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Original Article

Association between physical housing conditions and pulmonary tuberculosis incidence: A cross-sectional study

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Abstract

Background: Environmental determinants, particularly physical housing conditions, play an important role in facilitating the transmission of airborne infectious diseases such as tuberculosis. Poor ventilation, overcrowded living conditions, inadequate lighting, and substandard housing structures may increase the risk of pulmonary tuberculosis transmission within households and communities.

Objective: This study aimed to analyze the association between physical housing conditions and the incidence of pulmonary tuberculosis in the working area of UPTD Puskesmas Pengaringan, Ogan Komering Ulu Regency, Indonesia.

Methods: This study employed a descriptive analytical approach using a cross-sectional design. The study was conducted from October to December 2025 among suspected pulmonary tuberculosis patients attending UPTD Puskesmas Pengaringan. The study population consisted of 115 suspected tuberculosis patients, and a sample of 89 respondents was determined using the Slovin formula with a 5% margin of error. Participants were selected using purposive sampling based on predefined inclusion and exclusion criteria. Data were collected through structured interviews and direct observational measurements of housing conditions. Data analysis included univariate analysis to describe variable distributions and bivariate analysis using the Chi-square test with a significance level of $\alpha = 0.05$ to examine associations between housing conditions and pulmonary tuberculosis incidence.

Results: The results showed that 17 respondents (19.1%) were diagnosed with pulmonary tuberculosis. Bivariate analysis demonstrated significant associations between physical housing conditions and pulmonary tuberculosis incidence, including ventilation area ($p = 0.026$), residential density ($p = 0.047$), floor type ($p = 0.021$), and household lighting ($p = 0.011$). Respondents living in houses with inadequate ventilation, overcrowded conditions, inappropriate floor materials, and insufficient lighting had a higher proportion of pulmonary tuberculosis cases compared with those living in houses that met health standards.

Conclusion: Physical housing conditions are significantly associated with pulmonary tuberculosis incidence in the study area. Improvements in household environmental conditions, including adequate ventilation, appropriate housing density, suitable floor materials, and sufficient lighting, are essential components of community-based tuberculosis prevention strategies.

Background

Tuberculosis remains a major global public health problem that affects millions of people every year and causes substantial morbidity and mortality worldwide (Global Tuberculosis Report, 2022). The pathogen Mycobacterium tuberculosis causes pulmonary tuberculosis through complex mechanisms of pathogenicity and virulence that enable transmission and persistence in human populations (Rahlwes et al., 2023; Rastogi et al., 2023). Epidemiological evidence shows that multidrug-resistant tuberculosis and treatment complications continue to challenge disease control programs in many countries (Yin et al., 2022; Nenhan et al., 2025). Health systems in several regions still face structural challenges in achieving tuberculosis elimination targets (Long et al., 2021). The disease also produces long-term sequelae among patients, including children and adolescents who experience post-tuberculosis health complications (Igbokwe et al., 2023). These conditions indicate that tuberculosis remains a persistent infectious disease that requires comprehensive prevention strategies addressing both biomedical and environmental determinants.

Environmental and climatic factors influence respiratory health and contribute to the epidemiological dynamics of pulmonary tuberculosis (Bayram et al., 2023). Rising global temperatures and climate change affect respiratory epithelial barriers and increase vulnerability to pulmonary diseases (Celebi Sozener et al., 2023). Environmental stressors such as heat exposure can induce pulmonary cellular damage and inflammatory responses that weaken respiratory defense mechanisms (Hou et al., 2024). Human thermoregulation and physiological responses to heat stress also influence susceptibility to respiratory illnesses in vulnerable populations (Cramer et al., 2022). Climate change has therefore become a critical factor influencing population health and infectious disease transmission worldwide (Romanello et al., 2021). These environmental transformations highlight the importance of examining how ecological conditions interact with infectious diseases such as tuberculosis.

Meteorological variables such as temperature, humidity, and air pollution contribute to the transmission and incidence of pulmonary tuberculosis in many settings (Chang et al., 2024). Several studies demonstrate that extreme temperature events increase the risk of respiratory disease and cardiovascular mortality in affected populations (Xu et al., 2023). Air pollution and particulate matter exposure also contribute significantly to pulmonary tuberculosis occurrence in urban environments (Li et al., 2024; Wei et al., 2023). Time-series analyses indicate that variations in temperature and humidity correlate with fluctuations in tuberculosis notifications across different geographic regions (Xu et al., 2020). Environmental exposure to air pollutants and meteorological factors further influences hospitalization rates related to respiratory diseases (Jia et al., 2022). These findings confirm that environmental determinants play an essential role in shaping tuberculosis epidemiology.

Built environment characteristics, including housing conditions and population density, influence the spread of infectious diseases in communities (Hu et al., 2023). Physical housing conditions such as ventilation, humidity, and crowding facilitate airborne transmission of respiratory pathogens within households (Božič & Kanduč, 2021; Yang et al., 2021). Previous research shows that poor housing conditions significantly increase the risk of pulmonary tuberculosis transmission in residential environments (Budi et al., 2024). Studies conducted in community health settings also report associations between inadequate home environments and tuberculosis incidence among residents (Hidayanto Putra et al., 2023). Environmental determinants within residential areas therefore represent critical factors in tuberculosis prevention strategies. Understanding the role of housing environments is essential to reduce disease transmission at the household level.

Tuberculosis incidence also interacts with behavioral and social determinants that influence disease progression and treatment outcomes (Nurhayati & Febrianti, 2024). Patient adherence to anti-tuberculosis medication remains an important factor in successful disease management and prevention of complications (Vera Kurnia Putri et al., 2025; Media Febriana et al., 2025). Clinical interventions such as respiratory physiotherapy and breathing exercises contribute to improving respiratory function among pulmonary tuberculosis patients (KK et al., 2025). Public health education programs also improve community knowledge regarding respiratory infections and disease prevention (Angraeni et al., 2025). Cross-sectional studies frequently serve as an appropriate methodological approach to examine relationships between health determinants and disease outcomes in community settings (Anurak & Chaow, 2025; Yuliana & Aulia, 2024). These findings indicate that tuberculosis prevention requires integrated approaches that include behavioral, environmental, and clinical interventions.

Regional epidemiological data show that tuberculosis cases continue to occur in several districts and community health center service areas (Dinas Kesehatan OKU, 2024; UPTD Puskesmas Pengaringan, 2024). Spatial and temporal analyses demonstrate that environmental conditions significantly influence the distribution of tuberculosis cases across regions (Li et al., 2022; Zhang et al., 2023). Meteorological variability and air pollution exposure further increase tuberculosis risk in certain geographic locations (Nie et al., 2024; Qin et al., 2022). Ecological studies also confirm that multiple environmental determinants interact to influence tuberculosis incidence and mortality globally (Liyew et al., 2024). Despite the growing evidence regarding environmental determinants of tuberculosis, limited studies specifically examine the role of physical housing conditions in influencing pulmonary tuberculosis incidence at the community level.

Therefore, this study aims to analyze the association between physical housing conditions and pulmonary tuberculosis incidence.

Methods

Study Design

This study employed a descriptive analytical approach using a cross-sectional design to examine the association between physical housing conditions and the incidence of pulmonary tuberculosis. The cross-sectional design was selected because it allows the simultaneous assessment of exposure variables and disease outcomes within a defined population at a single point in time. This design is particularly appropriate for investigating relationships between environmental risk factors and disease occurrence without requiring long-term follow-up of participants. In this study, the exposure variables included physical housing characteristics such as ventilation area, residential density, floor type, and household lighting, while the outcome variable was the incidence of pulmonary tuberculosis among suspected patients. The study was conducted between October and December 2025 in the working area of the UPTD Puskesmas Pengaringan, Ogan Komering Ulu Regency, Indonesia. The reporting of this study follows the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guideline recommended by the EQUATOR Network, which provides a framework for transparent reporting of observational research including cross-sectional studies.

Sampling

The study population consisted of all suspected pulmonary tuberculosis patients who sought medical care at UPTD Puskesmas Pengaringan during the study period. According to the health center registry, the total number of suspected pulmonary tuberculosis patients recorded during the study period was 115 individuals. The required sample size was calculated using the Slovin formula with a 5% margin of error to obtain a representative sample of the population. Based on this calculation, a minimum sample size of 89 participants was determined to be sufficient to ensure adequate statistical power and representativeness. Participants were selected using purposive sampling to ensure that respondents met specific eligibility criteria relevant to the research objectives. The inclusion criteria included individuals who were suspected of having pulmonary tuberculosis, were willing to participate in the study, and were able to communicate effectively during interviews. The exclusion criteria included respondents who had died during the study period, individuals whose houses were undergoing renovation at the time of data collection, and respondents whose residential addresses could not be located or verified by the research team. This sampling strategy allowed the researchers to focus specifically on individuals who could provide reliable information regarding household environmental conditions related to tuberculosis risk.

Instruments

Data collection utilized a structured questionnaire and environmental measurement tools designed to assess housing conditions associated with pulmonary tuberculosis risk. The primary instrument consisted of a structured questionnaire that had previously undergone validity and reliability testing to ensure the accuracy and consistency of collected data. The questionnaire collected information on demographic characteristics, household conditions, and relevant environmental factors. In addition to the questionnaire, direct environmental measurements were conducted using a roll meter to determine the ventilation area of each house. The study included two types of variables: dependent and independent variables. The dependent variable was the incidence of pulmonary tuberculosis among patients in the working area of UPTD Puskesmas Pengaringan. The independent variables included physical housing conditions such as ventilation area, residential density, floor type, and household lighting. Ventilation area was measured based on the total area of windows or ventilation openings relative to the floor area of the house. Residential density was determined by calculating the number of occupants relative to the available living space. Floor type was categorized based on the material used in the household flooring, while household lighting was evaluated through observational assessment of natural and artificial lighting conditions within the home environment.

Data Collection

Data collection was conducted using both primary and secondary data sources to ensure comprehensive information regarding tuberculosis cases and housing conditions. Primary data were obtained through direct interviews with respondents using the structured questionnaire and through observational measurements of housing conditions. The observational assessment included direct measurement of ventilation area, evaluation of household density, identification of floor type, and observation of household lighting conditions. These measurements were performed during home visits to ensure accurate environmental assessment. Secondary data were obtained from official documents and medical records available at UPTD Puskesmas Pengaringan and the Ogan Komering Ulu District Health Office. These records provided information related to tuberculosis case registration and patient characteristics. During the data collection process, the principal investigator was accompanied by trained enumerators who assisted in conducting interviews, performing environmental observations, and verifying housing measurements. The enumerators received prior training to ensure standardization in measurement procedures and interview techniques, which helped minimize measurement bias and improve data quality.

Data Analysis

Data analysis was conducted in two stages using statistical methods appropriate for cross-sectional research. The first stage involved univariate analysis to describe the distribution and frequency of each study variable. The univariate analysis aimed to summarize respondent characteristics and environmental housing conditions, including ventilation area, residential density, floor type, and household lighting. The results of this analysis were presented in frequency distribution tables to provide a clear overview of the data patterns within the study population. The second stage involved bivariate analysis to examine the association between the dependent variable and independent variables. Specifically, the relationship between pulmonary tuberculosis incidence and physical housing conditions was analyzed. The statistical test used for this analysis was the Chi-square test because the variables analyzed were categorical variables representing housing conditions and disease incidence. The level of statistical significance was set at $\alpha = 0.05$, which means that associations were considered statistically significant if the p-value was less than 0.05. The results of the bivariate analysis were presented in cross-tabulation tables to illustrate the relationships between each independent variable and pulmonary tuberculosis incidence.

Ethical Consideration

This study was conducted in accordance with ethical principles for research involving human participants. Permission to conduct the study was obtained from the management of UPTD Puskesmas Pengaringan before data collection began. Each participant received a clear explanation regarding the objectives, procedures, benefits, and potential risks associated with the study. Respondents who agreed to participate were asked to sign a written informed consent form as evidence of their voluntary participation. The research team ensured that all collected information remained confidential and was used solely for research purposes. Personal identifiers were removed during data processing to protect participant privacy and anonymity. The researchers also ensured that participants had the right to withdraw from the study at any time without any consequences for their medical care or access to health services. These ethical safeguards were implemented to ensure that the study adhered to ethical research standards and respected the rights and dignity of all participants.

Results

Table 1 presents the frequency distribution of respondents based on the incidence of pulmonary tuberculosis and several physical housing condition variables in the working area of UPTD Puskesmas Pengaringan, Ogan Komering Ulu Regency, in 2025. The variables analyzed include the incidence of pulmonary tuberculosis, ventilation area of the house, residential density, type of floor, and household lighting conditions. The distribution is presented in terms of the number of respondents and percentages to describe the characteristics of the study population and the environmental housing conditions observed during the research period.

Table 1. Frequency Distribution of Respondents

Variables	Frequency (n)	Percentage (%)
Pulmonary Tuberculosis Incidence		
Pulmonary Tuberculosis	17	19.1
Non–Pulmonary Tuberculosis	72	80.9
House Ventilation Area		
Does not meet the standard	34	38.2
Meets the standard	55	61.8
Residential Density		
Does not meet the standard	41	46.1
Meets the standard	48	53.9
Type of House Floor		
Does not meet the standard	38	42.7
Meets the standard	51	57.3
Household Lighting		
Does not meet the standard	36	40.4
Meets the standard	53	59.6

Table 1 shows that out of 89 respondents, 17 individuals (19.1%) were diagnosed with pulmonary tuberculosis, while the majority of respondents, 72 individuals (80.9%), were categorized as non–pulmonary tuberculosis cases. This distribution indicates that pulmonary tuberculosis cases were present in a considerable proportion of the study population, although most respondents were not diagnosed with the disease.

The analysis of housing ventilation shows that 34 houses (38.2%) did not meet the recommended ventilation standards, while 55 houses (61.8%) met the required ventilation criteria. This finding indicates that the majority of houses in the study area had ventilation conditions that met health standards, although a substantial proportion still had inadequate ventilation that could potentially increase the risk of airborne disease transmission.

The distribution of residential density indicates that 41 houses (46.1%) had occupancy density that did not meet health standards, while 48 houses (53.9%) met the recommended occupancy criteria. This result suggests that nearly half of the respondents lived in houses with overcrowded conditions, which may facilitate the spread of infectious respiratory diseases.

The analysis of floor type shows that 38 houses (42.7%) had floor types that did not meet health standards, while 51 houses (57.3%) had adequate floor conditions. This finding demonstrates that although more than half of the houses had appropriate flooring materials, a considerable number of houses still had floor conditions that may contribute to poor household hygiene and environmental health risks.

Finally, the distribution of household lighting shows that 36 houses (40.4%) did not meet the recommended lighting standards, while 53 houses (59.6%) had adequate lighting conditions. This result indicates that most houses had sufficient lighting; however, a significant proportion of houses still experienced inadequate lighting conditions that may affect indoor environmental quality.

Overall, the findings in Table 1 demonstrate that although most respondents lived in houses that met several physical housing health standards, a considerable proportion of households still had environmental conditions that did not meet recommended criteria. These environmental factors may potentially contribute to the occurrence and transmission of pulmonary tuberculosis in the community.

Table 2. Association Between Physical Housing Conditions and Pulmonary Tuberculosis Incidence

Variables	Pulmonary TB		Non-Pulmonary TB		Total		p-value
	n	%	n	%	n	%	
House Ventilation Area							
Does not meet the standard	11	32.4	23	67.6	34	100	0.026
Meets the standard	6	10.9	49	89.1	55	100	
Residential Density							
Does not meet the standard	12	29.3	29	70.7	41	100	0.047
Meets the standard	5	10.4	43	89.6	48	100	
Type of House Floor							
Does not meet the standard	12	31.6	26	68.4	38	100	0.021
Meets the standard	5	9.8	46	90.2	51	100	
Household Lighting							
Does not meet the standard	12	33.3	24	66.7	36	100	0.011
Meets the standard	5	9.4	48	90.6	53	100	

Table 2 presents the results of the bivariate analysis examining the association between physical housing conditions and the incidence of pulmonary tuberculosis in the working area of UPTD Puskesmas Pengaringan in 2025. The analysis was conducted using the Chi-square test with a significance level of α = 0.05 to determine whether physical environmental conditions within households were significantly associated with pulmonary tuberculosis incidence among respondents.

The analysis of house ventilation shows that among respondents whose houses did not meet ventilation standards, 11 individuals (32.4%) were diagnosed with pulmonary tuberculosis, while 23 individuals (67.6%) were categorized as non–pulmonary tuberculosis cases. In contrast, among respondents living in houses that met ventilation standards, only 6 individuals (10.9%) experienced pulmonary tuberculosis, while 49 individuals (89.1%) were classified as non–pulmonary tuberculosis cases. The statistical analysis shows a p-value of 0.026, which indicates a significant association between ventilation conditions and pulmonary tuberculosis incidence. This finding suggests that inadequate house ventilation may increase the risk of tuberculosis transmission.

The analysis of residential density indicates that among respondents living in houses with occupancy density that did not meet health standards, 12 individuals (29.3%) experienced pulmonary tuberculosis, while 29 individuals (70.7%) were categorized as non–pulmonary tuberculosis cases. Among respondents living in houses with adequate residential density, 5 individuals (10.4%) experienced pulmonary tuberculosis, while 43 individuals (89.6%) did not experience the disease. The Chi-square analysis produced a p-value of 0.047, which indicates a statistically significant relationship between residential density and pulmonary tuberculosis incidence. This finding suggests that overcrowded housing conditions may facilitate the transmission of tuberculosis within households.

The analysis of house floor type shows that among respondents living in houses with floor types that did not meet health standards, 12 individuals (31.6%) experienced pulmonary tuberculosis, while 26 individuals (68.4%) were categorized as non–pulmonary tuberculosis cases. Among respondents living in houses with adequate floor conditions, only 5 individuals (9.8%) experienced pulmonary tuberculosis, while 46 individuals (90.2%) did not experience the disease. The statistical test resulted in a p-value of 0.021, indicating a significant association between house floor conditions and pulmonary tuberculosis incidence. This result suggests that poor housing sanitation conditions related to floor materials may contribute to environmental factors that support disease transmission.

The analysis of household lighting indicates that among respondents whose houses had lighting conditions that did not meet health standards, 12 individuals (33.3%) experienced pulmonary tuberculosis, while 24 individuals (66.7%) were categorized as non–pulmonary tuberculosis cases. Among respondents living in houses with adequate lighting conditions, only 5 individuals (9.4%) experienced pulmonary tuberculosis, while 48 individuals (90.6%) did not experience the disease. The Chi-square test produced a p-value of 0.011, indicating a statistically significant association between household lighting conditions and pulmonary tuberculosis incidence. This finding suggests that insufficient lighting within houses may contribute to environmental conditions that support the persistence and transmission of tuberculosis bacteria.

Overall, the results of the bivariate analysis demonstrate that all examined physical housing variables—including ventilation area, residential density, floor type, and household lighting—show statistically significant associations with pulmonary tuberculosis incidence in the study population. These findings highlight the importance of improving household environmental conditions as part of tuberculosis prevention strategies at the community level.

Discussion

The present study identified significant associations between several physical housing conditions and the incidence of pulmonary tuberculosis among respondents in the working area of UPTD Puskesmas Pengaringan. The results showed that inadequate house ventilation was significantly related to pulmonary tuberculosis incidence with a p-value of 0.026. The findings also demonstrated that residential density was significantly associated with pulmonary tuberculosis occurrence with a p-value of 0.047. The study further revealed that inappropriate floor types were significantly related to pulmonary tuberculosis incidence with a p-value of 0.021. In addition, inadequate household lighting showed a statistically significant relationship with pulmonary tuberculosis incidence with a p-value of 0.011. These findings indicate that physical environmental conditions within households play an important role in influencing the occurrence of pulmonary tuberculosis in the community.

Tuberculosis remains a global infectious disease that continues to pose major challenges to public health systems in many countries. Global health surveillance systems report that tuberculosis remains one of the leading causes of death due to infectious diseases worldwide (Global Tuberculosis Report, 2022). The bacterium Mycobacterium tuberculosis causes pulmonary tuberculosis through complex biological mechanisms that enable the organism to survive and replicate within the human respiratory system (Rahlwes et al., 2023). The structural and biochemical characteristics of this pathogen allow the bacterium to persist in the host and promote disease transmission within communities (Rastogi et al., 2023). The persistence of tuberculosis cases also reflects the continuing challenges faced by health systems in implementing effective tuberculosis control strategies (Long et al., 2021). The occurrence of post-tuberculosis complications among patients further highlights the importance of strengthening preventive strategies and environmental interventions in tuberculosis control (Igbokwe et al., 2023).

Environmental and climatic factors contribute significantly to respiratory health and influence the epidemiology of pulmonary tuberculosis in different regions. Climate change alters environmental conditions and affects respiratory health among vulnerable populations worldwide (Bayram et al., 2023). Rising global temperatures also disrupt epithelial barriers in the respiratory tract and increase susceptibility to respiratory diseases (Celebi Sozener et al., 2023). Heat exposure further induces cellular damage and inflammatory responses that may affect lung health and respiratory function (Hou et al., 2024). Human thermoregulation mechanisms also influence physiological responses to environmental heat stress and respiratory disease vulnerability (Cramer et al., 2022). Global environmental changes therefore create complex interactions between climate conditions and infectious disease transmission dynamics (Romanello et al., 2021). These environmental processes demonstrate the importance of examining household environmental conditions in relation to pulmonary tuberculosis risk.

Meteorological factors also influence the occurrence of pulmonary tuberculosis by affecting pathogen survival and human susceptibility to infection. Several epidemiological studies demonstrate that environmental factors such as temperature and humidity influence tuberculosis incidence across different geographic regions (Chang et al., 2024). Environmental exposure to air pollution and particulate matter further contributes to respiratory diseases and increases the risk of pulmonary tuberculosis in affected populations (Li et al., 2024). High concentrations of particulate matter can impair respiratory defense mechanisms and facilitate the transmission of airborne infectious pathogens (Wei et al., 2023). Environmental temperature fluctuations also influence respiratory morbidity and mortality through physiological stress responses in the human body (Xu et al., 2023). Additional studies report that variations in humidity and temperature correlate with fluctuations in tuberculosis notification rates across urban environments (Xu et al., 2020). These findings highlight the importance of environmental determinants in shaping tuberculosis transmission patterns.

The built environment within residential settings also plays a crucial role in influencing the spread of infectious diseases in communities. Housing conditions represent an important determinant of health because the household environment directly affects exposure to infectious agents (Hu et al., 2023). Airborne pathogens can spread more easily within enclosed indoor environments where ventilation conditions are inadequate (Božič & Kanduč, 2021). The transmission of respiratory droplets containing infectious agents can occur through airborne pathways within poorly ventilated living spaces (Yang et al., 2021). Several public health studies report that poor physical housing conditions contribute significantly to the occurrence of pulmonary tuberculosis among household members (Budi et al., 2024). Community-based epidemiological research also demonstrates that inadequate home environments increase the risk of tuberculosis transmission within residential areas (Hidayanto Putra et al., 2023). These findings emphasize the need to improve household environmental conditions to prevent tuberculosis transmission.

Behavioral and social determinants also contribute to the epidemiology of pulmonary tuberculosis and influence disease outcomes among affected individuals. Health behavior and lifestyle factors can influence susceptibility to tuberculosis infection and disease progression (Nurhayati & Febrianti, 2024). Treatment adherence remains a critical factor in ensuring successful tuberculosis management and preventing disease complications (Vera Kurnia Putri et al., 2025). Patient compliance with anti-tuberculosis medication significantly influences treatment success rates and recovery outcomes among tuberculosis patients (Media Febriana et al., 2025). Clinical management strategies such as respiratory physiotherapy and breathing exercises can improve respiratory function among pulmonary tuberculosis patients (KK et al., 2025). Public health education interventions also improve community knowledge regarding respiratory infections and preventive health behaviors (Angraeni et al., 2025). Cross-sectional research designs frequently provide important insights into the relationships between health determinants and disease outcomes in community settings (Anurak & Chaow, 2025).

Spatial and environmental epidemiology studies further demonstrate that tuberculosis distribution is influenced by geographic and environmental factors. Spatial analysis techniques reveal that tuberculosis cases tend to cluster in specific geographic areas where environmental conditions facilitate disease transmission (Li et al., 2022). Spatiotemporal studies show that tuberculosis incidence varies across regions and over time due to environmental and socioeconomic determinants (Zhang et al., 2023). Air pollution exposure and meteorological conditions also contribute to tuberculosis transmission dynamics in urban environments (Nie et al., 2024). Systematic reviews indicate that multiple ecological determinants interact simultaneously to influence tuberculosis incidence and mortality worldwide (Liyew et al., 2024). Additional epidemiological evidence demonstrates that environmental exposure to meteorological factors significantly influences tuberculosis risk across multiple countries (Qin et al., 2022). These findings suggest that environmental improvements at the household and community level are essential components of effective tuberculosis prevention strategies.

Conclusion and Recommendation

This study concludes that physical housing conditions are significantly associated with the incidence of pulmonary tuberculosis among respondents in the working area of UPTD Puskesmas Pengaringan. The results demonstrate that inadequate house ventilation, high residential density, inappropriate floor types, and insufficient household lighting are significantly related to pulmonary tuberculosis occurrence. These findings indicate that poor household environmental conditions may increase the risk of tuberculosis transmission within residential settings. The study recommends that local health authorities strengthen community-based environmental health interventions aimed at improving housing conditions, particularly ventilation, household density, flooring, and lighting. Health promotion programs should also emphasize household sanitation and environmental health awareness among community members. Future research should explore additional environmental and social determinants of tuberculosis transmission using larger populations and more comprehensive epidemiological approaches.

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Declaration of conflict of interest

The authors declare no competing interests.

Declaration on the Use of AI

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

References

Angraeni, D. F. A., Manalu, L. O., & Purwati, P. (2025). Edukasi media leaflet terhadap pengetahuan ibu balita dengan ISPA di Puskesmas Curugkembar Kabupaten Sukabumi. Bakti Nusantara Pengabdian Masyarakat Indonesia, 2(2), 32-38. https://doi.org/10.63202/bnpmi.v2i2.78

Anurak, A., & Chaow, C. (2025). Association Between Functional Status and Self-Care Behavior Among Adults at High Risk of Stroke : A Cross-Sectional Study. Journal of Community Nursing and Primary Care, 2(1), 15-20. https://doi.org/10.63202/jcnpc.v2i1.98

Bayram, H., Rice, M. B., Abdalati, W., Akpinar Elci, M., Mirsaeidi, M., Annesi-Maesano, I., et al. (2023). Impact of global climate change on pulmonary health: Susceptible and vulnerable populations. Annals of the American Thoracic Society, 20, 1088–1095. https://doi.org/10.1513/AnnalsATS.202212-996CME

Božič, A., & Kanduč, M. (2021). Relative humidity in droplet and airborne transmission of disease. Journal of Biological Physics, 47, 1–29. https://doi.org/10.1007/s10867-020-09562-5

Budi, W. S., Raharjo, M., & Nurjazuli. (2024). Analysis of Physical Conditions of Homes and Family Behavior on Tuberculosis Incidents: Literature Review. In Media Publikasi Promosi Kesehatan Indonesia (Vol. 7, Number 1, pp. 118–127). Muhammadiyah Palu University. https://doi.org/10.56338/mppki.v7i1.4665

Celebi Sozener, Z., Treffeisen, E. R., Ozdel Ozturk, B., & Schneider, L. C. (2023). Global warming and implications for epithelial barrier disruption and respiratory and dermatologic allergic diseases. Journal of Allergy and Clinical Immunology, 152, 1033–1046. https://doi.org/10.1016/j.jaci.2023.09.001

Chang, M., Emam, M., Chen, X., Lu, D., Zhang, L., & Zheng, Y. (2024). An investigation of the effects of meteorological factors on the incidence of tuberculosis. Scientific Reports, 14, 2088. https://doi.org/10.1038/s41598-024-52278-y

Chen, D., Lu, H., Zhang, S., Yin, J., Liu, X., Zhang, Y., et al. (2021). The association between extreme temperature and pulmonary tuberculosis in Shandong Province, China, 2005–2016: A mixed method evaluation. BMC Infectious Diseases, 21, 402. https://doi.org/10.1186/s12879-021-06116-5

Cramer, M. N., Gagnon, D., Laitano, O., & Crandall, C. G. (2022). Human temperature regulation under heat stress in health, disease, and injury. Physiological Reviews, 102, 1907–1989. https://doi.org/10.1152/physrev.00047.2021

Denpetkul, T., & Phosri, A. (2021). Daily ambient temperature and mortality in Thailand: Estimated effects, attributable risks, and effect modifications by greenness. Science of the Total Environment, 791, 148373. https://doi.org/10.1016/j.scitotenv.2021.148373

Dinas Kesehatan OKU. (2024). Profil Dinas Kesehatan Kabupaten OKUTahun 2024.

Ding, F., Liu, X., Hu, Z., Liu, W., Zhang, Y., Zhao, Y., et al. (2024). Association between ambient temperature, PM2.5 and tuberculosis in Northwest China. International Journal of Environmental Health Research, 34, 3173–3187. https://doi.org/10.1080/09603123.2023.2299236

Global Tuberculosis Report. (2022). World Health Organization (WHO). http://apps.who.int/bookorders.

Hidayanto Putra, S., Kurniawan, A., & Fanani, E. (2023). Hubungan Kondisi Fisik Rumah dengan Kejadian Tuberkulosis Paru di Wilayah Kerja Puskesmas Kedungkandang Kota Malang. Sport Science and Health, 6(9), 968–978. https://doi.org/10.17977/um062v6i92024p968-978

Hou, T., Zhang, J., Wang, Y., Zhang, G., Li, S., Fan, W., et al. (2024). Early pulmonary fibrosis-like changes in the setting of heat exposure: DNA damage and cell senescence. International Journal of Molecular Sciences, 25, 2992. https://doi.org/10.3390/ijms25052992

Hu, Y., Lin, Z., Jiao, S., & Zhang, R. (2023). High-density communities and infectious disease vulnerability: A built environment perspective for sustainable health development. Buildings, 14(1), 103. https://doi.org/10.3390/buildings14010103

Huang, K., Hu, C. Y., Yang, X. Y., Zhang, Y., Wang, X. Q., Zhang, K. D., et al. (2022). Contributions of ambient temperature and relative humidity to the risk of tuberculosis admissions: A multicity study in Central China. Science of the Total Environment, 838, 156272. https://doi.org/10.1016/j.scitotenv.2022.156272

Igbokwe, V., Ruby, L. C., Sultanli, A., & Belard, S. (2023). Post-tuberculosis sequelae in children and adolescents: A systematic review. The Lancet Infectious Diseases, 23, e138–e150. https://doi.org/10.1016/S1473-3099(23)00004-X

Jia, H., Xu, J., Ning, L., Feng, T., Cao, P., Gao, S., et al. (2022). Ambient air pollution, temperature and hospital admissions due to respiratory diseases in a cold, industrial city. Journal of Global Health, 12, 04085. https://doi.org/10.7189/jogh.12.04085

KK, I. F. J., Auliana, H., Damayanti, A. D., Putri, A., Susanti, M., Hidayati, T., … Herliza, S. (2025). Application of Active Cycle Breathing Technique (ACBT) Exercises on Hemodynamic Status in Pulmonary Tuberculosis Patients With Respiratory Problems : A Case Study. Lentera Perawat, 6(2), 227–233. https://doi.org/10.52235/lp.v6i2.450

Li, H., Ge, M., & Zhang, M. (2022). Spatio-temporal distribution of tuberculosis and the effects of environmental factors in China. BMC Infectious Diseases, 22, 565. https://doi.org/10.1186/s12879-022-07539-4

Li, W. X., Wang, X. D., Bi, B., Lu, J. J., Li, Z. Y., Cao, L., et al. (2024). Influence of temperature and humidity on the incidence of pulmonary tuberculosis in Hainan, China, 2004–2018. Biomedical and Environmental Sciences, 37, 1080–1085.

Li, Z., Liu, Q., Chen, L., Zhou, L., Qi, W., Wang, C., et al. (2024). Ambient air pollution contributed to pulmonary tuberculosis in China. Emerging Microbes & Infections, 13, 2399275. https://doi.org/10.1080/22221751.2024.2399275

Li, Z., Liu, Q., Zhan, M., Tao, B., Wang, J., & Lu, W. (2021). Meteorological factors contribute to the risk of pulmonary tuberculosis: A multicenter study in eastern China. Science of the Total Environment, 793, 148621. https://doi.org/10.1016/j.scitotenv.2021.148621

Liyew, A. M., Clements, A. C., Akalu, T. Y., Gilmour, B., & Alene, K. A. (2024). Ecological-level factors associated with tuberculosis incidence and mortality: A systematic review and meta-analysis. PLOS Global Public Health, 4, e0003425. https://doi.org/10.1371/journal.pgph.0003425

Long, C., Guo, S., Tian, P., & Sun, Y. (2024). Association between ambient temperature and increased total length of hospital stay of patients with cardiopulmonary disease in Hong Kong. Frontiers in Public Health, 12, 1411137. https://doi.org/10.3389/fpubh.2024.1411137

Long, Q., Guo, L., Jiang, W., Huan, S., & Tang, S. (2021). Ending tuberculosis in China: Health system challenges. The Lancet Public Health, 6, e948–e953. https://doi.org/10.1016/S2468-2667(21)00203-6

Long, R., Lau, A., Barrie, J., Winter, C., Armstrong, G., Egedahl, M. Lou, & Doroshenko, A. (2023). Limitations of Chest Radiography in Diagnosing Subclinical Pulmonary Tuberculosis in Canada. Mayo Clinic Proceedings: Innovations, Quality and Outcomes, 7(3), 165–170. https://doi.org/10.1016/j.mayocpiqo.2023.03.003

Maharjan, B., Gopali, R. S., & Zhang, Y. (2021). A scoping review on climate change and tuberculosis. International Journal of Biometeorology, 65, 1579–1595. https://doi.org/10.1007/s00484-021-02117-w

Meade, R. D., Akerman, A. P., Notley, S. R., McGinn, R., Poirier, P., Gosselin, P., et al. (2020). Physiological factors characterizing heat-vulnerable older adults: A narrative review. Environment International, 144, 105909. https://doi.org/10.1016/j.envint.2020.105909

Media Febriana, Lilis Suryani, Dianita Ekawati, & Chairil Zaman. (2025). Analysis of Medication Compliance In Pulmonary Tuberculosis Patients. Lentera Perawat, 6(1), 92–100. https://doi.org/10.52235/lp.v6i1.402

Nenhan, W., Lili, T., Yanfeng, Z., Shuangshuang, C., LiYing, T., Qiao, L., et al. (2025). Study of fluoroquinolones resistance in rifampicin-resistant tuberculosis patients in Beijing: Characteristics, trends, and treatment outcomes. Animal Models and Experimental Medicine, 8, 906–915. https://doi.org/10.1002/ame2.12505

Nie, Y., Yang, Z., Lu, Y., Bahani, M., Zheng, Y., Tian, M., et al. (2024). Interaction between air pollutants and meteorological factors on pulmonary tuberculosis in Northwest China: A case study of eight districts in Urumqi. International Journal of Biometeorology, 68, 691–700. https://doi.org/10.1007/s00484-023-02615-z

Nurhayati, & Febrianti. (2024). The Relationship between Knowledge Level and Smoking Habit Behavior with the Incidence of Pulmonary Tuberculosis Patients. Indonesian Journal of Health Services, 1(1), 1-6. https://doi.org/10.63202/ijhs.v1i1.4

Qin, T., Hao, Y., Wu, Y., Chen, X., Zhang, S., Wang, M., et al. (2022). Association between averaged meteorological factors and tuberculosis risk: A systematic review and meta-analysis. Environmental Research, 212, 113279. https://doi.org/10.1016/j.envres.2022.113279

Rahlwes, K. C., Dias, B. R. S., Campos, P. C., Alvarez-Arguedas, S., & Shiloh, M. U. (2023). Pathogenicity and virulence of Mycobacterium tuberculosis. Virulence, 14, 2150449. https://doi.org/10.1080/21505594.2022.2150449

Rastogi, N., Zarin, S., Alam, A., Konduru, G. V., Manjunath, P., Mishra, A., et al. (2023). Structural and biophysical properties of therapeutically important proteins Rv1509 and Rv2231A of Mycobacterium tuberculosis. International Journal of Biological Macromolecules, 245, 125455. https://doi.org/10.1016/j.ijbiomac.2023.125455

Romanello, M., McGushin, A., Di Napoli, C., Drummond, P., Hughes, N., Jamart, L., et al. (2021). The 2021 report of the Lancet Countdown on health and climate change: Code red for a healthy future. The Lancet, 398, 1619–1662. https://doi.org/10.1016/S0140-6736(21)01787-6

UPTD Puskesmas Pengaringan. (2024). Profil UPTD Puskesmas Pengaringan Tahun 2024.

Vera Kurnia Putri, Chairil Zaman, Akhmad Dwi Priyanto, & Dianita Ekawati. (2025). Analysis Factor of Compliance With Taking Anti-Pulmonary Tuberculosis Drugs in Patients With Pulmonary Tuberculosis. Lentera Perawat, 6(1), 59–68. https://doi.org/10.52235/lp.v6i1.398

Wagatsuma, K. (2024). Association of ambient temperature with tuberculosis incidence in Japan: An ecological study. IJID Regions, 12, 100384. https://doi.org/10.1016/j.ijregi.2024.100384

Wei, J., Li, Z., Lyapustin, A., Wang, J., Dubovik, O., Schwartz, J., et al. (2023). First close insight into global daily gapless 1 km PM2.5 pollution, variability, and health impact. Nature Communications, 14, 8349. https://doi.org/10.1038/s41467-023-43862-3

Wu, K., Ho, H. C., Su, H., Huang, C., Zheng, H., Zhang, W., et al. (2022). A systematic review and meta-analysis of intraday effects of ambient air pollution and temperature on cardiorespiratory morbidities: First few hours of exposure matters to life. EBioMedicine, 86, 104327. https://doi.org/10.1016/j.ebiom.2022.104327

Xu, M., Li, Y., Liu, B., Chen, R., Sheng, L., Yan, S., et al. (2020). Temperature and humidity associated with increases in tuberculosis notifications: A time-series study in Hong Kong. Epidemiology and Infection, 149, e8. https://doi.org/10.1017/S0950268820003040

Xu, R., Huang, S., Shi, C., Wang, R., Liu, T., Li, Y., et al. (2023). Extreme temperature events, fine particulate matter, and myocardial infarction mortality. Circulation, 148, 312–323.

https://doi.org/10.1161/CIRCULATIONAHA.122.063504

Yan, W., Qin, C., Tao, L., Guo, X., Liu, Q., Du, M., et al. (2023). Association between inequalities in human resources for health and all cause and cause specific mortality in 172 countries and territories, 1990–2019: Observational study. BMJ, 381, e073043. https://doi.org/10.1136/bmj-2022-073043

Yang, X., Yang, H., Ou, C., Luo, Z., & Hang, J. (2021). Airborne transmission of pathogen-laden expiratory droplets in open outdoor space. Science of the Total Environment, 773, 145537. https://doi.org/10.1016/j.scitotenv.2021.145537

Yi, X., & Liu, S. (2021). Impact of environmental factors on pulmonary tuberculosis in multi-levels industrial upgrading area of China. Environmental Research, 195, 110768. https://doi.org/10.1016/j.envres.2021.110768

Yin, J., Zhang, H., Gao, Z., Jiang, H., Qin, L., Zhu, C., et al. (2022). Transmission of multidrug-resistant tuberculosis in Beijing, China: An epidemiological and genomic analysis. Frontiers in Public Health, 10, 1019198. https://doi.org/10.3389/fpubh.2022.1019198

Yuliana, Y., & Aulia, S. (2024). Relationship between therapeutic communication and patient satisfaction at the community health center: A cross-sectional study. Journal of Community Nursing and Primary Care, 1(2), 51-56. https://doi.org/10.63202/jcnpc.v1i2.40

Zhang, F., Tang, H., Zhao, D., Zhu, S., Ruan, L., & Zhu, W. (2023). Short-term exposure to ozone and mortality from AIDS-related diseases: A case-crossover study in the middle Yangtze River region. Preventive Medicine, 175, 107689. https://doi.org/10.1016/j.ypmed.2023.107689

Zhang, X., Yu, S., Zhang, F., Zhu, S., Zhao, G., Zhang, X., et al. (2023). Association between traffic-related air pollution and osteoporotic fracture hospitalizations in inland and coastal areas: Evidences from the central areas of two cities in Shandong Province, China. Archives of Osteoporosis, 18, 96. https://doi.org/10.1007/s11657-023-01308-9

Zhang, Y., Ye, J., Hou, S., Lu, X., Yang, C., Pi, Q., et al. (2023). Spatial-temporal analysis of pulmonary tuberculosis in Hubei Province, China, 2011–2021. PLOS ONE, 18, e0281479. https://doi.org/10.1371/journal.pone.0281479