

An Ecological Study of Determinants of The Incidence of Tuberculosis in Malang Raya Area

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ARTICLE INFO	ABSTRACT
ORCID ID Author 1: https://orcid.org/0000-0001-7075-1641 Author 2: - Author 3: https://orcid.org/0000-0002-6748-2556	The Malang Raya area (Batu City, Malang City, and Malang Regency) is one of the areas in East Java where the TB rate remains quite high. It is 3,461 cases in 2020. This study aimed to find out the correlation between coverage of healthy houses, coverage of households with healthy lifestyle, population density, air temperature, humidity, and rainfall with the incidence of tuberculosis in Malang Raya in 2021. The study used an ecological study design approach. Secondary data were collected from the Health Office and the Central Bureau of Statistics (<i>Badan Pusat Statistika/BPS</i>) of Malang City, Malang Regency and Batu City. Data were analyzed using Pearson Product Moment and Spearman's rho test. The result of the study indicate the correlation among the coverage of healthy houses and coverage of households with healthy lifestyle correlates with the incidence of tuberculosis in Malang Raya in 2021.
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1. Introduction

Tuberculosis (TB) is one of the biggest contributing diseases to mortality in the world. The World Health Organization (WHO) reported that as many as 1.2 million deaths were caused by TB in 2019, so TB is still an important issue in global health problems. In 2019 WHO also estimates that around 10 million people suffer from TB disease. WHO targets TB incidence to fall by 20% in 2020 and death rates from TB to fall by 35%, but these targets are still far from expectations. In 2020 the TB incidence is still at a high rate, which has only decreased by 9% and the death rate has only fallen by 14%. Southeast Asia is a region that has the highest TB prevalence in the world with a percentage of 44%. One of the countries in Southeast Asia that has a high prevalence of TB is Indonesia where Indonesia is the second-ranked country after India in the world with the highest TB burden, with a percentage of 8.5% (World Health Organization, 2020).

Indonesia is still the second-largest country in the world with the highest TB burden. The province in Indonesia that still has a high number of TB cases is in East Java (Ministry of Health of Indonesia, 2020). The East Java Provincial Health Office reported that the trend of TB cases from 2018 to 2019 has increased. The Malang Raya area (Batu City, Malang City, and Malang Regency) is one of the areas in East Java where the TB rate is still quite high. The total

number of TB cases in the Malang Raya area is 5,311 (Central Bureau of Statistics of East Java Province, 2021).

The potential for TB can be influenced by individual including behavior and the environment. People's lifestyles, population density, and housing conditions are determinants that can affect the transmission of TB disease in an area (Health Office of Malang City, 2021). Healthy lifestyle behavior in the household can be a factor in the transmission of tuberculosis. There is a relationship between household healthy lifestyle and the incidence of tuberculosis ($p=0.001<0.05$) (Noerhalimah, 2020).

Environmental factors are also a major factor in the transmission of tuberculosis (Noerhalimah, 2020). One of these environmental factors is the physical condition of the house. There is a relationship between the physical condition of the house and the incidence of positive smear pulmonary TB at the Kotabumi II Health Center, Bukit Kemuning and Ulak Rengas, North Lampung Regency in 2012 (OR=3.72) (Sumarmi & Duarsa, 2022). The climate is also an environmental factor that can influence the incidence of disease. Research in neighboring countries, namely Brunei Darussalam and Malaysia, shows a relationship between climate components (temperature, humidity, rainfall) and the incidence of TB (Chaw et al., 2022). A factor that also plays a role in the transmission of TB disease is population density. The distribution of tuberculosis cases occurs in densely populated settlements (Sasmita et al., 2017).

Therefore, this study was conducted that aimed to find out the correlation between coverage of healthy houses, coverage of households with healthy lifestyle, population density, air temperature, humidity, and rainfall with the incidence of tuberculosis in Malang Raya in 2021.

2. Method

The study is a quantitative with an ecological study design approach. Ecological study focus on groups, not individuals as the analysis unit. Data collection was carried out by the documentation method. Secondary data collected from the Health Office and the Central Bureau of Statistics (Badan Pusat Statistika/BPS) of Malang City, Malang Regency and Batu City for both independent and dependent variables. The independent variables were the coverage of healthy houses, the coverage of households with healthy lifestyle, population density, air temperature, humidity and rainfall, while the dependent variable was the incidence of TB. The population was tuberculosis cases recorded in the Malang Raya area by the Health Service for 2020-2021 in which the entire population will be sampled. To describe the distribution of each variable we use frequency and percentage distribution table. To analyze the correlation between each independent variable to the dependent variable using the Pearson Product Moment and Spearman's rho test.

3. Result and Discussion

The average proportion of TB in Malang City in 2021 is 0.21% with the highest proportion being 0.74% and the lowest being 0.06%. The average proportion of TB in Malang Regency in 2021 is 0.61% with the highest proportion being 2.99% and the lowest being 0.06% (table 1).

Table 1. Proportion of TB incidence in Malang Raya

Region	Proportion (%)	Mean (%)	Min-Max (%)
Batu City	0.07	0.06	0.02-0.12
Malang City	0.16	0.21	0.06-0.74
Malang Regency	0.66	0.61	0.06-2.99

Source: Health Office of Batu City (2021); Health Office of Malang City (2021); Health Office of Malang Regency (2021)

Table 2. Coverage of Healthy Houses in Malang Raya

Region	Coverage (%)	Mean (%)	Min-Max (%)
Batu City	90.40	88.03	79.00-100.00
Malang City	75.90	74.10	54.14-84.69
Malang Regency	88.79	87.59	63.33-100.00

Source: Health Office of Batu City (2021); Health Office of Malang City (2021); Health Office of Malang Regency (2021)

The coverage of healthy houses in Batu City in 2021 was 90.40% (table 2). In Malang City was 75.90%. Meanwhile, the coverage of healthy houses in Malang Regency was 88.79%. The average healthy houses coverage in Batu City in 2021 per sub-district (table 2) was 88.03% with the lowest coverage of 79% and the highest coverage of 100%. The average healthy houses coverage in Malang City was 74.10% with the lowest coverage of 54.14% and the highest coverage of 84.69%. The average healthy houses coverage in Malang Regency was 87.59% with the lowest coverage of 63.33% and the highest coverage 100%.

Table 3. Coverage Household with Healthy Lifestyle in Malang Raya

Region	Coverage (%)	Mean (%)	Min-Max (%)
Batu City	51.74	59.13	39.91-76.04
Malang City	52.09	53.55	46.29-64.92
Malang Regency	34.63	34.85	2.00-57.15

Source: Health Office of Batu City (2021); Health Office of Malang City (2021); Health Office of Malang Regency (2021)

Table 3 shows that households with healthy lifestyle with the highest coverage are in Malang City, which is 52.09%, while households with healthy lifestyle with the lowest coverage are in Malang Regency, 34.63%. The average Coverage households with healthy lifestyle in Batu City in 2021 per sub-district is 59.13% with the lowest coverage of 39.91% and the highest coverage of 76.04%. In Malang City, the average coverage households with healthy lifestyle per sub-district is 53.55% with the lowest coverage of 46.29% and the highest coverage of 64.92% and the average coverage home with healthy lifestyle in Malang Regency per sub-district is 34.85% with the lowest coverage of 2% and the highest coverage of 57.15%.

Table 4. Population Density in Malang Raya

Region	Population Density (people/km ²)	Mean	Min-Max
Batu City	1078	1600.00	479-2176
Malang City	7677	8551.60	5216-10654
Malang Regency	896,29	112475.88	35210-282589

Source: Central Bureau of Statistics of Batu City (2022); Central Bureau of Statistics of Malang City (2022); Central Bureau of Statistics of Malang Regency (2022)

The highest population density in Malang Raya was in Malang Regency, it was 89,629 people/km² (table 4). The average population density by sub-district in Malang Regency was 1122475.88 people/km² with the lowest population density of 35210 people/km² and the highest population density of 282589 people/km².

Table 5. Annual Average Air Temperature in Malang Raya in 2021

Region	Air Temperature (°C)
Batu City	22.42
Malang City	25.10
Malang Regency	23.92

Source: Central Bureau of Statistics of Batu City (2022); Central Bureau of Statistics of Malang City (2022); Central Bureau of Statistics of Malang Regency (2022)

The highest annual average air temperature during 2021 in Malang Raya was in Malang City (25.10°C), while the lowest was in Batu City (22.42°C).

Table 6. Annual Average Humidity in Malang Raya in 2021

Region	Humidity (%)
Batu City	86.83
Malang City	134.83
Malang Regency	77.58

Source: Central Bureau of Statistics of Batu City (2022); Central Bureau of Statistics of Malang City (2022); Central Bureau of Statistics of Malang Regency (2022)

Malang City recorded the highest annual average humidity at 134.83%. While Malang Regency had the lowest; 77.58% (table 6). On the other hand, Malang Regency received the highest annual average rainfall during 2021 (204.75 mm), followed by Malang City at 203.98 mm and Batu City at 194 mm (table 7).

Table 7. Annual Average Rainfall in Malang Raya in 2021

Region	Rainfall (mm)
Batu City	194.00
Malang City	203.98
Malang Regency	204.75

Source: Central Bureau of Statistics of Batu City (2022); Central Bureau of Statistics of Malang City (2022); Central Bureau of Statistics of Malang Regency (2022)

Table 8. Correlation of Factors Influencing TB Incidence in Malang Raya

Variable	p-value	Correlation Coefficient (r)
Coverage of healthy houses	0.029	-0.341
Coverage of households with healthy lifestyle	0.005*	0.431
Population density	0.896	-0.021
Air temperature	0.459	0.751
Humidity	0.929	0.111
Rainfall	0.124	0.981

*: Spearman's rho test

Source: Primary Data (2024)

There is a correlation between the coverage of healthy houses and the incidence of TB in Malang Raya with a p-value of 0.029 (<0.05) (table 8). Similarly, the coverage of households with healthy lifestyle also correlated with the incidence of TB at p-value 0.005. Population density showed no correlation to the incidence of TB in Malang Raya ($p > 0.05$). Likewise, humidity and rainfall showed no correlation with the incidence of TB in Malang Raya.

3.1 Correlation between Coverage of healthy houses with TB Incidence

There is a relationship between the coverage of healthy houses with the incidence of TB in Malang Raya area. It is similar with the study conducted by Heriyani et al., (2013) which states that there is a relationship between the components of a healthy home that consist of occupancy density, air temperature, ventilation, and lighting with TB incidents. The study by Tahalele et al., (2019) stated that there is a relationship between humidity and TB incidence also, which is a component of a healthy home, and TB disease transmission.

The requirements for good residential density in a house are a minimum bedroom area of 8 meters which is not recommended for use by more than 2 people (Ministry of Health of Indonesia, 2011). Houses with residential densities that exceed the requirements will affect the humidity in the house. High residential densities can increase humidity caused by sweat produced by humans during activities and water vapor released by humans when breathing (Romadhan et al., 2019). The humidity requirements in the house are in the range of 40-60% and the air temperature requirements are in the range of 18-30°C (Ministry of Health of Indonesia, 2011). Requirements for house ventilation area according to Permenkes RI Nomor 1077/MENKES/PER/V/2011 Concerning Housing Health Requirements, namely more than 10% of the house's floor area. The ventilation area does not affect TB transmission because the ventilation function is not used properly (Rosiana, 2013). Ventilation functions so that air circulation inside the house remains fresh (Yuliani et al., 2018). Research conducted by Rosiana, (2013) states that there is no relationship between ventilation area and the incidence of TB because most houses use windows as a means of obtaining air circulation rather than ventilation, so these windows are not categorized as ventilation and in the end no

measurements are taken. The existence of ventilation can also affect the occurrence of disease transmission in the house (Mariana & Chairani, 2018). Ventilation plays a role in air circulation in the house, the air in the house that is polluted by bacteria will be replaced with clean air. Apart from that, ventilation also acts as a way for sunlight to enter the house (Suma et al., 2021). According to several theories and research, lighting can play a role in the development of TB-causing bacteria. Mycobacterium tuberculosis. Bacteria survive for a long time in rooms that don't get enough ultraviolet light from the sun. The nature of light that can kill bacteria plays a very important role in preventing the transmission of tuberculosis at home (Suma et al., 2021). The requirement for good lighting in the house is a minimum of 60 lux.

3.2 Correlation among Coverage of Household with Healthy Lifestyle and TB Incidence

Person's life behavior influences the transmission of TB. These behaviors include consuming nutritious food, doing physical activity, not smoking, and maintaining hygiene such as regularly washing hands with soap. These behaviors can be influential because they are related to a person's immunity. A person will be vulnerable to contracting a disease if he has poor immunity (Sari & Fitriyani, 2021). A study by Saputra et al., (2020) stated that healthy lifestyle is a factor associated with the incidence of tuberculosis. If the healthy lifestyle rate increases by one percent, the incidence of tuberculosis will decrease by 12 cases. Similarly, a research by Purwanto (2020) also shows that there is a significant relationship between healthy lifestyle and the incidence of TB. This is the same as the results of the correlation analysis in this study which shows that there is a relationship between the coverage of homes with healthy lifestyles and the incidence of TB in Malang Raya in 2021. This research is also in line with research conducted by Noerhalimah (2020), which shows that there is a relationship between the Coverage houses with healthy lifestyle and the incidence of TB (p -value = 0.001).

3.3 Correlation between Population Density and TB Incidence

High population density increases the risk of transmission of TB disease which is transmitted through droplets so the risk of contact with TB sufferers is also high. TB transmission usually occurs in areas with densely populated conditions (Sasmita et al., 2017). The population density is not correlated with TB incidence in Malang Raya in 2021. The result is in line with research of Sun et al., (2015) that the prevalence of TB shows no relationship with population density because the area studied has a small population with limited population and mobility. TB transmission is related to various causal factors such as environmental, social, and individual factors (Sasmita et al., 2017).

3.4 Correlation between Air Temperature and TB Incidence

Mycobacterium tuberculosis grows optimally at 37°C (Surjati, 2020), bacteria grow rapidly at a temperature range of 25°C-40°. Based on data on air temperature in Malang Raya, areas that have the potential to become locations for TB bacteria to grow rapidly are Malang City with an average annual temperature of more than 25°C and Malang City has a moderate number of TB cases. This study has similar results with the study by Sadeq & Bourkadi (2018), that the average annual air temperature does not correlate with TB incidence. This can be caused by the presence of intermediary factors between meteorological elements and tuberculosis, namely the conditions of the home environment.

3.5 Correlation between Humidity and TB Incidence

Good humidity according to the Ministry of Health of Indonesia (2011) is in the range of 40% -70% and is said to be bad if the humidity is less than 40% or more than 70%. High humidity will slow down air circulation, this condition will cause Mycobacterium tuberculosis bacteria to stay in the air for a long time (Mohidem et al., 2021). High humidity causes the formation of larger aerosols consisting of Mycobacterium tuberculosis bacillus. This results in many microorganisms entering the body, increasing the ability of bacteria to transmit disease, and disrupting the immune system (Ghadimi-Moghadam et al., 2020).

This study's findings are in line with research by Xu et al. (2021) which states that there is a non-linear relationship between humidity and tuberculosis. The cause of TB is the result of the interaction of environmental and social factors. There is no relationship between humidity and TB cases because meteorological factors in TB cases can be influenced by disturbing factors from several social factors.

3.6 Correlation between Rainfall and TB Incidence

Beiranvand et al. (2016), stated that rainfall is a direct indicator of humidity which affects the incidence of TB in Iran. Rainfall and humidity have a close relationship, humidity will be high if rainfall is high and vice versa. As with humidity, the rainfall factor may not be the main factor causing TB transmission because other factors play a more important role. There is no relationship between climatic elements (air temperature, humidity, and rainfall) with the incidence of TB due to the short period the research was conducted (Sari & Fitriyani, 2021).

4. Conclusion

The coverage of healthy houses and coverage of households adopting healthy lifestyle correlates with the incidence of tuberculosis in Malang Raya in 2021. We suggest that the health office facilitate the adoption of healthy lifestyle practices among households by empowering health cadres, supporting family welfare (*PKK*) and ten neighborhood groups (*dasawisma*) through mentoring and monitoring activities for at-risk households.

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