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Determinants of Pulmonary Tuberculosis Incidence in the Working Area of Kedungmundu Health Center, Semarang City

Natijatul Ulfah[1], Eram Tunggul Pawenang[2]

[1,2)] Department Public Health, Faculty of Medicine, Semarang State University, Semarang, Indonesia

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Correspondence:
natijatululfahh@gmail.com

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Abstract

Background: Indonesia has the second-largest TB caseload in the world. The incidence of TB has increased by 18%, and the mortality rate has increased by 55% in 2020-2021. TB cases in Semarang City in 2022 were 4.653, and it is known that Kedungmundu Health Center is the most significant contributor to TB cases.

Objective: This study aims to identify the determinants of pulmonary tuberculosis incidence in the working area of Kedungmundu Health Center, Semarang City.

Methods: This type of research is observational analytic with a case-control design. The sample was 62, consisting of 31 cases and 31 controls in a 1:1 ratio. The analysis was conducted univariately and bivariately.

Results: The results of the analysis showed an association in the variables of ventilation area (p=0.002, OR 6.04, 95% CI=2.01-18.17), lighting level (p=0.022, OR 3.87, 95% CI=1.34-11.17), and window opening habit (p=0.001, OR 7.58, 95% CI=2.39-24.06) while humidity level, occupancy density, and smoking habit were not associated with TB incidence.

Conclusion: The incidence of pulmonary TB is influenced by ventilation area, lighting level, and window opening habits.

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INTRODUCTION

Tuberculosis (TB) is still the leading cause of death due to a single infectious agent. Globally, there has been an increase in TB mortality from 2019 to 2021, with an estimated 1.4 million, 1.5 million, and 1.6 million deaths, respectively. Although by 2022, the number of TB deaths will decrease to 1.1 million, it is still high. Regionally, Southeast Asia has the highest caseload, accounting for 46% of the total global population. This is followed by Africa (23%), the Western Pacific (18%), and several other regions[1].

In 2022, Indonesia is still the second-largest contributor to the global TB caseload. The estimated incidence of TB reached 969.000 cases, with an IR (Incidence Rate) of 354 per 100,000 population and a death toll of 144,000 or 52 per 100,000 population. TB incidence increased by 18%, and mortality increased by 55% in 2020-2021. The number of confirmed TB cases in 2022 was 724,309, dominated by provinces with large populations. Central Java, Indonesia's third most populous province, has 77.426 confirmed TB cases[2]. TB cases increased in several Central Javan districts/cities, including the province's capital. There were 4,653 TB cases in Semarang City and 3,221 cases in 2021[3].

Kedungmundu Health Center has the highest number of TB cases compared to other health centers in Semarang City. Based on the health dashboard of Semarang City Health Office, it is known that the number of cases from January to June 2023 was 163 cases. A preliminary study was conducted on July 13 and 18, 2023, through interviews with eight TB patients who sought treatment at the Kedungmundu Health Center, Semarang City. Of the eight patients, five TB patients (62.5%) lived in houses with poor lighting, with 2 of them not having the habit of opening windows and one patient claiming not to have windows. Other information obtained was that 2 out of 3 male patients had a smoking habit, and one female patient was a passive smoker who lived with three active smokers in her house.

Mycobacterium tuberculosis is the causative agent of TB, a rod-shaped cell with a size of 0.2-0.4x 2-10 µm, has an obligate aerobic nature, and is resistant to acids[4]. The ideal temperature range for bacterial growth is 35-37°C[5]. The effect of humidity on the survival and infectivity of these bacteria is not directly known. Generally, pathogenic bacteria survive in humid environmental conditions ≥70%. Low moisture (30-40%) can affect mucus production on the surface of the respiratory tract to be reduced, making it vulnerable to *M. tuberculosis*[6].

The source of TB transmission comes from active TB patients with BTA+. Droplets or sputum containing *M. tuberculosis* will be spread in the air when the patient speaks, coughs, or sneezes[4]. TB infection occurs if these droplets are inhaled and enter the body through the respiratory tract. Most (85%) of the organs attacked are the lungs; the rest are other organs, such as the skin, bones, and kidneys[7]. The cause of infection in the human body is influenced by immunopathogenesis due to the interaction between the host and the TB causative agent and is supported by favorable environmental conditions.

The physical environment of residential homes can be a risk factor for pulmonary TB. Lighting levels, humidity levels, ventilation area, and oc-

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cupancy density that do not meet the requirements of a healthy home can be a medium for pathogenic bacteria to grow and develop[8]. Lack of natural lighting and ventilation area can increase air humidity[9]. Overcrowded occupancy impacts reduce the availability of O2 and raise CO2 in room[10]. Research conducted by Perdana and Putra found that the lighting level is the most dominant factor in the incidence of pulmonary TB[11]. Different results were obtained from research by Fahdhienie et al., where the humidity level is the most risky factor for pulmonary TB[12].

A healthy home will be realized if the house's occupants have good habits and behavior. Habits that are contrary to health can be a trigger for TB, such as not having the habit of opening windows and smoking. Hasan et al. found that someone who does not have the habit of opening windows is more at risk of TB by 4.282 times compared to those who have the habit of opening windows. The study also mentioned the correlation between smoking habits and the incidence of TB with an OR= 3.325[13]. Another study found that people who smoked had a 1.9 times risk of developing TB compared to people who did not smoke[14]. Based on the above, a study was conducted to identify the determinants of pulmonary TB incidence in the working area of Kedungmundu Health Center, Semarang City.

Based on the background above, a study was conducted to identify the determinants of tuberculosis in Semarang.

METHODS

This study is an observational analytic study. The design used case-control, where data concerning independent variables as risk factors were studied first with a retrospective approach. The research activities were carried out from December 2023 to February 2024 in the working area of Kedungmundu Health Center, Semarang City. This area covers seven urban villages, including Kedungmundu, Tandang, Jangli, Sendangguwo, Sendangmulyo, Sambiroto, and Mangunharjo.

The case population was people with bacteriologically confirmed pulmonary TB recorded in the SEMAR BETUL application (Semarang Berantas TB) in January-November 2023 who lived in the working area of Kedungmundu Health Center, Semarang City. The control population was the neighbors of the case sample who did not suffer from pulmonary TB. Based on Lameshow's calculation, it has been set at 95% significance level and 80% test strength; the minimum sample is 31. The ratio of case and control samples used was 1:1, so the sample of this study amounted to 62 respondents. The sampling technique used was purposive sampling, which considered ease of mobility and accessibility.

The independent variables of this study are ventilation area, lighting level, humidity level, occupancy density, smoking habit, and window opening habit. At the same time, the dependent variable is the incidence of pulmonary TB. Data collection techniques used interview and observation methods with research instruments in the form of interview & observation sheets and supported by measuring instruments in the form of meters, luxmeters, and hygrometers.

Data were analyzed univariately and bivariately-univariate analysis to determine the frequency distribution of respondents' characteristics. Bivariate analysis was used to determine

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the relationship between two variables using the Chi-square test and Fisher test as a backup method if the chi-square test requirements were unmet. The Health Research Ethics Committee of Semarang State University's Faculty of Medicine has deemed this study ethically feasible, assigning it 043/KEPK/FK/KLE/2024.

RESULTS

Based on Table 1, it is known that this study involved 62 respondents, 31 of whom were diagnosed with pulmonary TB and 31 who were not suffering from pulmonary TB. Most respondents were female, with 34 (54.8%) people. Respondents who worked were known to be more than those who did not. In this study, it is known that 35 respondents work (56.5%). Regarding the latest level of education, most of the respondents, 34 people (54.8%), had completed secondary education, and a small number of respondents did not pursue formal education, five people (8.1%). Table 2 shows the characteristics of research respondents based on age. The average age of respondents was 48.71 years. The respondent's median age is 50 years. The minimum age is 13 years, and the maximum is 77 years. Further-more, the standard deviation value is 16.204.

Based on Table 3, it is known that houses with ventilation areas that do not meet the requirements are more inhabited by the case group, namely 21 people (67.7%), compared to the control group of 8 people (25.8%). The results of statistical tests using Chi-square obtained a p-value of 0.002, so it can be concluded that there is a significant relation-ship between the ventilation area and the incidence of pulmonary TB in the working area of Kedungmundu Health Center, Semarang City. The OR=6.04 (95% CI=2.01-18.17) indicates that people who live in houses with unqualified ventilation areas have a 6.04 times greater risk of developing pulmonary TB than those with qualified ventilation areas.

Lighting levels that do not meet the requirements are higher in the case group (61.29%) than in the control group (29.03%). The *Chi-square* test results obtained a p-value of 0.022, indicating a significant relationship between lighting levels and the incidence of pulmonary TB. The OR value=3.87 (95% CI=1.34-11.17) means that people who live in houses with unqualified lighting levels are at risk of 3.87 times suffering from pulmonary TB compared to those who live in homes with qualified lighting levels.

In the humidity level variable, it is known that respondents who live in homes with unequalfied humidity levels were found in the case group as many as 15 people (48.4%) and in the control group as many as 10 people (32.3%). Meanwhile, respondents who lived in homes with humidity levels that met the requirements were more in the control group, namely 21 people (67.7%). The bivariate analysis results using the Chi-square test obtained a p-value of 0.30. This means there is no significant relationship between the level of humidity and the incidence of pulmonary TB in the working area of Kedungmundu Health Center, Semarang.

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Table 1 Frequency distribution of respondent characteristics based on gender, employment status, and latest education

Characteristics	N	%
Incidence of pulmonary TB		
Sick	31	50,0
Not sick	31	50,0
Gender		
Male	28	45,2
Female	34	54,8
Employment status		
Not working	27	43,5
Work	35	56,5
Last education		
Not in school	5	8,1
Basic education	16	25,8
Secondary education	34	54,8
Higher education	7	11,3

Table 2 *Characteristics* of respondents based on age

Characteristic	Mean	Median	Minimum	Maximum	SD
Age	48,71	50	13	77	16,204

Table 3 Bivariate analysis of risk factors suspected of influencing the incidence of pulmonary TB

Variables	Incidence of pulmonary TB				*p-value*	OR CI 95%
	Case		Control			
	n	f	n	f		
Ventilation area						
Not eligible	21	67,7	8	25,8	0,002	6,04
Qualified	10	32,3	23	74,2		(2,01-18,17)
Lighting level						
Not eligible	19	61,3	9	29,0	0,022	3,87
Qualified	12	38,7	22	71,0		(1,34-11,17)
Humidity level						
Not eligible	15	48,4	10	32,3	0,300	-
Qualified	16	51,6	21	67,7		
Occupancy density						
Not eligible	3	9,7	3	9,7	1,000	-
Qualified	28	90,3	28	90,3		
Smoking habits						
Yes	13	41,9	7	22,6	0,174	-
No	18	58,1	24	77,4		
Window opening habits						
No	25	80,6	11	35,5	0,001	7,58
Yes	6	19,4	20	64,5		(2,39-24,06)

Table 3 shows that the density of eligible and ineligible dwellings is the same as that of the case and control groups. Each group had 28 eligible occupancy densities and three unqualified occupancy densities. The p-value obtained in Fisher's Exact Test is 1.000. This means there is no significant relationship between occupancy density and the incidence of pulmonary TB in the working area of Kedungmundu Health Center, Semarang City.

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Based on the results of the study show that respondents who have smoking habits are fewer than respondents who do not have smoking habits. Smoking habits in the case group were 13 people and seven in the control group. The correlation test using Chi-Square obtained a p-value of 0.174, which showed no significant relationship between smoking habits and the incidence of pulmonary TB in the working area of Kedungmundu Health Center, Semarang.

The relationship between the habit of opening windows and the incidence of pulmonary TB in the working area of Kedungmundu Health Center, Semarang City, was analyzed using the Chi-square test, which obtained a p-value of 0.001. This means a significant relationship exists between the habit of opening windows and the incidence of pulmonary TB in the working area of Kedungmundu Health Center, Semarang City. The OR value=7.58 (95% CI= 2.39-24.06) means that people who do not open windows have a 7.58 risk of developing pulmonary TB compared to people who have a habit of opening windows.

DISCUSSION

Kedungmundu Health Center has an uneven population distribution in the Tembalang Subdistrict. Being at an altitude of 125 meters above sea level (≤150 meters above sea level) makes this area susceptible to the incidence of TB in Semarang City. The elevation of this area can affect the level of humidity, temperature, oxygen density, and UV exposure, which in turn can also affect the survival of pathogenic bacteria[15].

Ventilation Area

Based on the study results, there is a significant relationship between the ventilation area and the incidence of pulmonary TB in the working area of Kedungmundu Health Center, Semarang City. This study's results align with research conducted by Zulaikhah (2019), which states that the risk of people living in houses with unqualified ventilation areas is 5.57 times greater than those living with qualified ventilation areas. This is because houses with unqualified ventilation areas can block the incoming light and the humidity increases[16].

The ventilation area is considered to meet health requirements if it has an area of at least 10% of the floor area. Ventilation as a ventilation system ensures air exchange and keeps the humidity in the room optimal[17]. The presence of ventilation can increase O_2 levels and reduce CO_2[18]. Conclusive evidence was obtained from one of the university buildings in Taipei City. After ventilation improvements were made, there was a decrease in CO_2 levels, and no new TB cases were found at the university[19]. Reducing CO_2 levels may play a role in inhibiting the growth and proliferation of M. tuberculosis[20]. In addition, adequate ventilation can remove these pathogenic bacteria from the house. Inadequate ventilation makes it difficult for sunlight to enter the home, causing the pathogen bacteria not to be killed naturally and can live longer in the room[21].

Lighting Level

Lighting levels in this study showed a significant association with the incidence of pulmonary TB. The results of this study are corroborated by research by Perdana (2018), which states that inadequate lighting levels (<60 lux) have a 25.32 times risk of developing pulmonary TB[11]. The area where the respondents live

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is densely populated, which is a factor in the lack of lighting in their houses. Many respondents' houses are adjacent to the houses on the right and left, so the lighting is mainly obtained at the front of the house only through windows, vents, and doors. In addition, few houses utilized glass tiles to meet the lighting needs inside the house.

Lack of lighting will cause the room to be dark and humid, allowing M. tuberculosis bacteria to survive for up to 2 hours or even months in the air[8]. Homes require exposure to UV light in sunlight to inhibit the growth of pathogenic bacteria in the house. This can be achieved by maximizing access to light through ventilation holes, frequently opened windows and doors, and glass roof tiles. By providing reasonable access to sunlight, the lighting in the house is fulfilled[22].

Humidity Level

Based on the bivariate analysis results in Table 3, humidity is unrelated to the incidence of pulmonary TB. There is no relationship between humidity levels and the incidence of pulmonary TB because the data distribution between the case and control groups is not much different. Most respondents from both groups live in homes with an acceptable humidity level, ranging from 40% to 70%.

Weather conditions can influence the measurement results of humidity levels in Tembalang District. The research was conducted between 08.30-12.00 WIB, and usually, the air temperature gradually increased significantly over time. An increase in temperature in the air tends to result in a decrease in air humidity. This is triggered by higher sunlight intensity, which evaporates more water from the ground surface and reduces water vapor content[23]. However, sudden weather changes occur from late December 2023 to early January 2024. Rain may fall suddenly, resulting in fluctuations in air humidity in the area.

Occupancy Density

There was no significant relationship between occupancy density and the incidence of pulmonary TB because the study groups, both cases and controls, had the same data distribution. Both had a high percentage of people living in healthy homes with humidity levels that met health requirements. Based on Permenkes No. 2 of 2023, the space requirement per person calculated from basic human activities in the house at least has a capacity of ≥ 9 m^2 [17]. 90.3% of respondents' houses were classified as spacious and proportional to the number of occupants, so they were still within the ideal space capacity. However, some respondents still have houses with limited area, so they are forced to use the living room as their sleeping place.

Their family members are not entirely inside the house in their daily lives. Instead, they spend more time outside the house because of the demands of work and education. On average, they leave the house in the morning and return home in the afternoon. Activities carried out outside the home or public places such as offices, factories, and schools allow a person to meet and interact with others. With different health statuses, this interaction can then lead to the risk of pulmonary TB transmission.

Smoking Habits

From the results of the bivariate test, it was found that there was no correlation between

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smoking habits and the incidence of pulmonary TB. The absence of this correlation is because most respondents do not have a smoking habit. The imbalance could influence this in the proportion of gender of the respondents involved. The prevalence of smoking in women is generally lower than in men. In Indonesia, only 1.06% of the female population aged 15 years and over have a smoking habit[24]. The female respondents in this study were 34 people (54.8%), and none of them smoked. The high awareness of the dangers of smoking and the bad stigma about women smokers in the neighborhood made all female respondents choose not to smoke. From the results of the interviews, it is also known that only a few are passive smokers because they are exposed to cigarette smoke by family members who live in their homes.

In this study, smoking habits are only determined by the amount of cigarettes consumed, the number of smokers, and the place of exposure to cigarette smoke, without considering the length of time a person smokes cigarettes. This then underestimates the magnitude of the effects of exposure to cigarette smoke. Long-term exposure to cigarette smoke can lead to decreased lung function and increase the likelihood of infection.

Window Opening Habits

In the variable of the habit of opening windows, it is known that 25 case groups do not have the habit of opening windows in the morning compared to the control group of 6 people. Based on observations in the field, the respondents' houses were equipped with windows. However, most respondents have not utilized the window function properly. It was not uncommon to find the windows of the house tightly closed. The interviews revealed that this behavior of not opening the windows was due to security factors, namely, the fear of strangers entering the house because the house was close to the road. In addition, the existence of activities that are mainly carried out outside the home is also a dominating reason. It was also found that some respondents' houses had windows that were damaged and deliberately disabled because they had a shop on the terrace of their house.

The results of this study are linear with research conducted by Hanifah (2024), which states that there is a relationship between the habit of opening windows in the morning and the incidence of pulmonary TB in people of productive age in Rantau Alai District. In her research, an OR value of 7.35 was obtained, which means that people who do not have the habit of opening windows have a risk of 7.35 of developing pulmonary TB compared to people who have the habit of opening windows[25]. Meanwhile, Budi's research obtained an OR value of 3.27. Indoor circulation can run optimally when the window is open. This also allows sunlight to enter and kill pathogenic bacteria in the room[26].

CONCLUSION

The incidence of pulmonary TB in the working area of the Kedungmundu Health Center, Semarang City, is influenced by the ventilation area, the level of lighting, and the habit of opening windows.

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