DOI: 10.36566/ijhsrd/Vol7.Iss1/301
https://ijhsrd.com/index.php/ijhsrd

Indonesian Journal Of Health Sciences Research and Development
e- ISSN: 2715-4718

Research Article

LOGISTIC REGRESSION ANALYSIS FOR PULMONARY TUBERCULOSIS RELATED TO ENVIRONMENTAL FACTORS IN KATOBU HEALTH CENTRE

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ABSTRACT

Background: Pulmonary tuberculosis is one of the infectious diseases that has infected nearly one-third of the world's population, with many facing difficulties in its control due to a significant number of patients who do not achieve a cure. This is attributed to the challenge of pinpointing the factors that could serve as the primary causes. This study aims to predict the dominant factors contributing to the occurrence of pulmonary tuberculosis.
Methods: This analytical observational study applied a case-control study design. A total of 30 patients with pulmonary tuberculosis were included as the case group, and healthy individuals without clinical symptoms of pulmonary tuberculosis were put as the control group. Data analysis used the Chi-Square test and binary logistic regression.
Results: The research findings indicate a significant correlation between housing density (p=0.020<0.05), ventilation (p=0.009<0.05), room humidity (p=0,.000<0.05), lighting (p=0.002<0.05), type of flooring in the house (p=0.007<0.05) and smoking habits (p-value=0.001). The results of the multiple logistic regression analysis using the backward LR method indicate that room humidity (p-value=0.001<0.05) is the dominant factor in the occurrence of pulmonary tuberculosis.
Conclusion: The incidence of pulmonary tuberculosis is higher among smokers living in homes with overcrowding, inadequate humidity and lighting, and dirt or wood floors. Room humidity plays a significant role in the development of pulmonary tuberculosis. Therefore, providing education on how to maintain and pay attention to the physical condition of the home is crucial to avoid the occurrence of pulmonary tuberculosis.

Keywords: *Tuberculosis, housing, density, humidity, lighting, floor, smoking*

INTRODUCTION

Mycobacterium tuberculosis, a pathogenic microbe in the human body, causes pulmonary tuberculosis, an infectious disease. Pulmonary tuberculosis affects the lungs but can also affect areas outside the lungs, such as the skin, lymph nodes, bones, and meninges(1). This disease is characterized by several symptoms, such as weight loss over three consecutive months without reason, fever for more than a month, cough lasting more than two weeks, chest pain, shortness of breath, decreased appetite, straightforward fatigue (malaise), night sweats even without activity, and sputum mixed with blood (2).

Tuberculosis (TB) is one of the top 10 causes of death worldwide, and a leading cause of death from infectious agents(3). Global estimates place the number of TB patients at 10.6 million (range 9.8-11.3 million); HIV-negative individuals account for 1.4 million (range 1.3-1.5 million) deaths from TB, while HIV-positive individuals account for 187,000 deaths (range 158,000-218,000). In Indonesia, pulmonary tuberculosis remains a health issue, with an estimated incidence of TB in Indonesia in 2021 at 969,000 or 354 per 100,000 population; TB-HIV cases amount to 22,000 per year or 8.1 per 100,000 population. Estimates place TB-related deaths at 144,000, or 52 per 100,000 population, and TB-HIV deaths at 6,500, or 2.4 per 100,000 population(4).

Several factors contribute to the annual increase in TB prevalence, including sociodemographic factors (age, occupation, education level), behavioral factors (habits of opening windows every morning and smoking), environmental factors of the home (ventilation area, housing density, lighting intensity, type of flooring, humidity of the house, temperature, and type of walls), and history of contact(5,6). John Gordon asserts that one of tuberculosis's influential factors is the environment. The physical environment includes the house(7). The physical environment of the house related to the occurrence of tuberculosis is one that does not meet the criteria for a healthy home, such as the high humidity levels in the homes of tuberculosis patients due to inadequate ratio between ventilation and the size of the house, insufficient lighting, and low temperatures inside the house(8,9). Furthermore, when an infected person coughs or sneezes, thousands of Mycobacterium tuberculosis germs can spread through the air into the home environment. Contaminated air within a house with Mycobacterium tuberculosis germs significantly increases the risk of transmission to others(10). Based on the description above, pulmonary tuberculosis remains a health issue in Indonesia, influenced by many factors that affect the incidence of tuberculosis. This needs to be noted for policy makers in order to minimize the incidence of tuberculosis in the future. One effort that can be made is to identify early on the determining factors for stunting. Therefore, an analysis method in the form of modeling is needed to be able to predict tuberculosis risk factors. One of the analyses used is Logistic Regression. Logistic regression is a data analysis method used to find the relationship between response variables (y) that are binary or dichotomous. Therefore, this study aims to analyze the magnitude of the dominant risk factors causing tuberculosis.

METHODS

Study design

This research using analytical observational study used a case-control study design.

Participants and Data Collection

The population of this study consisted of all patients with tuberculosis. The control population included healthy individuals who did not exhibit clinical symptoms of tuberculosis in the working area of the Katobu Community Health Center in Raha City, Southeast Sulawesi, in the year 2023. The researchers obtained a total of 60 samples at a case-to-control sample ratio of 1:1, selecting 30 case groups and 30 control groups through proportional random sampling. The researchers collected data with questionnaires for interviews, observation sheets for observations, a rolling meter for ventilation area data, a lux meter for lighting data, and a hygrometer for air humidity measurements.

Measurement and statistical analysis

The researchers categorized tuberculosis incidence into suffering and non-suffering; the age characteristic factor into productive and non-productive; education into elementary, junior high, senior high, and higher education levels; and employment into two groups: unemployed and employed. Furthermore, the researchers categorized the physical environmental factors of the house, such as housing density, ventilation, humidity, lighting, and type of flooring, as either meeting or not meeting the requirements. The researchers categorized smoking habits into two groups: high-risk and low-risk. The researchers analyzed the data in three stages: the first stage was univariate analysis to determine each variable distribution and percentage; the second stage was bivariate analysis with the Chi-Square test to examine the correlation between two variables, the independent and the dependent. Finally, the third stage was multivariate analysis to identify the most dominant variable among all the variables selected using binary logistic regression.

Ethical considerations

The Health Research Ethics Committee of Mandala Waluya University approved this research (dated: October 5, 2023, decision no. 41/KEP/UMW/XI/2023, protocol no. 05102341042).

RESULTS

At a ratio of 1:1, the researchers gathered 30 patients with pulmonary tuberculosis who were willing to be respondents, along with healthy residents as a control group. The researchers conducted the sample selection using proportional random sampling techniques based on four sub-districts: Raha II with 10 patients, Watone with 7 patients, Wamporiki with 6 patients, and Raha III with 7 patients. In this study, gender served as a matching variable. Matching is the process of selecting a group of cases whose the same conditions as a group of cases. Matching minimizes bias by controlling the selection of case and control groups. The results show most respondents are at productive age, totaling 40 (66.7%), with a history of higher education of 27 (45.0%), unemployed 34 (56.7%), and the female gender comprising 53 (88.3%). Table 1 displays the characteristics of the respondents.

Table 1. Respondent Characteristics

Respondent Characteristics	n	%
Ages of the Patients		
Productive	40	66.7
Not Productive	20	33.3
Educational Background		
Primary/Elementary	5	8.30
Junior High School	11	18.3
Senior High School	17	28.3
Higher Education	27	45.0
Occupation		
Unemployed	34	56.7
Employed	26	43.3
Sex Types of the Infants		
Males	7	11.7
Females	53	88.3

Bivariate analysis determines the significant correlations of the investigated variables with the occurrence of pulmonary tuberculosis. The results of the bivariate analysis indicate that children suffering from pulmonary tuberculosis are more likely to live in unhealthy houses. Around 21 (70%) of the patients lived in overcrowded housing, 22 (73.3%) had inadequate ventilation, and 20 (66.7%) had insufficient lighting. Additionally, 26 (86.7%) of the patients lived in damp conditions, and 16 (53.5%) had low-quality floors. Furthermore, about 23 (76.7%) of the patients had high-risk smoking habits. Furthermore, the results of the statistical tests conclude that housing density, ventilation, humidity, lighting, flooring, and smoking habits significantly influence the incidence of pulmonary tuberculosis, with p-values and odds ratios of 0.002 (OR: 4.030); 0.009 (OR: 4.750); 0.000 (OR: 13.000); 0.002 (OR: 6.571); 0.007 (OR: 5.714); and 0.001 (OR: 7.667), respectively. (Tabel 2).

Table 2. Assosiation between pulmonary tuberkulosis components with pulmonary tuberkulosis

Variable	Pulmonary Tuberkulosis		p-value	OR	95% CI (lower – upper)
	Case (%)	Control (%)			
Housing density					
Not meeting the conditions	21 (70.0)	11 (36.7)	0.020*	4.030	1.372 - 11.839
Meeting the conditions	9 (30.0)	19 (63.3)			
Ventilation					
Not meeting the conditions	22 (73.3)	11 (36.7	0.009*	4.750	1.584 - 14.245
Meeting the conditions	8 (26.7)	19 (63.3)			
Humidity					
Not meeting the conditions	26 (86.7)	10 (33.3)	0.000*	13.000	3.551 – 47.597
Meeting the conditions	4 (13.3)	20 (66.7)			
Lighting					
Not meeting the conditions	20 (66.7)	7 (23.3)	0,002*	6.571	2.109 - 20.479
Meeting the conditions	10 (33.3)	23 (76.7)			
Floor					
Not meeting the conditions	16 (53.5)	5 (16.7)	0,007*	5.714	1.724 - 18.944
Meeting the conditions	14 (46.7)	25 (83.3)			
Smoking habit					
High risk	23 (76.7)	9 (30.0)	0,001*	7.667	2.424 – 24.245
Low risk	7 (23.3)	21 (70.0)			

Data were used Chi-Square Test and Odds Ratio *a p-value <0.05 was statistically significant

The researchers conducted a multivariate analysis to identify the most significant variables. Table 3 indicates that home humidity is the most significant and influential factor in the occurrence of pulmonary tuberculosis. The evidence is the odds ratio (OR) on EXP (B) of 15.312. The result indicates respondents living in homes with low humidity levels < 40% or >60% have a 15.312 times higher risk of suffering from pulmonary tuberculosis. The smallest significance value, a p-value of 0.001, further supports this result, suggesting that home humidity is the most significant factor in the occurrence of pulmonary tuberculosis.

Table 3. Binary Logistic Regression Analysis on determinants of pulmonary tuberculosis incidence

Risk Factor	p-value	Exp(B)	95% CI	
			Lower	Upper
Housing density	0.101	3.225	0.795	13.09
Humidity	0.001*	15.312	3.212	72.998
Smoking habit	0.004*	9.017	2.037	39.911
Constant	0	0		

Data were used with multiple logistic regression tests with simultaneously (3 steps)
*p-value < α 0.05 was statistically significant

DISCUSION

The research found the physical conditions of the home environment, combined with the smoking habits of its occupants, could increase the transmission of pulmonary tuberculosis. More than 50% of the patients lived in homes with high occupancy, where the ventilation area was less than 10% of the floor area, humidity levels did not meet standards, lighting was below 60 lux, the floors were made of wood, and the residents had high-risk smoking habits. The density of occupants in a residence has a significant impact on its inhabitants, particularly those with a smoking habit(11). An imbalance between the size of the house and the number of occupants, along with inadequate ventilation conditions, would lead to overcrowded(12,13). This made the occupants of the house unhealthy because the amount of carbon dioxide was higher than oxygen, air circulation became poor, and humidity increased, leading to the growth of mold and bacteria. Therefore, if one family member contracted an infectious disease, it could easily spread to other members, with an average patient capable of transmitting the disease between to 2-3 people in the household(14,15). Relevant previous research with the findings of this study revealed that houses with poor physical conditions from health standards, such as inadequate lighting, high humidity, minimal ventilation, non-waterproof flooring, and a high number of occupants, would increase the risk of pulmonary tuberculosis transmission among the residents(16–19).

One important consideration is - other buildings should not obstruct sunlight's direct entry into the room. The window serves not only as a ventilation device but also as a source of light. Glass tiles provide an excellent source of light(20). In addition, poor floor quality from the standards such as made from boards will cause the floor to be water-permeable, making it easy to get wet, dirty, dusty, and difficult to clean. This condition will lead to increased humidity in the house, increasing the growth of bacteria and the release of building materials(21). In general, bacteria require a relatively high humidity level, around 85%, while at lower humidity levels, evaporation from the bacteria will occur(22).

In addition to the environment, unhealthy behaviors of household members, such as smoking habits, will further increase the risk of transmitting pulmonary tuberculosis(23). The research results found that most patients with pulmonary tuberculosis were heavy smokers and often had direct contact with family members or coworkers who smoke. Smoking habits can weaken the immune system and affect lung defense. A decline in lung defense can make a person more susceptible to infections from tuberculosis-causing bacteria. Previous research revealed that smoking was one of the unhealthy behaviors that led to pneumonia(24,25). For tuberculosis patients, smoking can worsen their condition and increase the risk of death. Additionally, smoking can trigger a relapse in tuberculosis patients who received their treatment or even received a cure(26). The habit of smoking can lower the body's immunity, making it easier for TB germs to enter a person's body(27).

This found that indoor humidity was the main trigger for the growth of Mycobacterium tuberculosis bacteria. Smokers living in unhealthy home environments can cause humidity. This is due to the lack of quantity and poor ventilation conditions in every room in the house. Indoor humidity is caused by climate, ventilation, pipe leaks and soil moisture. Relatively low humidity, which is less than 20%, can cause dryness of the mucous membranes, while high humidity will increase the growth of microorganisms(28,29). Previous researchers have revealed that the impact of room humidity that is too high or too low can cause the growth of microorganisms that can cause germs, such as ARI, tuberculosis, and others(30,31). Extremely humid rooms can promote the growth of disease-causing bacteria and influence the occurrence of respiratory infections, such as pulmonary tuberculosis. The bacteria responsible for pulmonary tuberculosis thrive in high-humidity environments because water makes up more than 80% of the bacterial cell volume and is essential for bacterial cell growth and survival(32). High humidity can cause the nasal mucous membranes to dry out, making them less effective at blocking microorganisms, thereby increasing the risk of tuberculosis transmission(33,34).

CONCLUSION

This study found that environmental factors such as housing density, ventilation, humidity, lighting, house floor, and smoking habits contribute to pulmonary tuberculosis. The home humidity is the most important factor. Due to minimal ventilation, the humidity in the house does not meet the standards of <40% and >60%, resulting in poor air circulation. Insufficient lighting (less than 60 lux) makes the house dark, and the lack of sunlight entering the house contributes to this condition. Additionally, the flooring made of loosely fitted boards allows moisture from the ground to easily rise to the surface, causing humidity issues. Furthermore, the density of the housing and the smoking habits of the residents will further increase bacterial growth in a damp home environment. Therefore, providing education on how to maintain and pay attention to the physical condition of the house that will be inhabited and the number of people living in the house in order to improve health quality and avoid the occurrence of pulmonary tuberculosis is important. The findings of this study are useful for the long-term national tuberculosis program.

ACKNOWLEDGMENT

The author would like to express gratitude to all the health workers at the Katobu Community Health Center in Raha City, Southeast Sulawesi dan all the respondents who willingly participated without any coercion.

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