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Analysis of Physical Environmental Factors Related to Tuberculosis Occurrence in Elementary Schools in North Semarang Sub-District

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ABSTRACT

Tuberculosis (TB) is a contagious infectious disease caused by Mycobacterium tuberculosis. It is one of the leading causes of death in the world. The increase in tuberculosis cases continues to rise. Tuberculosis is an environmentally-based disease; tuberculosis bacteria can be transmitted under certain environmental conditions. Physical environmental factors are thought to be risk factors that have a role in triggering the transmission of tuberculosis bacteria. The aim of the study was to analyze the relationship between physical environmental factors and the incidence of tuberculosis in elementary schools in North Semarang District. The study used quantitative observational analysis with cross sectional research design. This study was conducted in elementary schools in North Semarang District in September 2023 - January 2024.

The population in this study was all elementary schools in North Semarang District, which amounted to 33 elementary schools. Sampling using total sampling. This research instrument uses an observation sheet, a luxmeter, a thermohygrometer, and a roll meter. Data were processed with the Chi-Square test. The results showed that there was an association between the variables of lighting (p-value=0.0001), humidity (p-value=0.027), and temperature (p-value=0.0001) with the incidence of tuberculosis in elementary schools in North Semarang District. Meanwhile, the variables of ventilation area (p-value=1.000), and occupancy density (p-value=0.455) had no association with the incidence of tuberculosis in elementary schools in North Semarang Subdistrict. The suggestion in this study is that elementary schools in North Semarang Subdistrict are expected to conduct early prevention and implement tuberculosis control programs so that this disease does not become more widespread.

Introduction

Tuberculosis (TB) remains a public health problem with very high morbidity and mortality rates(1). Based on the Global Tuberculosis Report 2022, tuberculosis is one of the diseases with a high cause of death worldwide. Globally in 2021, it was estimated that there were 10.6 million diagnosed TB cases, an increase of 4.5% from 2020, which had an estimated 10.1 million cases. In 2021, Indonesia ranked second in the world after India with a high number of TB cases. The number of TB cases in Indonesia was estimated to reach 969,000 cases with 93,000 deaths per year. This figure increased by 17% compared to 2020 with 824,000 cases (2).

In 2021, Central Java Province ranked second in Indonesia with the highest number of TB cases after West Java Province, with 43,121 cases. Based on data from the Central Java Province Statistics Agency (BPS), Semarang City ranked fifth in Central Java Province with 172.30 TB cases per 100,000 population after Tegal, Magelang, Surakarta, and Salatiga Cities(3). The number of TB cases (all types) in Semarang City in 2021 by gender was 3,221 cases, with 1,770 cases (55%) in the male group and 1,451 cases (45%) in the female group. This figure increased compared to 2020, which had 2,584 cases, with 1,384 cases (54%) in the male group and 1,200 cases (46%) in the female group(4)(5).

Tuberculosis bacteria are transmitted through infected droplets in the air and can spread when a person with active TB releases droplets of saliva or sputum when speaking, coughing, or sneezing, which are then inhaled by someone else(6). Although TB is classified as an infectious disease, its transmission is not as rapid as flu or common cold(7). TB is an environment-based disease; tuberculosis bacteria can be transmitted under certain environmental conditions(8). Physical environmental factors are suspected to be risk factors that play a role in triggering the transmission of tuberculosis bacteria. Physical environmental factors include room lighting, humidity, temperature, ventilation area, and room density/occupancy density. Indoor physical environmental conditions that do not meet requirements are suspected to be one of the factors affecting the proliferation of tuberculosis bacteria. Physical environments that can affect the proliferation of tuberculosis bacteria are poor or unhealthy environments, such as lack of indoor lighting, poor ventilation, and indoor occupancy density(1)(9).

Previous research studies conducted by Erlin Fitria Dewi, Suhartono, and Mateus Sakundarno Adi in 2016 showed that physical environmental factors, namely temperature and

humidity, have a relationship with the incidence of tuberculosis in Magelang City(10). Physical environmental factors in the form of ventilation area and lighting levels also have a relationship with the incidence of pulmonary tuberculosis in research conducted by Susiani Wulandari in 2012(11). In addition, based on research conducted by Suherman, Cokroaminoto, and Ike Mardiati in 2014, physical environmental factors including room lighting, humidity, and occupancy density have a significant relationship with the incidence of tuberculosis(12).

Children are among the vulnerable groups at high risk for TB transmission. If TB in children is not handled promptly and appropriately, it can cause prolonged suffering that usually develops into more serious diseases such as miliary TB and meningitis, and can inhibit child growth(13). Based on data from the Ministry of Health (Kemenkes), the most cases of children infected with TB are found on the island of Java. Central Java Province recorded 5,121 TB cases in children aged 0-14 years, after West Java Province with 13,922 cases(14).

Tuberculosis cases in children in the North Semarang District area are quite numerous. Based on data from the Semarang City Health Office, 31 new tuberculosis cases were found in children in North Semarang District in 2023(15). Schools are secondary educational environments where children spend approximately 8 hours a day at school, or nearly one-third of their time each day is spent at school. This can trigger the transmission and spread of tuberculosis. Poor environmental conditions will facilitate bacteria to live, reproduce, and transmit diseases. Considering that children are the nation's future generation, this research needs to be conducted to determine the relationship between physical environmental factors and the incidence of tuberculosis in elementary schools in the North Semarang District area, Semarang City, Central Java.

Methods

The type of research used is quantitative research using an analytical observational method and a cross-sectional research design. The population in this study consists of all elementary schools in the North Semarang District area, totaling 33 elementary schools. The sample in this study takes the entire population to be used as the research sample, namely 33 elementary schools, with a sampling technique using total sampling. This research was conducted at elementary schools in the North Semarang District area from September 2023 to January 2024.

The research instruments consisted of observation sheets, a lux meter, a thermohygrometer, and a roll meter. Data analysis used the Chi-Square statistical test.

Results

Table 1. Frequency Distribution of Variables in Elementary Schools in the North Semarang District Area

No.	Variable	Frequency (N)	Percentage (%)
	Lighting		
1.	Meets Requirements (≥300 lux)	15	45.5
2.	Does Not Meet Requirements (<300 lux)	18	54.5
	Humidity		
1.	Minimum humidity for bacterial growth (<60% RH)	14	42.4
2.	Optimum humidity for bacterial growth (≥60% RH)	19	57.6
	Temperature		
1.	Minimum temperature for bacterial growth (<31°C and >37°C)	9	27.3
2.	Optimum temperature for bacterial growth (31° - 37°C)	24	72.7
	Ventilation Area		
1.	Meets Requirements (≥15% of Floor Area)	29	87.9
2.	Does Not Meet Requirements (<15% of Floor Area)	4	12.1
	Occupancy Density		
1.	Meets Requirements (≥2m² / person)	32	97.0
2.	Does Not Meet Requirements (<2m² / person)	1	3.0
	Tuberculosis Incidence		
1.	Cases Present	18	45.5
2.	No Cases	15	54.5

Table 2. Cross-Tabulation Results of the Relationship Between Variables and Tuberculosis Incidence in Elementary Schools in the North Semarang District Area

Variable	TB Incidence						P value
	Yes		No		Total		
	N	%	N	%	N	%	
Lighting							
Meets Requirements	0	0	15	100	15	100	0.0001
Does Not Meet Requirements	18	100	0	0	18	100	
Humidity							
Minimum for bacterial growth	4	28.6	10	71.4	14	100	0.027
Optimum for bacterial growth	14	73.7	5	26.3	19	100	
Temperature							

Variable	TB Incidence						P value
	Yes		No		Total		
Minimum for bacterial growth	0	0	9	100	9	100	0.0001
Optimum for bacterial growth	18	75	6	25	24	100	
Ventilation Area							
Meets Requirements	16	55.2	13	44.8	29	100	1.000
Does Not Meet Requirements	2	50	2	50	4	100	
Occupancy Density							
Meets Requirements	18	56.2	14	43.8	32	100	0.455
Does Not Meet Requirements	0	0	1	100	1	100	

Discussion

1. Relationship Between Lighting and Tuberculosis Incidence

Poor lighting can cause high humidity in a room and has the potential to serve as a medium for rapid bacterial proliferation, such as tuberculosis bacteria(16). Based on the analysis conducted on 33 elementary schools, it was found that most schools had lighting that did not meet requirements (<300 lux) and had a higher tendency to experience tuberculosis incidence compared to lighting that was ≥300 lux. The relationship test results obtained a value (p-value 0.0001 < 0.05), leading to the conclusion that there is a relationship between lighting and tuberculosis incidence in elementary schools in the North Semarang District area. This lighting issue may occur because objects such as buildings, trees, and other structures located in front of windows or doors can obstruct light from entering the room. In addition, insufficient number and size of windows can also be a factor causing sunlight to be blocked from entering the classroom.

The results of this study are in line with research conducted by Sukma Sahadewa, et al. (2019) in Krian District, Sidoarjo Regency, which showed that there is a significant relationship between lighting as a risk factor for tuberculosis incidence; poor lighting has a 6.667 times greater risk of experiencing pulmonary TB incidence than good lighting levels(17).

2. Relationship Between Humidity and Tuberculosis Incidence

Tuberculosis is caused by bacteria that can spread through the air, so air quality affects the spread of tuberculosis. Rooms with high humidity can accelerate bacterial growth(18). Based on the analysis conducted on 33 elementary schools, it was found that most schools had optimum humidity for bacterial growth (≥60% RH) and had a higher tendency to experience tuberculosis incidence compared to minimum humidity for bacterial growth (<60% RH). The

relationship test results obtained a value (p-value 0.027 < 0.05), leading to the conclusion that there is a significant relationship between humidity and tuberculosis incidence in elementary schools in the North Semarang District area.

The results of this study are in line with research conducted by Erlin Fitria Dewi, et al. (2016) in Magelang City, which showed that there is a relationship between humidity levels and pulmonary tuberculosis incidence in Magelang City; humidity that does not meet requirements is influenced by poor construction such as wall types that are not waterproof(10).

3. Relationship Between Temperature and Tuberculosis Incidence

Room temperature is influenced by outside air temperature, air movement, air humidity, and the temperature of surrounding objects. The presence of temperature plays a very important role in the growth of Mycobacterium tuberculosis, where the growth rate of these bacteria is determined based on the surrounding air temperature(19). Based on the analysis conducted on 33 elementary schools, it was found that most schools had optimum temperature for bacterial growth (31°C - 37°C) and had a higher tendency to experience tuberculosis incidence compared to minimum temperature for bacterial growth (<31°C and >37°C). The relationship test results obtained a value (p-value 0.0001 < 0.05), leading to the conclusion that there is a relationship between temperature and tuberculosis incidence in elementary schools in the North Semarang District area. Field results show that the high temperature is caused by the hot air in Semarang City. However, the lack of air circulation causes the room to become humid, thus creating a favorable environment for the growth of tuberculosis bacteria.

The results of this study are also in line with research conducted by Ni Komang Ayu Tria Meriyanti, et al. (2018) in the working area of Puskesmas II West Denpasar, which showed that there is a relationship between temperature and pulmonary tuberculosis incidence. The air temperature in the Denpasar City area and its surroundings tends to be hot because it is located in an area close to the coast; however, rooms with inadequate lighting and ventilation make the rooms humid, and these conditions support the spread of pulmonary TB(20).

4. Relationship Between Ventilation Area and Tuberculosis Incidence

Ventilation has one function, which is to free room air from pathogenic bacteria, especially tuberculosis bacteria. Tuberculosis bacteria transmitted through droplet nuclei can float in the air due to their very small size. If ventilation in a room meets requirements, then bacteria can be carried by air out of the room(21). Based on the analysis conducted on 33

elementary schools, it was found that most elementary schools had ventilation areas that met requirements (>15% of floor area) and had a tendency not to experience tuberculosis incidence. The relationship test results obtained a value (p-value 1.000 > 0.05), leading to the conclusion that there is no relationship between ventilation area and tuberculosis incidence in elementary schools in the North Semarang District area.

The results of this study are also in line with research conducted by Novita Indriyani, et al. (2016) in the Tulis District area of Batang Regency, which obtained a p-value of 0.811 > 0.05, indicating no relationship between ventilation area and pulmonary tuberculosis incidence, with OR = 1.257, meaning that occupants with ventilation that does not meet requirements have a 1 times greater risk than ventilation that meets requirements(18).

5. Relationship Between Occupancy Density and Tuberculosis Incidence

Occupancy density can promote the transmission of respiratory microorganisms through coughing and sneezing by propelling mucus droplets full of bacteria from the respiratory tract into the air. These droplets are called droplet nuclei, which can float in the air for a long time, providing an opportunity to be inhaled by other individuals. Therefore, the more occupants there are, the higher the risk of disease transmission(21). Based on the analysis conducted on 33 elementary schools, it was found that most classroom occupancy densities met requirements (≥ 2 m²/person) and had a tendency not to experience tuberculosis incidence. The relationship test results obtained a value (p-value 0.455 > 0.05), leading to the conclusion that there is no relationship between occupancy density and tuberculosis incidence in elementary schools in the North Semarang District area.

The results of this study are in line with research conducted by Ardhitya Sejati, et al. (2015) at Puskesmas Depok 3, Sleman Regency, which obtained a p-value of 0.422 > 0.05, indicating no relationship between occupancy density and tuberculosis incidence. The lack of proven relationship between occupancy density and tuberculosis incidence is because observation results obtained data showing that the average house area is still proportional to the number of occupants, thus not causing overcrowding(22).

Conclusion

There is a relationship between the variables of lighting, humidity, and temperature with tuberculosis incidence in elementary schools in the North Semarang District area (p-value < 0.05). Meanwhile, for the variables of ventilation area and occupancy density, there is no

relationship with tuberculosis incidence in elementary schools in the North Semarang District area (p-value > 0.05).

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