of home floor is non-slip, waterproof, flat, and not difficult to clean, for example plastered, made of ceramics and tiles. While the type of floor that is not waterproof is made of soil or plaster with cracked or damaged conditions. The type of flooring can affect the risk of TBC transmission (Kementerian Kesehatan, 2023).

Relationship between Type of House Wall and Tuberculosis Incidence in Tembalang Subdistrict

Statistical test results showed a p value = 0.011 (p<0.05), indicating a significant relationship between the type of wall and the incidence of Tuberculosis in Tembalang Subdistrict. The Odds Ratio (OR) analysis showed an OR = 4.667 (95% CI = 1.507-14.455), which means that if the type of wall is not qualified, it increases the possibility of TB transmission with a 4.7 times greater risk.

This study is in line with research conducted by Rezeki et al. (2025) which stated that there is a significant relationship between the type of wall and tuberculosis with the result of OR = 10. Alchamdani & Ningsi (2022) stated that the type of wall that is not permanent and not waterproof is one of the risk factors for the physical environment of the house that can increase the risk of suffering from tuberculosis.

The type of house wall affects the humidity and the risk of pulmonary tuberculosis transmission. Impermanent walls increase the risk by 6,969 times. The use of waterproof materials such as plaster or anti-mold paint can help create a healthier home environment and reduce the spread of TBC (Alchamdani & Ningsi, 2022).

Relationship between House Ceiling Condition and Tuberculosis Incidence in Tembalang Sub-district.

Statistical test results showed a p value = 0.101 (p>0.05), indicating no significant relationship between the state of the ceiling and the incidence of Tuberculosis in Tembalang Subdistrict.

This research is in line with research conducted by Dani in 2019. Based on the results of the study, it shows that the proportion of unqualified ceilings is more in the case group (43.2%) compared to the control group (21.6%). The results of the analysis using the Chi- Square test showed a value of p=0.082 so that there was no significant relationship (Imaduddin et al., 2019). Dian in 2024 found that there was no significant relationship between the ceiling of the house and the incidence of relapsed pulmonary TBC at the Puskesmas in Malang Regency. That the ceiling that does not meet the requirements has a risk of 3.714 times greater than people who live in homes with eligible ceiling conditions (Zustianingtyas et al., 2024).

A good home ceiling must be easy to clean, can withstand dust and dirt from the roof and withstand raindrops that penetrate through the cracks in the roof, not prone to accidents, not made of materials that can release substances that can endanger health, and materials that can allow the growth and development of pathogenic microorganisms, one of which is tuberculosis germs (Imaduddin et al., 2019).

Relationship between Ventilation Area and Tuberculosis Incidence in Tembalang Subdistrict

The result of statistical test showed p value = 0.043 (p<0.05), indicating a significant relationship between ventilation area and the incidence of Tuberculosis in Tembalang Sub-district. The Odds Ratio (OR) analysis showed an OR = 2.810 (95% CI = 1.129-6.991), which means that if the ventilation area does not meet the requirements, it increases the possibility of TB transmission with a risk of 2.8 times greater.

This study is in line with research conducted by Nike in 2020 that there is a relationship between ventilation area and pulmonary tuberculosis in the working area of the bailaing health center. This study is also in line with Aisyah's research in 2022 that ventilation area affects the incidence of pulmonary tuberculosis in Kebasen District, Banyumas Regency. The results of the chi-square test showed that a person who has an unqualified home ventilation area (<10% of the floor area) has a risk of suffering from pulmonary tuberculosis 13.75 times greater than someone who has a qualified home ventilation area (Aryani & Syapitri, 2018).

Home ventilation that is less than 10% of the floor area increases the risk of pulmonary TB. Poor air circulation makes it easier for Mycobacterium tuberculosis bacteria to survive (Zulaikhah et al., 2019). Good ventilation helps to reduce humidity, bring in sunlight, and suppress transmission. The solution is to open vents or doors regularly, and add air holes if possible.

Relationship between Light Intensity and Tuberculosis Incidence in Tembalang Subdistrict

Statistical test results showed a p value = 0.0001 (p<0.05), indicating a significant relationship between light intensity and the incidence of Tuberculosis in Tembalang Subdistrict. The Odds Ratio (OR) analysis showed an OR = 17.000 (95% CI = 5.520-52.359), which means that if the light intensity is not qualified, it increases the possibility of TB transmission with a 17 times greater risk.

The results of the chi square test p = 0.030 <0.05, which means that there is a significant relationship between house lighting and the incidence of pulmonary tuberculosis in the working area of the Paragutan Health Center, South Tapanuli Regency in 2021. Jeni et al (2023) stated that there was a relationship between lighting and the incidence of tuberculosis in the working area of the Perbaungan Health Center with a value of p = 0.002 and OR = 3.647 (95% CI = 1.570-8.470), which means that respondents who have lighting that does not meet the requirements are almost 4 times more at risk of developing pulmonary TB than respondents who have a

lighting level that meets the requirements (Noerfitra & Surya, 2023).

According to the Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023, the minimum indoor lighting standard is 60 lux. However, many houses still do not meet this standard due to the lack of ventilation, houses that are close together, and lack of awareness to open windows. Lack of lighting prevents natural UV rays from entering, even though these rays are effective in killing Mycobacterium tuberculosis bacteria. Artificial lighting such as lamps is also often inadequate because the intensity is too dim. Therefore, the community needs to raise awareness to open windows every morning to allow maximum sunlight to enter. In addition to window installation, the use of glass roof tiles can also be an alternative to still meet the needs of room lighting (Bidarita Widiati, 2022).

Relationship between Humidity Level and Tuberculosis Incidence in Tembalang Subdistrict

Statistical test results showed a p value = 0.0001 (p<0.05), indicating a significant relationship between the level of humidity and the incidence of Tuberculosis in Tembalang Subdistrict. The Odds Ratio (OR) analysis showed an OR = 14.538 (95% CI = 4.617-45.782), which means that if the humidity is not qualified, it increases the possibility of TB transmission with a 14.5 times greater risk.

The results of this study are in line with a study there is a relationship between the level of humidity and the incidence of pulmonary TB in the working area of the Bandar Khalifah Health Center with a p value = <0.001 and OR = 21,000 (95% CI = 5.047 - 87.378) which means that respondents who live in homes with unqualified humidity levels have a 21 times greater risk of developing pulmonary tuberculosis, compared to respondents who live in homes with qualified humidity levels (Tajung, 2021). In the study of Tamara et al in 2025 that the p-value of the statistical test was 0.004, which indicates that Ha is accepted. There is a significant relationship between air humidity and tuberculosis, as shown by the ratio of air humidity obtained (OR=15.4), which means that respondents with unqualified air humidity experience tuberculosis 15.4 times more than respondents with qualified air humidity (Rezeki et al., 2025).

Humid home conditions are an ideal environment for the growth and sustainability of Mycobacterium tuberculosis. This leads to an increased risk of pulmonary TB transmission. Inadequate ventilation and lighting exacerbate the humidity in the house. According to Permenkes RI No. 2 Year 2023, the ideal humidity in the house is 40-60%. Efforts that can be made to maintain ideal humidity in the house include opening windows, doors, and increasing ventilation so that air circulation and sunlight can enter optimally (Kementerian Kesehatan, 2023).

Relationship between Room Temperature and Tuberculosis Incidence in Tembalang Subdistrict

Statistical test results showed a p value = 0.821 (p>0.05), indicating no significant relationship between room temperature and the incidence of Tuberculosis in Tembalang Subdistrict.

This is in line with research from Siti, et al. in 2020 which states that based on statistical tests there is no significant relationship between house temperature and the incidence of pulmonary TB in the Pekalongan Health Center working area, East Lampung Regency with a p value of 0.353 (Wahyuningsih et al., 2024). Then research conducted by Jenni et al in 2023 stated that temperature is not a risk factor for the incidence of pulmonary TB in the Perbaungan Health Center work area with a p value = 0.540 and OR = 1.285 (95% CI = 0.576-2.864) which means that respondents who have a house temperature of 30^{o}C are 1.285 times more at risk of developing TB than respondents who have a temperature of 18^{o}C or 30^{o}. This study states that temperature is not a risk factor for pulmonary TB (Tajung, 2021).

Abnormal home environment temperatures provide a medium for the growth of microorganisms, including Mycobacterium tuberculosis. Therefore, it is important to maintain a stable home temperature by opening windows every morning, adding glass roof tiles, providing kitchen smoke holes, and improving air circulation to ensure that the temperature and humidity remain within safe and healthy limits. The existence of good air circulation is expected to reduce the transmission of pulmonary TB in the house (Rahmawati et al., 2021).

Conclusion

This study shows that home environmental conditions that do not meet health standards have a significant association with an increased risk of Tuberculosis (TB) in Tembalang Sub-district, Semarang City. Factors such as poor air circulation, high occupancy density, inappropriate floor and wall types, poor ventilation, low lighting, and high humidity were shown to contribute to TB transmission. Meanwhile, ceiling conditions and room temperature showed no significant effect. The findings in this study emphasize the need to improve the living environment through education and community involvement in improving housing quality as a preventive measure to reduce TB transmission.

Acknowledgments
The author would like to thank the managers of the tuberculosis program at Rowosari Health Center and Kedungmundu Health Center, as well as the academic community of the Master of Environmental Health Study Program, Diponegoro University for providing facilities and infrastructure that support this research.

Author Contributions
This study was designed and conceptualized by V.R.A, M.R, and O.S. V.RA contributed to data collection, data analysis, and manuscript writing. M.R and O.S supervised the research and critiqued the manuscript.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflicts of interest.

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