Risk Factors of Physical Condition of House and Clean and Healthy Living Behavior (PHBS) to Tuberculosis in Kaluku Bodoa Health Center Area, Makassar City

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Abstract: *Background*: Tuberculosis remains the 10th leading cause of death globally, accounting for approximately 1.3 million fatalities. The physical conditions of a house, including ventilation, humidity, temperature, occupancy density, lighting, and Clean and Healthy Living Behavior (PHBS), are crucial factors that should be considered in relation to TB incidence.

Objective: This study aims to analyze the relationship between house physical conditions and PHBS with the incidence of TB in the working area of the Kaluku Bodoa Public Health Center, Makassar City.

Methods: This study employed an observational analytic design with a cross-sectional approach. The sample size for the study comprised 150 respondents. Data were processed using univariate analysis, presented in tables, and further analyzed descriptively and bivariately using the Chi-square test to determine the relationship between house physical conditions and CHLB with TB incidence in the working area of the Kaluku Bodoa Public Health Center, Makassar City.

Results: There was a significant relationship between ventilation, lighting, occupancy density, and PHBS with TB incidence in the Kaluku Bodoa Public Health Center, Makassar City. At the same time, temperature and humidity were found to have an insignificant effect on TB incidence.

Conclusion: The findings of this study can be used to guide government policies aimed at improving the quality of life for individuals with TB. Environmental health officers can implement intensive programs emphasizing the importance of handwashing, maintaining cleanliness, and ensuring proper ventilation to reduce the risk of TB transmission.

Keywords: Physical Environment, Kaluku Bodoa Public Health Center, TB Incidence.

INTRODUCTION

Globally, the number of reported tuberculosis (TB) cases reached 6.4 million, accounting for 64% of the total 10 million TB cases. Tuberculosis remains the 10th leading cause of death worldwide, resulting in approximately 1.3 million fatalities. According to the World Health Organization (WHO), TB continues to be a critical global public health issue. In 2020, WHO reported 9 million cases of pulmonary TB, with 1 million deaths attributed to the disease [1].

Based on the 2018 Basic Health Research (Riset Kesehatan Dasar) data, the TB prevalence in Indonesia was 0.42%. According to the Indonesia Tuberculosis Dashboard as of March 23, 2021, the estimated number of TB cases in Indonesia was 845,000, with 568,987 cases officially notified between 2000 and 2020, resulting in 12,469 deaths. The treatment success rate for TB in 2019 was reported at a national average of 86.6% [2].

The South Sulawesi Provincial Health Office's 2021 report revealed an estimated total of 31,022 TB cases in South Sulawesi. However, only 14,808 cases were officially reported, reflecting a notification rate below 47.73%. Approximately 53% of cases remain unidentified, posing a significant risk for disease transmission. Kaluku Bodoa Public Health Center is one of the health centers located in Tallo District, with the highest number of TB cases in Makassar City. The number of pulmonary TB patients diagnosed in the working area of Kaluku Bodoa Health Center was 124 in 2019, increasing to 131 in 2020 and 142 in 2021. From January to June 2022, 117 patients were reported [3].

These data indicate that TB cases occur annually in various regions, necessitating preventive actions and health sector development to reduce and prevent the spread of TB. TB is a communicable and environmentally-based disease influenced by various factors, including the physical condition of residential environments.

Research has shown a significant relationship between house physical conditions and TB incidence. For instance, Siregar (2021) found that housing conditions such as building materials, humidity, occupancy density, lighting, and temperature were significantly associated with TB incidence in the Sibuhuan Health Center's working area. In addition to

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physical conditions, Clean and Healthy Living Behavior (CHLB) is also a contributing factor to TB incidence [4]. Therefore, surveys and studies on CHLB in relation to TB are crucial.

Family income is another risk factor for TB in the Kaluku Bodoa Health Center's working area. Patients with low family income are 2.4 times more likely to develop TB than those with high family income. Other risk factors include occupancy density (OR = 4.561 > 1), contact history (OR = 3.333 > 1), ventilation (OR = 7.855 > 1), and nutritional status (OR = 3.909 > 1). Smoking habits, however, were not found to be a risk factor for pulmonary TB (OR = 0.508 < 1) [5].

Initial observations in the Kaluku Bodoa Health Center's working area revealed environmental conditions with blocked drainage due to garbage accumulation, frequent flooding, inadequate infrastructure, and low educational levels among residents. These factors, combined with limited awareness of CHLB and poor housing conditions, contribute to the increased TB incidence in the area.

Referring to previous studies, this research focuses on environmental factors, particularly the physical conditions of houses, including ventilation, temperature, humidity, lighting, and occupancy density [6]. These variables were chosen because earlier studies only examined ventilation and occupancy density. Other physical factors, such as temperature and humidity, are critical as Mycobacterium tuberculosis thrives at temperatures between 31°C and 37°C and humidity above 60%. Lighting also plays a role in killing bacteria and microorganisms, especially in residential environments.

Occupancy density is another critical variable, as higher population density increases the risk of TB transmission. According to the 2011 Indonesian Ministry of Health Regulation No. 1027, housing occupancy density must meet the requirement of less than 8 m² per two occupants.

If these risk factors are neglected, they can lead to increased TB transmission, morbidity, and mortality in communities [7]. TB control efforts, including disease mapping, are essential to quickly identify the spatial distribution of TB cases. Disease mapping helps tailor TB control programs and understand the spatial distribution of the disease.

Based on this background, the researcher is interested in conducting a study titled "Risk Factor Analysis of Housing Physical Conditions and PHBS with Tuberculosis Incidence in the Kaluku Bodoa Health Center's Working Area, Makassar City." The findings from this study are expected to provide valuable insights and recommendations for institutions, health offices, public health centers, and the community in improving TB control programs from environmental and behavioral perspectives.

MATERIAL AND METHOD

Research Design

The type of research conducted in this study is observational analytic with a cross-sectional approach, where independent and dependent variables are compared simultaneously to determine the relationship between the physical environment of the house and the incidence of tuberculosis (TB) in the working area of Kaluku Bodoa Health Center, Makassar City.

Study Sample

The population in this study comprises all TB patients residing in the working area of Kaluku Bodoa Health Center, totaling 241 respondents. The sample for this research consists of 150 respondents. The sampling technique employed is purposive sampling based on the inclusion and exclusion criteria set by the researcher, as follows:

1) Inclusion Criteria
    a. Houses that have not undergone physical renovation in the past four months.
    b. Residing within the working area of Kaluku Bodoa Health Center.
    c. Willingness to be interviewed.
    d. Aged 17-70 years.
2) Exclusion Criteria
    a. Respondents who have moved to another house.
    b. Houses that have undergone physical renovation within the past four months.

Data Processing and a Data Analysis

In this study, the researcher used questionnaires and observation sheets. The questionnaire contains a

list of questions corresponding to the variables being studied, while the observation sheet records the measurements of the variables studied, supporting the results of the questionnaire. The instrument used for the questionnaire employs the Guttman scale. The Guttman scale typically contains definitive answers such as "yes" or "no" and can be scored with a maximum of 1 and a minimum of 0, ensuring clear and consistent measurements with binary choices of "Yes" or "No."

The collected data will be tabulated and analyzed using univariate descriptive analysis and bivariate analysis with the Chi-square test to determine the relationship between the physical condition of the house and PHBS (Clean and Healthy Lifestyle Behavior) with the incidence of tuberculosis in the wo-rking area of Kaluku Bodoa Health Center, Makassar City. The Chi-square test was chosen because it is a non-parametric method suitable for analyzing the relationship between two categorical variables.

Ethical Approval

This study has received ethical approval from the Health Research Ethics Committee (KEPK) of the Polytechnic of Health Ministry of Health Makassar with approval number 1284/M/KEPK-PTKMS/IX/2024 dated September 27, 2024. Informed consent was obtained from all research respondents, data confidentiality was maintained and privacy was guaranteed.

RESULT

Based on the research that has been carried out, the following results were obtained:

Table **1** presents the frequency distribution of respondent characteristics in this study, including gender, age group, education level, occupation, tuberculosis (TB) incidence, and the implementation of Clean and Healthy Living Behavior (PHBS). The analysis results show that the majority of TB patients are male (66.7%), with the most affected age group

Table 1: Frequency Distribution of Respondents with Tuberculosis Incidents (n=150)

Respondent Characteristics	Frequency Distribution of Respondents with Tuberculosis Incidents	
	N	%
Gender		
a. Man	100	66.7
b. Woman	50	33.3
Age Group		
a. 17-26 years	23	15.3
b. 27-36 years	29	19.3
c. 37-46 years	45	30
d. 47-46 years	26	17.3
e. 57-66 years	20	13.3
f. >66 years	7	4.7
Education		
a. Not attending school	1	0.7
b. Elementary school	64	42.7
c. Junior hight school	12	8
d. Senior high school	69	46
e. S1	4	2.7
Work		
a. Government employees	1	0.7
b. Entrepreneurs	17	11.3
c. Laborer	46	30.7
d. Student	12	8
e. Doesn't work	33	22
f. Others	41	27.3
Tuberculosis Incidence		
a. TB sufferers	137	91.3
b. TB suspect	13	8.7
PHBS Implementation		
a. Bad	131	87.3
b. Good	19	12.7
Amount	150	100

Table 2: Physical Condition of the House and Implementation of PHBS with Tuberculosis Incidents

Respondent Characteristics	Frequency Distribution of Respondents with Tuberculosis Incidents				Total		p-value	OR	95%CI
	TB		TB suspect						
	n	%	n	%	n	%			
Ventilation									
TMS	136	25	7	75	146	100	0.0001	40.800	3.881-428.889
MS	1	93	25	7	4				
Temperature									
TMS	116	89,9	13	10.1	129	100	0.128	0.899	0.849-0.953
MS	21	100	0	0	21				
Humidity									
TMS	123	91.1	12	8.9	135	100	0.772	0.732	0.88-6.061
MS	14	93.3	1	6.7	15				
Residential Density									
TMS	129	94.2	8	5.8	13	100	0.001	10.078	2.676-37.956
MS	8	61.5	5	38.5	137				
Lighting									
TMS	100	88.5	13	11.5	113	100	0.031	0.885	0.28-0.946
MS	37	100	0	0	37				
Implementation of PHBS									
Bad	127	96.9	4	3.1	131	100	0.001	28.575	7.466-109.373
Good	20	52.6	9	47.4	19				

being 37-46 years (30%). The dominant education levels are elementary school graduates (42.7%) and high school graduates (46%), indicating that most TB patients have a lower-middle level of education.

In terms of occupation, most respondents work as laborers (30.7%) or are unemployed (22%), suggesting a link between employment status, economic conditions, and TB risk. The TB incidence among respondents reaches 91.3%, while 8.7% are TB suspects. Additionally, the implementation of PHBS among respondents remains low, with 87.3% categorized as having poor PHBS. These findings indicate that socioeconomic factors and health behaviors play a significant role in the spread of TB in the working area of Kaluku Bodoa Public Health Center.

Table **2** illustrates the relationship between house physical conditions and the implementation of PHBS with TB incidence. The analysis results show that inadequate ventilation has a significant relationship with TB incidence (p = 0.0001; OR = 40.800). This confirms that houses with poor ventilation have a higher risk of TB transmission. Residential density also significantly affects TB incidence (p = 0.001; OR = 10.078), where overcrowded housing increases the risk of disease transmission due to limited air circulation.

Lighting factors also show a significant relationship with TB incidence (p = 0.031), with houses that have poor lighting being more at risk compared to those that receive sufficient natural light. Meanwhile, temperature and humidity do not show a significant relationship with TB incidence. Poor PHBS practices contribute significantly to TB incidence, with a p-value of 0.001 and OR = 28.575, meaning that individuals with poor PHBS have a 28 times higher risk of contracting TB compared to those who implement good PHBS practices.

DISCUSSION

Tuberculosis (TB) is a contagious disease that continues to be a significant concern across various groups. As an airborne disease, the primary focus is often directed toward clean air. Clean air typically refers to the absence of problematic contamination [8]. Based on the results of this study, the discussion is presented as follows:

Univariate Analysis

Gender

The frequency distribution based on gender shows that the majority of respondents in this study are male, totaling 100 individuals (66.7%), while female respondents make up only 50 individuals (33.3%). This data indicates that males have a higher proportion of TB cases in the working area of the Kaluku Bodoa Health Center. The study by Arisandi & Muhajir (2022)

also found that males are more susceptible to TB due to social factors, such as smoking habits, which are more common among males and can weaken the immune system [9].

Age

The frequency distribution by age reveals that the most dominant age group is 37-46 years, accounting for 30% (45 individuals). This age group falls within the productive age range, which is typically characterized by high mobility, increasing exposure to TB. Similarly, research by Aida *et al*. (2022) suggests that individuals in the productive age group are more likely to engage in outdoor activities, leading to greater chances of encountering others infected with *Mycobacterium tuberculosis* [10]. Adults in this age group often face densely populated work or social environments, raising the risk of TB transmission. Respondents aged 27-36 years rank second at 19.3%, followed by those aged 47-56 years at 17.3%. Additionally, according to Fajriah Saraswati *et al*. (2022), adults aged 26-59 years are more likely to experience stress, lack of sleep, and insufficient rest due to numerous physical activities both inside and outside the home [11]. These factors can weaken the immune system, making them more susceptible to TB, whether at work or in their residential environment.

Educational Background

Most respondents have completed their education at the elementary school level (42.7%) and high school/vocational school level (46%). A lower level of education can impact health knowledge and behavior, particularly regarding Clean and Healthy Lifestyle Behavior (PHBS), which is crucial for preventing TB transmission. Education affects the knowledge and information respondents have. A lack of understanding about the importance of home ventilation and a clean physical environment increases the risk of TB. According to Fajriah Saraswati *et al*. (2022), while education level is not always a direct determinant of TB occurrence, having sufficient education does not guarantee successful treatment outcomes for TB or other diseases [11]. Other factors, such as frequent outdoor activities, can expose individuals to *Mycobacterium tuberculosis* again.

Type of Occupation

The majority of respondents work as daily laborers (30.7%), and 22% are unemployed. This study contrasts with research by Bayan (2022) conducted at the Urin Hospital in Banjarmasin, where most TB patients were private employees (31.6%). Occupation is closely related to income level. The type of work affects daily life, including access to nutritious food and healthcare maintenance. Daily laborers often work in densely populated environments with poor ventilation, putting them at higher risk of TB. Moreover, individuals living in inadequate housing due to economic constraints are also at risk. According to Maelani & Cahyati (2019), occupation does not always determine an individual's behavior in adopting PHBS to prevent TB transmission, as both productive and non-productive age groups may still have the motivation to live healthily and prioritize their health [12].

Tuberculosis Incidence

The data reveals that 91.3% of respondents (137 individuals) have been diagnosed with TB, while the remaining 8.7% (13 individuals) are TB suspects. This finding emphasizes that the working area of the Kaluku Bodoa Health Center is a region with a high incidence of TB. Factors such as the physical condition of houses, including ventilation, humidity, and occupancy density, as well as PHBS practices, significantly contribute to TB transmission in this area [13].

PHBS Implementation

The study data shows that 131 respondents (87.33%) fall into the poor PHBS category, while only 19 respondents (12.66%) exhibit good PHBS practices. This indicates that the average respondent demonstrates poor PHBS practices. Observations reveal that most residents do not regularly wash their hands with soap, some do not cover their mouths when coughing or sneezing, and others dispose of sputum carelessly. Additionally, some respondents do not wear masks when coughing or sick, lack knowledge about proper cough and sneeze etiquette, contributing to TB spread.

Bivariate Analysis

The Relationship between Ventilation and Tuberculosis Incidence in the Working Area of Kaluku Bodoa Health Center, Makassar City

Ventilation is one of the physical environmental factors in households that significantly impacts tuberculosis (TB) incidence. Adequate ventilation is essential to ensure proper air circulation in the house, enabling the exchange of clean air with contaminated air [14]. This study found that houses with inadequate ventilation (less than 10% of the floor area) had a significantly higher risk of TB incidence compared to houses with adequate ventilation. This finding aligns with the theory that *Mycobacterium tuberculosis*, the

causative agent of TB, spreads via droplet nuclei that can remain airborne for a long time in poorly ventilated environments with high humidity.

The study revealed a chi-square test result for the ventilation variable and TB incidence with a p-value of 0.0001 (<0.05), indicating a significant relationship between ventilation and TB incidence in the Kaluku Bodoa Health Center's working area. The odds ratio was 40.800 (95% CI: 3.881–428.889), suggesting that inadequate household ventilation increases the risk of TB transmission by 40.8 times. This finding aligns with research by Sahadewa *et al*. (2019), which showed an odds ratio of 7.800 (>1), rejecting the null hypothesis and indicating that poor ventilation increases TB risk by 7.8 times compared to respondents living in houses with adequate ventilation.

According to Swaminathan *et al*. (2021), environmental factors contributing to increased transmission risk include exposure to TB in confined spaces and recirculation of contaminated air, such as houses with inadequate ventilation, which can elevate the risk of TB spread among household members [15].

Poor ventilation systems also result in limited air exchange, leading to the accumulation of pollutants and microorganisms inside the house. This study highlighted that houses with inadequate ventilation have up to 40 times higher TB risk compared to houses meeting ventilation standards. Installing adequate ventilation, windows, and doors that allow fresh air to enter can reduce the risk of TB transmission indoors, as clean air dilutes the bacterial concentration in the air [7].

Indoor temperature is another factor considered in this study. An unsuitable temperature, whether too high or too low, can create a conducive environment for microorganism growth, including *Mycobacterium tuberculosis* [16]. In this study, indoor temperature was categorized as adequate if it ranged between 18°C and 30°C. Temperatures outside this range can create uncomfortable room conditions and increase humidity, which in turn supports microorganism growth.

The Relationship between Temperature and Tuberculosis Incidence in the Working Area of Kaluku Bodoa Health Center, Makassar City

The study showed no significant relationship between temperature and TB incidence in the Kaluku Bodoa Health Center's working area, with a chi-square test p-value of 0.128 (>0.05) and an odds ratio of 0.899 (95% CI: 0.849–0.953). This finding aligns with Rahmawati *et al*. (2021), who also found no significant relationship between temperature and TB incidence in the working area of Pekalongan Health Center (p-value = 0.353 > 0.05).

Observations revealed that not all houses had ideal temperature conditions, influenced by other housing factors such as the absence of ventilation holes and insufficient lighting due to the lack of glass tiles. Extremely low indoor temperatures can lead to health issues, including hypothermia, while excessively high temperatures can cause dehydration and heatstroke.

Although this study did not find a significant relationship between indoor temperature and TB incidence (p-value 0.128), maintaining an appropriate indoor temperature is crucial for creating a healthy home environment. Humid and warm room conditions, for instance, can prolong bacterial survival and increase disease transmission risks [17]. Conversely, overly cold temperatures can cause discomfort and weaken household members' immune systems, making them more susceptible to infections.

The Relationship between Humidity and Tuberculosis Incidence in the Working Area of Kaluku Bodoa Health Center, Makassar City

Excessive or insufficient indoor humidity also poses a risk factor for TB incidence. This study categorized household humidity as adequate if it ranged between 40% and 60%. High humidity levels above 60% create a conducive environment for bacterial and fungal growth, as high humidity prolongs airborne bacterial survival, increasing the likelihood of infection transmission.

The study found no significant relationship between humidity and TB incidence in the Kaluku Bodoa Health Center's working area, with a p-value of 0.772 (>0.05) and an odds ratio of 0.732 (95% CI: 0.88–6.061). This finding aligns with Maulinda *et al*. (2021), which reported a p-value of 0.395, indicating no significant effect of humidity on pulmonary TB (p-value > 0.05). However, this study contrasts with Andas *et al*. (2019), which reported a significant TB risk factor with a p-value of 0.001 and an odds ratio of 6.600, indicating that communities with indoor humidity >70% had a sixfold higher TB risk than those with humidity levels between 40%-70%.

Observations showed that humidity measurements were conducted using a hygrometer between 8:00 and

12:00 WITA, during which many household members were active outside. Although statistical tests indicated no significant relationship between humidity and TB incidence (p-value 0.772), non-ideal humidity levels can still affect respiratory health and increase infection risks. Previous studies also highlighted that high indoor humidity without proper air circulation could accelerate bacterial and fungal growth, potentially worsening TB conditions or increasing infection risks for healthy individuals [18].

The Relationship between Residential Density and Tuberculosis Incidence in the Working Area of Kaluku Bodoa Health Center, Makassar City

Residential density is another household physical variable that significantly impacts TB incidence. Overcrowded houses increase the risk of infectious disease transmission, including TB. This study found that inadequate residential density (more than two persons per 8 square meters) was associated with an increased TB incidence.

The study revealed a significant relationship with a p-value of 0.001 (<0.05) and an odds ratio of 10.078 (95% CI: 2.676–37.956), indicating that residents in overcrowded houses had a 10,078 times higher risk of TB incidence in the Kaluku Bodoa Health Center working area. This finding aligns with Siregar and Lubis (2022), who reported a p-value of 0.030 (<0.05), also indicating a significant relationship between residential density and TB incidence in the Pargarutan Health Center's working area [19]. This is attributed to bacterial colonies and overcrowding per square meter synergistically creating pollution sources that suppress immune reactions and promote pathogenic bacterial growth.

Observations showed that some houses were occupied by two to four families, with two to three members per family, in spaces inadequate to meet residential density standards. Additionally, some houses had residents diagnosed with TB, exacerbating the risk of TB transmission [20]. Inadequate residential density also limited ventilation and increased individual contact, accelerating bacterial spread in poorly ventilated rooms.

The Relationship between Lighting and Tuberculosis Incidence in the Work Area of Kaluku Bodoa Public Health Center, Makassar

Adequate lighting, particularly natural sunlight, is known to have a disinfectant effect that can kill microorganisms, including *Mycobacterium tuberculosis*. Sunlight contains ultraviolet (UV) rays capable of destroying bacterial and viral DNA in the air and on surfaces inside the home. In this study, lighting is considered sufficient if the light intensity in the house exceeds 60 lux, as per the Ministry of Health Regulation No. 2 of 2023 [21].

The study results indicate a significant relationship between adequate lighting and tuberculosis (TB) incidence, with a p-value of 0.031 (<0.05) and an odds ratio (OR) of 0.885 (95% CI: 0.828–0.946). This aligns with the findings of Manalu *et al*. (2022), which showed an OR of 0.415, with a CI of 0.186–0.926 and a p-value of 0.048, indicating that houses with insufficient lighting are 0.415 times more at risk of TB. However, this study differs from Marbun's (2022) findings, which reported a p-value of 0.757 (>0.05), suggesting that other environmental factors may pose a greater risk in the spread of TB [22].

Houses with insufficient lighting are at higher risk of TB incidence. Poor lighting is often caused by house designs that do not allow sunlight to enter, such as limited windows or obstructions from nearby buildings. Ensuring adequate natural lighting in homes is thus an essential preventive measure to reduce TB risk.

The Relationship between Clean and Healthy Living Behavior (PHBS) and Tuberculosis Incidence in the Work Area of Kaluku Bodoa Public Health Center, Makassar

Clean and healthy living behavior (*Perilaku Hidup Bersih dan Sehat* or PHBS) is an important aspect of preventing communicable diseases, including tuberculosis. PHBS includes daily behaviors to maintain personal and environmental hygiene, such as washing hands with soap, covering the mouth when coughing or sneezing, keeping the home environment clean, and ensuring adequate ventilation and lighting. In this study, poor PHBS was strongly associated with TB incidence.

The chi-square test results showed a p-value of 0.001 (<0.05), indicating a significant relationship between PHBS and TB incidence in the work area of Kaluku Bodoa Public Health Center, with an OR of 28.575 (95% CI: 7.466–109.373). This is consistent with the findings of Magfirah and HS (2022), who reported a p-value of 0.019, indicating a meaningful relationship between PHBS and pulmonary TB prevention in the work area of UPTD Lampahan Public Health Center, Bener Meriah District [23].

Observations revealed that many respondents had not fully implemented PHBS. Common practices such

as not regularly washing hands with soap, failing to cover the mouth when coughing or sneezing, spitting indiscriminately, not wearing masks when experiencing cough, and a lack of awareness of proper coughing and sneezing etiquette were prevalent.

The study showed that respondents with good PHBS had a lower risk of TB infection compared to those with poor PHBS. Poor PHBS increased the risk of TB by nearly 28 times. Behaviors like not wearing masks, neglecting environmental cleanliness, or living in houses with poor ventilation facilitate the spread of *Mycobacterium tuberculosis* among family members [24]. Therefore, raising awareness about the importance of PHBS is an effective step in preventing TB in households.

The study demonstrates that physical house conditions such as ventilation, lighting, and occupancy density, along with PHBS, have a significant relationship with TB incidence. Health interventions targeting improvements in housing conditions and promoting PHBS can greatly reduce TB transmission risks in the community. However, this study has several limitations. First, the cross-sectional design observes variables at a single point in time, making it difficult to establish causal relationships. The results are associative rather than strongly causal. Longitudinal or experimental studies are recommended to strengthen these findings. Additionally, the study was limited to the work area of Kaluku Bodoa Public Health Center, which may not reflect conditions in other regions with different socio-economic and environmental characteristics. As housing conditions and PHBS practices can vary across regions, the findings may not be fully generalizable to broader populations [25].

Despite these limitations, the study has several strengths. One notable strength is the selection of relevant and critical variables in the context of environmental health. By focusing on various aspects of housing conditions, such as ventilation, temperature, humidity, and occupancy density, the study makes a significant contribution to understanding the environmental factors influencing TB spread.

Furthermore, the study emphasizes the importance of environment-based interventions, which can serve as critical recommendations for public health policymakers. By identifying ventilation, lighting, and occupancy density as major risk factors, the study provides valuable insights for designing more effective TB prevention programs, particularly in areas with substandard housing conditions.

Overall, this study contributes to a deeper understanding of the relationship between environmental and behavioral factors and TB incidence. It serves as a foundation for developing more effective public health policies to reduce TB prevalence in Indonesia.

LIMITATION OF RESEARCH

The limitation of this research is that the data variables analyzed in this study included ventilation, lighting, occupancy density, temperature, humidity, and PHBS, but did not account for other factors that may contribute to TB incidence, such as nutritional status, access to healthcare services, and individual genetic and immunological factors. Additionally, the use of the Chi-square test in the analysis only allowed for the identification of statistical associations between variables without controlling for confounding factors or establishing causal relationships. For future research, longitudinal studies, such as cohort studies, are recommended to more accurately evaluate the temporal relationship between risk factors and TB incidence. Longitudinal studies allow researchers to monitor respondents over a period of time, enabling them to determine whether risk factors precede TB incidence.

CONCLUSION

The study results is a significant relationship between ventilation, lighting, occupancy density, and clean and healthy living behavior (PHBS) with TB incidence in the Kaluku Bodoa Public Health Center, Makassar. At the same time, temperature and humidity factors have an insignificant effect on TB incidence. These findings can be utilized to inform government policies aimed at improving the quality of life for individuals with TB. Environmental health officers can implement intensive programs emphasizing the importance of handwashing, maintaining cleanliness, and ensuring proper ventilation to reduce the risk of TB transmission

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