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Ecological Studies of Climate Factors and Pulmonary Tuberculosis Cases in Padang City 2020-2023

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ABSTRACT

Introduction: Tuberculosis (TB) is actually a disease that can be prevented and cured. In 2022, TB became the second leading cause of death in the world after Coronavirus (COVID-19), and caused twice as many deaths as HIV/AIDS. Several studies have stated that climate factors such as exposure to high temperatures, dry environments and exposure to ultraviolet light can influence the growth of Mycobacterium tuberculosis.

Objective: This research aims to determine the distribution and correlation of climate factors with the number of pulmonary TB cases in Padang City in 2020-2023.

Method: This research is an ecological study with the study population of Padang City. In this study the dependent variable is pulmonary TB cases and the independent variables are temperature, precipitation, and humidity. Pearson correlation is used to determine whether or not there is a relationship, the strength of the relationship, and the direction of the relationship between two normally distributed numerical variables. This research also describes descriptively the distribution of pulmonary TB cases in Padang City based on sub-districts using spatial analysis.

Result: There is significant relationship in 2022 between temperature (p=0.010) and precipitation (p=0.019) with pulmonary TB cases in Padang City. However, there are no variables of climates related to pulmonary TB when analyzed cumulatively from 2020-2023. Based on the results of spatial analysis, it can be seen that Koto Tangah sub-district is consistently in the high category of pulmonary TB cases in 2020-2023.

Conclusion: The research results found that temperature and precipitation in 2022 were significantly related with the incidence of pulmonary TB, while the humidity variable had no significant relationship with the incidence of pulmonary TB cases in Padang City. It is recommended to make climate factors such as one of the considerations in making policies related to the prevention of pulmonary TB.

Keywords: Tuberculosis; Climate; Temperature; Precipitation; Humidity

INTRODUCTION

In actuality, tuberculosis (TB) is a disease that may be treated and prevented. After COVID-19 infection, tuberculosis (TB) was the second most common cause of mortality worldwide in 2022, accounting for twice as many deaths as HIV/AIDS. Every year, more than 10 million people worldwide contract tuberculosis (TB) (1–3). Mycobacterium tuberculosis (M.Tb), a rod-shaped bacteria, is the source of tuberculosis (TB), an infectious disease that mostly affects the lung parenchyma (pulmonary TB), but can also spread to other organs (extra-pulmonary TB) (4,5).

Pulmonary tuberculosis (PTB) is always the most well-known respiratory disease. This isn't just because PTB is one of the top 10 causes of death globally; it's also a significant global health issue, particularly for nations where per capita income is still low. As a result, a large number of studies have documented environmental epidemiology health risk assessment, particularly for PTB to create a better database that may aid in the formulation of public health policies, the creation of environmental regulations, the planning of research, etc (6–8).

One global public health concern is climate change. The pattern and burden of tuberculosis, a global public health issue impacting low- and middle-income nations, are influenced by factors related to changing climate (9). Numerous environmental risk factors, including low socioeconomic status, crowded living circumstances, smoking, HIV/AIDS, diabetes mellitus, and other immune-suppressive disorders, all have an impact on tuberculosis (TB) (7,10).

According to a number of studies, environmental elements including exposure to high temperatures, dry conditions, and UV light can affect how M. tuberculosis bacteria grow. in order to alter the chance of contracting M. tuberculosis. For instance, cold temperatures tend to force people to stay indoors, which raises the risk of contracting M. tuberculosis, even if low wind speeds might not encourage the spread of M. tuberculosis (11). Active pulmonary tuberculosis commonly manifests as cough, occasionally with phlegm, hemoptysis, thoracalgia, physical exhaustion, weight loss, fever, and insomnia (4,12).

Research related to climate and TB has not yet been carried out much in Indonesia, especially in the city of Padang. Even though in 2021 and 2020 Indonesia and the Philippines will be the two countries with a decrease in TB incidence, Indonesia is still ranked as the second largest contributor to TB cases (10%) in the world after India.1 In order to improve interventions and direct resource allocation in illness management, it is essential to comprehend the spatial distribution of a disease. The spatial pattern of tuberculosis has been evaluated using a variety of spatial statistic techniques, including hotspot analysis (Getis-Ord Gi*), spatial autocorrelation analysis (Moran's I), and space-time scan statistic (SaTScan) (13).

West Sumatra is ranked third for the prevalence of TB cases in Indonesia, West Sumatra province health profile data reports that Padang City is recorded as the city with the most TB cases in West Sumatra Province (14,15). This research aims to look at the distribution and correlation of climate factors with number of pulmonary TB cases in Padang City in 2020-2023.

METHOD

This study is a correlation quantitative that uses an ecological study approach with the study population of Padang City. The data in this study, the dependent variable are pulmonary TB cases and the independent variables are precipitation, air temperature and humidity. Then the data was compiled monthly from January 2020 to December 2023. This research is a time series that was analyzed univariate and bivariate using the Pearson correlation method because the data is normally distributed (Pvalue>0.05). Pearson correlation is used to determine whether or not there is a relationship, the strength of the correlation, and the direction of the correlation between two normally distributed numerical variables. The data used is secondary data for the incidence of pulmonary tuberculosis sourced from the Padang City health office from January 2020 to December 2023. Meanwhile, climate data was obtained from the Teluk Bayur Maritime BMKG station, Padang City. Researchers used an alpha of 5% (it is said to be significant if the P value<0.05). This research also describes descriptively the distribution of pulmonary TB cases in Padang City based on sub-districts using spatial analysis.

RESULTS

The Distribution of Pulmonary TB Cases in Padang City

The result of univariate analysis stated the average number of pulmonary TB cases that occurred from 2020 to 2023 was 208.8 cases. Meanwhile, the highest number of cases will be in 2023, with 368 cases in November (Table 1). The number of pulmonary TB cases from 2020-2022 has increased, data shows in 2020 (1,540) TB cases, 2021 (2,183) TB cases, 2022 (3,174) TB cases and there has been a decrease in 2023 with a total of 3,093 TB cases.

Table 1. Univariate Analysis of Pulmonary TB in Padang City 2020-2023

Year	Mean	Median	SD	Min-Max
2020	128.33	110.50	57.42	49 - 219
2021	181.92	180.00	29.23	137-226
2022	264.50	274.50	41.44	202-319
2023	260.75	245.50	50.25	190-368
2020-2023	208.88	217.00	72.64	49-368

The total of pulmonary TB cases in Padang City has increased from 2020 to 2022 and decreased in 2023. This situation tends to fluctuate due to various environmental factors. The average increase in the number of cases occurs in June and November (Figure 1).

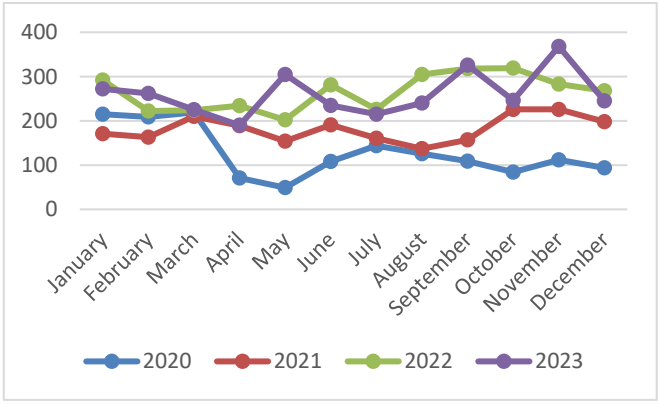

Figure 1. Pulmonary TB Cases Distribution by Month in Padang City 2020-202

The give a distribution of pulmonary TB cases in Padang City in 2020-2023 this research also depicted spatially as shown in Figure 2 below.

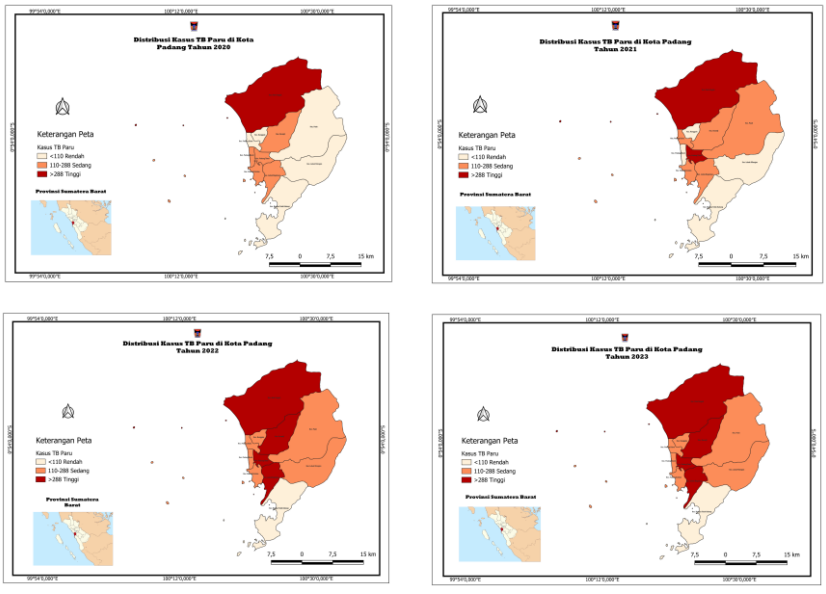

Figure 2. Pulmonary TB cases in Padang City by District 2020-2023

The distribution of pulmonary TB cases in Padang City spread across 11 sub-districts from 2020-2022, there are different patterns in each sub-district area. In 2020, there was one sub-district with a high number of pulmonary TB cases (>288 cases), namely Koto Tangah sub-district (307 cases) and Bungus Teluk Kabung sub-district was the sub-district with the lowest cases (34 cases). In 2021, there are two sub-districts with a high number of pulmonary TB cases (>288 cases), namely Koto Tangah sub-district (410 cases) and Padang Timur sub-district (516 cases) and Bungus Teluk Kabung sub-district which is the sub-district with the lowest cases (39 cases).

In 2022 there were three sub-districts with a high number of pulmonary TB cases (>288 cases), namely Koto Tangah sub-district (572 cases), Padang Timur sub-district (354 cases), Kuranji sub-district (438 cases), Lubuk Begalung sub-district (487 cases) and Bungus Teluk Kabung sub-district is still the sub-district with the lowest cases (78 cases). In 2023 there will be three sub-districts with a high number of pulmonary TB cases (>288 cases), namely Koto Tangah sub-district (592 cases), Lubuk Begalung sub-district (436 cases), Kuranji sub-district (507 cases), Padang Timur sub-district (331 cases) and Bungus Teluk Kabung sub-district is still the sub-district with the lowest cases (67 cases).

Based on the results of this spatial analysis, it can be seen that Koto Tangah sub-district is a sub-district that is consistent with the number of cases in the high category so that this sub-district can be proposed to the Health Service to be made a priority in the problem of handling TB cases followed by Kuranji, Lubuk Begalung and Padang Timur sub-districts.

The Distribution of Climate Factors in Padang City

Temperature

An overview of the climate (temperature) of Padang City in 2020-2023 can be seen in (Table 2). The average air temperature in Padang City during 2020-2023 was 27.58ºC with the highest temperature recorded in April and May 2023 at 28.7 ºC while the lowest temperature was in November 2022 at 26.40 ºC.

Table 2. Univariate Analysis of Temperature in Padang City 2020-2023

Year	Mean	Median	SD	Min-Max
2020	27.65	27.50	0.55	26.90-28.50
2021	27.51	27.40	0.40	27.00-28.50
2022	27.32	27.35	0.58	26.40-28.10
2023	27.84	27.80	0.54	27.10-28.70
2020-2023	27.58	27.55	0.54	26.40-28.70

The air temperature in Padang City during 2020-2023 tends to fluctuate every year. The average increase in air temperature every year usually occurs in February and December (Figure 3).

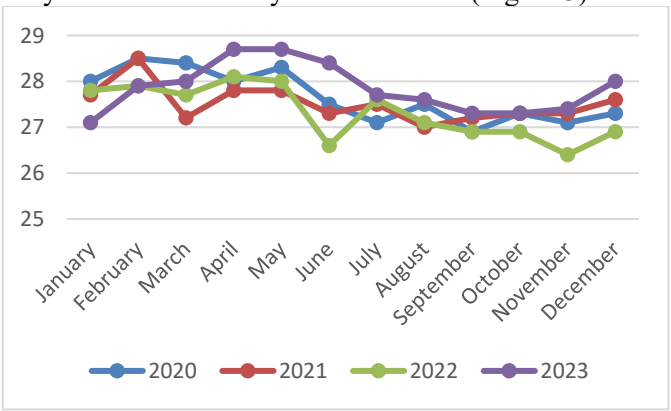

Figure 3. Temperature distribution by month in Padang City 2020-2023

Precipitation

An overview of the climate (precipitation) of Padang City in 2020-2023 can be seen in (Table 3). The average precipitation in Padang City during 2020-2023 was 362.18 mm with the highest precipitation recorded in November 2022 at 816.6 mm while the lowest precipitation was in October 2023 at 44.80 mm.

Table 3. Univariate Analysis of Precipitation in Padang City 2020-2023

Year	Mean	Median	SD	Min-Max
2020	374.25	353.65	162.15	199.20-685.60
2021	343.68	313.45	156.99	80.30-638.70
2022	391.44	313.20	210.85	110.60-816.60
2023	339.36	350.90	171.26	44.80-624.00
2020-2023	362.18	331.95	172.24	44.80-816.60

Precipitation in Padang City during 2020-2023 tends to fluctuate every year. The average increase in precipitation each year usually occurs in March and November (Figure 4).

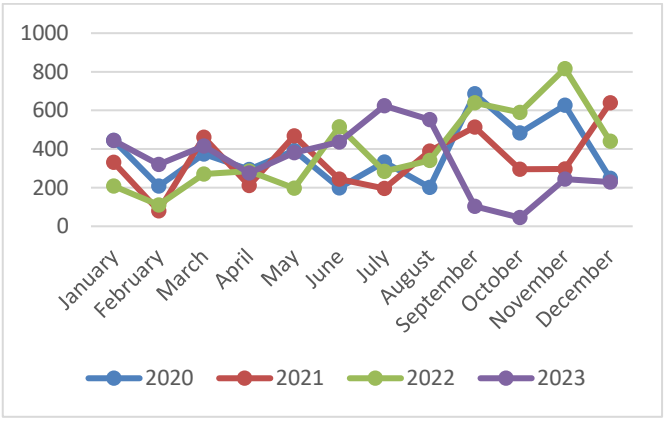

Figure 4. Precipitation distribution by month in Padang City 2020-2023

Humidity

An overview of the climate (humidity) of Padang City in 2020-2023 can be seen in (Table 4). The average humidity in Padang City during 2020-2023 was 80.68% with the highest humidity recorded in June 2022 at 88.4% while the lowest humidity was in February 2021 at 73.90%.

Table 4. Univariate Analysis of Humidity in Padang City 2020-2023

Year	Mean	Median	SD	Min-Max
2020	80.25	79.50	2.56	77-85
2021	81.05	81.40	3.65	73.90-85.20
2022	82.36	82.54	3.18	77.62-88.41
2023	79.08	79.00	1.88	75-82
2020-2023	80.68	80.00	3.05	73.90-88.41

Humidity in Padang City during 2020-2023 tends to fluctuate every year. The average increase in humidity each year usually occurs in March (Figure 5).

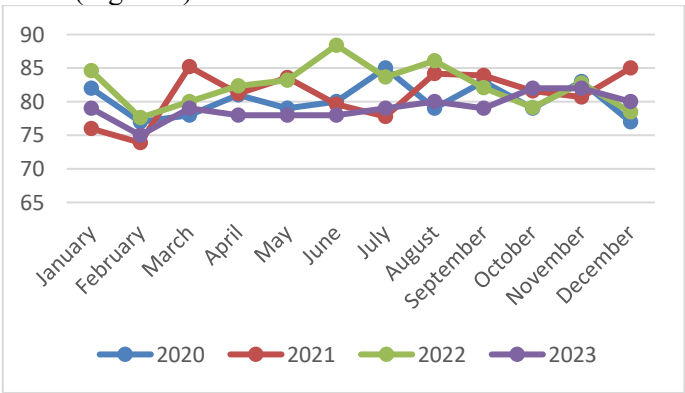

Figure 5. Humidity distribution by month in Padang City 2020-2023

The Relationship of Temperature and Pulmonary TB

Based on the results of statistical tests with Pearson correlation, it was found that there was no correlation between temperature and the number of pulmonary TB cases in Padang City in 2020-2023 (p=0.362, r=-0.135). However, in 2022 it shows that there is a correlation between temperature and the number of pulmonary TB cases in Padang City (p=0.010) with a strong relationship and a negative pattern (r=-0.709). This indicates that if the temperature is low it will be followed by an increase in the number of pulmonary TB cases. Meanwhile, for 2020, 2021 and 2023, it is known that there is no correlation between temperature and the number of pulmonary TB cases in Padang City (Table 5).

Table 5. Bivariate Analysis between Temperature and Pulmonary TB 2020-2023

Year	P-Value	r
2020	0.196	0.401
2021	0.569	-0.183
2022	0.010*	-0.709
2023	0.212	-0.389
2020-2023	0.362	-0.135

*Pvalue < 0,05

The Relationship of Precipitation and Pulmonary TB

The number of pulmonary tuberculosis cases in Padang City in 2020–2023 did not correlate with precipitation, according to the results of statistical tests using Pearson correlation (p=0.843, r=0.029). Nonetheless, data from 2022 indicates a substantial positive association (r=0.663) between precipitation and the number of pulmonary tuberculosis cases in Padang City (p=0.019). This indicates that if precipitation increases, it will be followed by an increase in the number of pulmonary TB cases. Meanwhile, for 2020, 2021 and 2023, it is known that there is no correlation between precipitation and the number of pulmonary TB cases in Padang City (Table 6).

Table 6. Bivariate Analysis between Precipitation and Pulmonary TB 2020-2023

Year	P-Value	r
2020	0.728	-0.113
2021	0.977	0.009
2022	0.019*	0.663
2023	0.241	-0.366
2020-2023	0.843	0.029

*Pvalue < 0,05

The Relationship of Humidity and Pulmonary TB

Based on the results of statistical tests with Pearson correlation, it was found that there was no correlation between humidity and the number of pulmonary TB cases in Padang City in 2020-2023 (p=0.489, r=0.102). Meanwhile, for 2020, 2021, 2022 and 2023, it is known that there is no correlation between humidity and the number of pulmonary TB cases in Padang City (Table 5).

Table 7. Bivariate Analysis between Humidity and Pulmonary TB 2020-2023

Year	P-Value	r
2020	0.838	-0.066
2021	0.690	0.129
2022	0.500	0.216
2023	0.383	0.277
2020-2023	0.489	0.102

DISCUSSION

Time series is a statistical method that is widely used recently in infectious disease research (4). Pulmonary TB infection can be transmitted through the sputum of TB sufferers which is spread due to various factors, including climatic factors which influence the survival of microorganisms in the sputum. This transmission is usually divided into two stages, namely (1) M. Tuberculosis which is outside the host's body can be directly influenced by climatic factors; (2) M. Tuberculosis in the host's body is influenced indirectly by climatic factors (4,16).

Based on existing research, temperature, humidity, precipitation and wind speed are climate factors that can significantly influence the incidence of tuberculosis (17). Climate factors are one of the causes of airborne disease in addition to other environmental factors. Apart from that, human health is also influenced by climate change and tuberculosis is one of the diseases that can be caused (18). In the human body, high air temperatures result in a reduction in the amount of mucus fluid in the respiratory tract, thus affecting the growth of M.tb. Mucus fluid (mucus) in the respiratory system helps to trap and expel pathogens such as M.tb, however, due to high air temperatures, the

body will be susceptible to losing mucus fluid through sweat, which can reduce the defense function of the respiratory system and result in the development of M.tb germs (19).

Temperature is not significantly correlated with pulmonary TB cases with (p=0.36) this is in line with previous research which shows there is no relationship between temperature and the incidence of pulmonary TB cases (20). However, in 2022 there will be a significant relationship between temperature and cases. Pulmonary TB with (p=0.010, r=-0.76) and is in line with previous research which shows that temperature has an effect on the incidence of pulmonary TB cases (21,22). M.tb can grow and reproduce at temperatures of 35 to 37 °C, and can survive for 4 to 5 years at −8 to −6 °C (23). Increasing global warming causes temperature increases in some arid and semi-arid areas faster than in other areas, so this triggers a significant increase in infectious diseases (24). These findings are in line with research by Xiao et al (2017) in China which shows that the temperature Low air can increase the incidence of pulmonary TB cases (p<0.01, r=-0.11). Research conducted by M.Xu in Hong Kong, also showed that TB incident notifications increased when the environmental temperature was low. This is because low temperatures can reduce the human immune system, allowing M.tb to reproduce easily in the human body (10).

There was no relationship between precipitation and pulmonary TB cases (p=0.843). This could happen due to low dispersion and transmission of aerosols/droplets containing M.tb bacteria in the ambient air (24). However, there is a P value <0.05 in 2022 (p=0.019) followed by an increase in cases of pulmonary TB, precipitation and tuberculosis These are two different things that can be interconnected, where high precipitation can create a humid environment so that it can affect the survival of MTB bacteria in the external environment (25). Then, high precipitation also affects indoor air quality. In the rainy season or in areas with high precipitation, people tend to spend more time indoors. If indoor ventilation is inadequate, humid air can increase the risk of transmission of airborne infectious diseases, including TB. TB bacteria can survive longer in closed conditions with high humidity due to lack of good air circulation (26).

Most bacteria and fungi are able to survive in air humidity that reaches or exceeds 70% (27). Where the average air humidity in the city of Padang in 2020-2023 is 80.68%. However, there was no significant relationship between air humidity and pulmonary TB cases (p=0.489). This is in line with previous research which stated that there was no significant relationship between humidity and the incidence of pulmonary TB cases. At a certain relative humidity, M.tb is more likely to evaporate in the air to form a certain diameter that can be suspended in the air for a longer time (especially droplets containing M.tb)(23) However, humidity tends to be adjusted to precipitation and this may have an indirect effect on the prevalence of pulmonary TB. However, this effect is much smaller than that of precipitation and is not statistically significant (21).

CONCLUSION

According to study findings, there was no significant correlation between the incidence of pulmonary tuberculosis cases in Padang City and the humidity variable in 2022, although there was a correlation between temperature and precipitation. In addition to environmental factors, exposure to sunlight, wind speed, residential density, healthy housing, and the host individual themselves can all contribute to the occurrence of pulmonary tuberculosis cases.

SUGGESTION

This study can serve as a reference for future research that examines many facets of risk factors and other variables in regards to the correlation between the prevalence of pulmonary tuberculosis and climate. Prioritizing TB control regions for local health services can be done using the spatial distribution of pulmonary tuberculosis cases as a guide.

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