THE ASSOCIATION BETWEEN THE PHYSICAL CONDITIONS OF THE HOME ENVIRONMENT AND TUBERCULOSIS INCIDENCE DUE TO MYCOBACTERIUM TUBERCULOSIS

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Abstract: This study aims to analyse the presence of *Mycobacterium tuberculosis* (MTB) in the air and the physical conditions of the environment in relation to the incidence of tuberculosis (TB) in Lubuk Alung Sub-district, Padang Pariaman Regency. This research is an observational study with a case-control study design, with the data analysis focusing on the odds ratio (OR) value. The results revealed an OR value of 2.667, with a 95% confidence interval of 0.212-33.486. This suggests that home environments failing to meet health standards are associated with a threefold higher risk of TB compared with those meeting the requirements. The physical conditions of respondents' home environments did not meet the necessary standards, as indicated by inadequate ventilation relative to floor area, insufficient home temperature, excessive humidity, inadequate occupancy density, and insufficient natural lighting due to limited sunlight penetration.

Keywords: Home conditions, environment, Mycobacterium tuberculosis (MTB), Tubercolosis, (TB), Lubuk Alung Health Centre.

Introduction

One of the diseases that arise due to environmental factors is tuberculosis (TB), an infectious disease primarily affecting lung tissues and caused by *Mycobacterium tuberculosis* (MTB). TB can affect individuals of all ages with varying clinical presentations, ranging from asymptomatic to severe manifestations (Sharma & Sarkar, 2018). According to Dodd *et al.* (2021), TB remains a global concern, with no country in the world being TB-free to date.

Indonesia ranks third in terms of TB, following India and China, with 824,000 cases and 93,000 deaths reported annually, equating to approximately 11 deaths each hour. Based on the Global TB Report for 2022, the highest incidence of TB occurs within the productive age group, especially those aged 25 to 34 years. In Indonesia specifically, the greatest number of TB cases is observed among individuals aged 45 to 54 years (Oktaviani & Nufus, 2022).

Basic human needs encompass shelter, clothing and food. The home serves as the hub of life, providing space for all family members to convene, engage in activities, and spend the majority of their time. However, inadequate home construction and environmental conditions that fail to meet health standards are risk factors for the transmission of various diseases. Manuel (1999) and Oakman *et al.* (2020) outlined the criteria for a healthy home, which entail meeting physiological needs, such as ventilation, lighting, and adequate space for all family members, while minimising disruptive noises.

The home must also adhere to standards aimed at preventing disease transmission among family members, which include the provision of clean water, proper management of household waste and excrement, and the elimination of disease-carrying vectors, such as rats, cockroaches, and flies. Additionally, residential density should not exceed specified limits, sufficient sunlight should enter living areas, and measures should be in place to safeguard food and drinks from contamination. Furthermore, a healthy home must meet safety requirements to prevent accidents, both arising from external

and internal conditions, including structure that is resilient and resistant to damage and collapse, complying with road demarcation standards, being non-flammable, and minimising risks of occupants falling and slipping.

According to Regulation No. 1077/V/2011 issued by the Minister of Health of the Republic of Indonesia, several diseases, including chronic obstructive pulmonary disease, lung cancer, chronic bronchitis, low birth weight infant mortality, infant mortality in the first week of life, otitis media, acute respiratory infection, and TB, are prevalent in environments with poor indoor air quality (Ginting *et al*., 2022). Cosivi *et al.* (1998) and Gopalaswamy *et al.* (2020) stated that TB, an infectious disease caused by MTB, poses a serious health threat. TB can affect various human organs, particularly the lungs, leading to severe complications and potentially fatal outcomes if left untreated or improperly managed.

Padang Pariaman Regency ranks second highest for TB incidence in West Sumatra Province. In 2015, it recorded 1,125 new cases of acid-resistant bacteria suspected of being TB, known as smear (+), with a prevalence of 0.18%. In 2022 there were 1,244 new cases of acid-fast bacteria (+) with a prevalence of 0.17%. Data from the Health Office of Padang Pariaman Regency revealed that in 2018, out of 6,894 suspects examined, 368 were estimated to have TB . Despite the target case detection rate being 70%, the actual rate stood at only 40%, with a programme success rate of 84% against a target of 90% (Sri Deva, 2018; Dewata *et al*., 2023). The high number of TB cases in Indonesia, especially in Padang Pariaman Regency, West Sumatra Province, has prompted the government to take immediate action to mitigate TB instances.

The government's effort are reflected in the policy outlined in Regulation No. 67/2016 concerning "TB control". This encompasses health promotion, TB surveillance, risk factor control, case detection and management, immunisation, and preventive drug administration (Adzra & Susilawati, 2023). Free treatment is provided for six months to TB patients, aiming to ensure consistent medication intake until treatment completion, regular sputum re-examination, family counselling (Zwarenstein *et al*, 1998), and the implementation of the directly observed treatment short-course (DOTS) strategy chemotherapy recommended by the World Health Organisation (Texeira & Magesa, 2022). However, despite governmental efforts, maximum results have yet to be achieved. This may be attributed to suboptimal implementation of the DOTS strategy in both government and private hospitals, funding constraints, and inadequate cross-programme and cross-sector collaboration in the TB control initiatives.

Numerous physical conditions in people's home environments in Lubuk Alung Sub-district fail to meet the standards of a healthy home. These conditions include overcrowding, inadequate ventilation relative to room size, excessive humidity, and high indoor temperatures. Such substandard physical conditions pose a risk for the transmission of various diseases, including TB.

Researchers selected Lubuk Alung Sub-district as a case study for TB due to its notably low treatment success among 13 health centres in Padang Pariaman Regency, West Sumatra Province. The substandard physical conditions of the local residents' home environments also prompted the investigation. Thus, the study aimed to analyse the presence of MTB in the air and assess the correlation with TB incidence in Lubuk Alung Sub-district, Padang Pariaman Regency.

Methods

This study adopts an observational approach (Arlym *et al*., 2019; Marni *et al*., 2022). Data collection follows a case-control study design. The case population includes all households with newly diagnosed tuberculosis (TB) patients in Lubuk Alung Sub-district. The control population consists of households in Lubuk Alung Sub-district without individuals suffering from pulmonary or extrapulmonary TB.

The sample cases in this study consisted of five homes with new cases of TB from May 23, 2022, to November 23, 2022, in Lubuk Alung Sub-district. The control sample included 10 homes without individuals suffering from pulmonary or extrapulmonary TB in the same sub-district. TB patient data were sourced from secondary records at the Lubuk Alung Health Centre, using purposive sampling techniques (Marni & Zairo, 2022).

Physical home environment assessments were conducted between 9 a.m. and 11 a.m. Western Indonesian Time using a home observation sheet. Measurements included temperature and humidity using a thermos hygrometer, and lighting levels were assessed using a lux meter. Air samples were collected using an EPAM-5000 in a typical family gathering room, and dust samples were sent to the Laboratory of the Faculty of Mathematics and Natural Sciences at Universitas Negeri Padang for MTB bacteria examination via aerosol PCR.

The dependent variable in the study was TB incidence, while the independent variables were the presence of MTB in the air and the physical conditions of the home environment. Processed data were presented in frequency distribution tables and cross-tabulations. Bivariate analysis, including the calculation of the odds ratio (OR) value (Aditama *et al.*, 2019), was conducted to assess the influence of risk factors on TB incidence.

Results

The results of the univariate and bivariate analyses regarding the presence of MTB in the air and the physical conditions of the home environment are presented in Table 1. Among the 15 respondents, MTB presence in the air was negative in 11 cases (73.4%) with the reamaining four being positive (26.6%). The details are shown in Tables 1 and 2.

Ventilation measurements from 15 respondents revealed that ventilation did not meet the requirements in 12 (80%) homes, exceeding the three (20%) homes that met the requirements. Temperature measurements from 15 respondents indicated that temperatures met the requirements in 10 (66.6%) homes, surpassing the 5 (33.4%) homes that did not meet the requirements. Humidity measurements from 15 respondents showed that humidity did not meet the requirements in eight (53.4%) homes, exceeding the sevem (46.6%) homes that met the requirements.

Occupancy density measurements from 15 respondents revealed that occupancy density did not meet the requirements in 10 (66.6%) homes, surpassing the five (33.4%) homes that met the requirements. Lighting measurements from 15 respondents indicated that lighting did not meet the requirements in 12 (80%) homes, exceeding the three (20%) homes that met the requirements.

Table 1: The results of MTB examination in respondents' home environment

The presence of MTB	Amount (homes)	Percentage (%)
Positive	4	26,6
Negative	11	73,4
Total	15	100

Table 2: The results of the MTB presence in respondents' home environment

The presence of MTB	n	Percentage (%)	n	Percentage (%)
Positive	8	80	3	60
Negative	2	20	2	40
Total	10	100	5	100

Assessment of the floors of 15 respondents' homes found that all 15 homes (100%) met the requirements, based on the Technical Guidelines for Assessment of Healthy Homes by the Ministry of Health of the Republic of Indonesia in 2007 (Mustari, 2021), which specifies that floors meeting the requirements are plastered/tiled/ceramics/boards (homes on stilts). Assessment of the walls of 15 respondent's homes found that all 15 homes (100%) met the requirements, based on the same technical guidelines, which specify that walls meeting the requirements are permanent and waterproof boards.

Overall assessment of the physical condition of the home environment of the 15 respondents' homes revealed that five (33.3%) homes met the requirements, while 10 (66.7%) did not meet the requirements.

The assessment of the floor in the respondent's home involves observing whether the material used for the floor is waterproof. The results of this assessment, presented in Table 3, indicate that all homes, both those of TB sufferers and non-TB sufferers, met the requirements for the floor material.

Table 3: Analysis of the home environment's physical conditions with incidence of TB

Physical Conditions of the Home Environment	Control		Cases		OR
	n	%	n	%	
1. Ventilation					
Fulfil	3	30	0	0	-
Does not fulfil	7	70	5	100	
2. Temperature					
Fulfil	6	60	4	80	0,375
Does not fulfil	4	40	1	20	
3. Humidity					
Fulfil	6	60	1	20	6,000
Does not fulfil	4	40	4	80	
4. Density					
Fulfil	5	50	0	0	-
Does not fulfil	5	50	5	100	
5. Lighting					
Fulfil	2	20	1	20	1
Does not fulfil	8	80	4	80	
6. Floor					
Fulfil	10	100	5	100	-
Does not fulfil	0	0	0	0	
7. Wall					
Fulfil	10	100	5	100	-
Does not fulfil	0	0	0	0	
8. Physical conditions of the home environment					
Fulfil	4	40	1	10	2,667
Does not fulfil	6	60	4	80	

Source: Data analysis, 2022.

However, the analysis did not yield OR and CI values due to constant data. Consequently, the risk associated with a floor that does not meet the requirements for the occurrence of TB could not be calculated.

The assessment of the walls in the respondents' homes was carried out by observing the materials used to construct the walls (Figure 1). As depicted in Table 3 above, the results of the wall observation assessment in the respondents' home indicated that the walls in both TB sufferers' and non-TB sufferers' homes met the requirements. However, the analysis did not yield OR and CI values due to constant data, precluding the calculation of the risk associated with walls that did not meet the requirements for the occurrence of TB.

The assessment of the overall physical condition of the home environment encompasses several components, including ventilation, temperature, humidity, occupancy density, lighting, floors, and walls. As illustrated in Table 3, out of the five respondents with TB, four (80%) homes did not meet the requirements. Conversely, among the 10 respondents without TB, six (60%) homes did not meet the requirements. These findings suggest that individuals with TB tend to reside in homes that do not meet the specified criteria.

The analysis resulted in an OR of 2.667, with a 95% CI of 0.212-33.486. This indicates that the risk of developing TB is three times greater in homes where the physical conditions do not meet the requirements compared to those that do. As evident from the assessment presented in Table 3, individuals with TB tend to reside in homes that fail to meet these requirements.

The home environment's physical conditions significantly influence the transmission of TB. Factors such as ventilation, temperature, humidity, occupancy density, lighting, floors, and walls, as described above, play crucial roles in this transmission process.

The respondents' home environments did not meet the requirements based on the assessment of various components. Many homes exhibited deficiencies, such as inadequate ventilation relative to the floor area, insufficient temperature control, excessive humidity, occupancy density surpassing recommended levels, and inadequate natural lighting due to limited sunlight penetration.

To provide a clearer depiction of the building layout and the physical environment of houses in Lubuk Alung District, Padang Pariaman Regency, refer to Figure 2 below.

Figure 1: The shape of the walls of the respondents' house for both TB sufferers and non-TB sufferers

Figure 2. The building layout and the physical conditions of the house environment in Lubuk Alung District, Padang Pariaman Regency

Conclusions

The presence of MTB bacteria in a respondent's home increases the risk of developing TB by three times compared to homes without MTB bacteria. Similarly, homes with inadequate physical conditions face a threefold higher risk of TB development than those meeting the requirements. To mitigate this risk, communities should focus on enhancing home environments, particularly by installing mechanical ventilation systems to improve air circulation. Additionally, for homes with shared walls, installing roof air vents can aid in ventilation. Future research should encompass larger sample sizes and explore factors contributing to the presence of MTB bacteria in homes, irrespective of TB status among occupants.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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