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Research article

Mapping Ambient Temperature and Leptospirosis Cases: A Spatial Approach in Central Java

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ABSTRACT
Background: Leptospirosis remains a global public health concern as a neglected and re-emerging tropical disease with substantial morbidity and mortality. This study investigates the association between ambient temperature and leptospirosis cases in Central Java to elucidate disease transmission patterns.
Methods: A quantitative approach was employed, integrating geographic information system (GIS) analysis with descriptive spatial methods. The study examined leptospirosis cases and ambient temperature trends from 2018 to 2022 across all districts and cities within Central Java Province.
Results: These findings underscore the necessity of incorporating temperature-based risk assessment into public health strategies, particularly through the implementation of spatially driven monitoring systems to identify high-risk regions and mitigate leptospirosis transmission in temperature-prone areas. Spatial analysis revealed that areas characterized by high to moderate minimum, maximum, and average temperatures, such as Banyumas, Demak, and Semarang City, exhibited a greater case of leptospirosis compared to areas with lower temperatures.
Conclusion: This study showed that areas with high and medium minimum, maximum, and average temperatures, such as Banyumas, Demak, and Semarang City, tended to have higher leptospirosis cases than areas with low minimum temperatures, highlighting the need for spatial-based monitoring systems to detect high-risk areas, particularly those with warm ambient temperatures.

BACKGROUND

Leptospirosis is a disease that remains a public health problem in the world. It is not only a neglected infection but also one of the re-emerging tropical diseases with significant morbidity and mortality rates globally (Karpagam & Ganesh, 2020). The main reservoir for the spread of pathogenic Leptospira is rodents, which naturally harbor these bacteria in the renal tubules (Costa et al., 2015; Jayasundara et al., 2021). The disease can be transmitted to humans through direct contact with urine or reproductive fluids of infected animals, contaminated water or soil, and wounds to the skin and mucous membranes (Schafer et al., 2023).

The global incidence of leptospirosis is reported at 14.8 cases per 100,000 people per year, with an estimated one million cases and 60,000 deaths due to severe clinical manifestations such as pulmonary hemorrhage syndrome and Weil's disease (Bharti et al., 2003; Munoz-Zanzi et al., 2020). Tropical regions, including Southeast Asia, record the highest incidence rates, which are influenced by ambient temperatures that are ideal for the development of Leptospira that cause leptospirosis (Antima & Banerjee, 2023; Schafer et al., 2023). Indonesia, as one of the tropical countries, has a high incidence of leptospirosis. It reached 1,613 leptospirosis cases with 148 deaths (CFR 9.2%), with Central Java being

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one of the provinces with the highest caseload (Directorate of Prevention and Control of Infectious Diseases, 2023).

Leptospirosis disease is influenced by temperature as an abiotic environmental factor (Chadsuthi et al., 2022; Cucchi et al., 2019; Nugroho et al., 2017). Leptospira grows optimally at temperatures around 28 to 30°C. Air and water temperatures corresponding to this range favor bacterial survival and development, which can increase the risk of leptospirosis infection (Antima & Banerjee, 2023). Central Java has ambient temperature characteristics that support Leptospira growth, with an average air temperature of 18-34°C (Central Java Provincial Government, 2024). With the ambient temperature conditions and leptospirosis cases that have been described, making Central Java province one of the leptospirosis endemic areas in Indonesia.

Although various studies related to the relationship between ambient temperature and leptospirosis have been conducted, studies that look at the relationship between the two variables using a spatial approach are still limited. This makes this study important to understand the pattern of disease spread and develop more effective prevention and control strategies based on a spatial perspective.

METHODS

Design, samples and data

Quantitative methods were applied using geographic information systems and analyzed descriptively. This study focuses on ambient temperature consisting of maximum temperature (ºC), minimum temperature (ºC), average temperature (ºC), and Leptospirosis cases from 2018 to 2022 with the unit of analysis of all districts/cities in Central Java province. The spatial data analysis process used the protocol from Susanna et al. (2022) with adjustments (Susanna et al., 2022).

Secondary data consisted of monthly reports of leptospirosis cases and ambient temperature in Central Java province from 2018 to 2022. Leptospirosis data was obtained from leptospirosis case reports at the Ministry of Health of the Republic of Indonesia. Ambient temperature data was obtained from reports of five weather monitoring stations (Tunggul Wulung Meteorological Station, Tanjung Emas Maritime Meteorological Station, Ahmad Yani Meteorological Station, Tegal Maritime Meteorological Station, and Central Java Meteorological Station). Furthermore, a base map of Central Java consisting of 35 districts/cities with surrounding boundaries was obtained from GADM Map and Data.

Data Analysis Procedure

Spatial analysis was conducted to observe the relationship pattern between the dependent and independent variables. Based on the selected communities, an interpolation process was performed to create an overlay map of leptospirosis cases and ambient temperature. Interpolation of the Central Java grid map was used to estimate the magnitude of ambient temperature variables outside the measurement points (weather stations) by applying the following steps. First, a grid map of the five weather stations was created. Interpolation was done by entering point values or coordinate attribute data (longitude and latitude) into the ambient temperature variable attribute table. The coordinate points were then merged into the ambient temperature variable map. Second, the independent variable vector data is digitized by inserting the ambient temperature variable spatial data into the base map, then processing and selecting color symbols (single-band pseudocolor) with ramp reds. As a result, digital categories of high and low ambient temperature variables were formed based on the magnitude of the data. Third, the vector data of the dependent variables were digitized by inserting the spatial data of leptospirosis into a base map, depending on the community, followed by processing and selecting a point symbol (centroid). Digital categories for large and small cases were generated based on the disease data. Fourth, the two vector maps were interpolated with the plugin's interpolation menu. Therefore, a raster plot of the interpolated results was obtained and used to analyze or predict the value of the ambient temperature variable in each community.

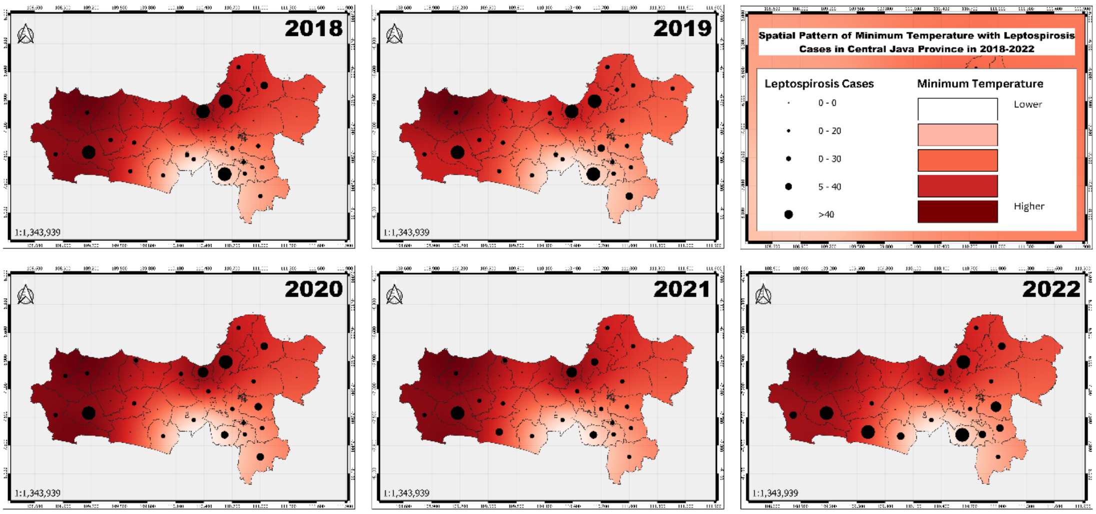
The resulting color gradations and dot symbols do not indicate any ratios but only report ordinal values, including the high-low variation of ambient temperature and the number of leptospirosis cases. These color gradations range from dark red to white, indicating high to low ambient temperature variations. Furthermore, the colors were digitally created using a single pseudocolor with ramp reds from the Quantum Geographic Information System (QGIS) software with a natural grouping of five classes, where very dark red = very high, dark red = high, red = medium, pink = and white = very low. Point symbols (centroids) vary from large to small, representing the spread of cases. Similarly, the size of the dot symbols was digitally generated using simple markers or standard symbols from QGIS software with a linear classification between 1 and 20. The spatially analyzed data was further processed by overlaying graphs and thematic maps to show patterns of relationships based on time and location.

RESULTS

Spatial Pattern of Minimum Temperature with Leptospirosis Cases

The spatial pattern of minimum temperature in Central Java Province each year shows a consistent pattern. In Figure 1, it can be seen that during 2018-2022 high minimum temperatures dominate most districts/cities in Central Java Province, namely in the western, northern and northeastern regions, moderate minimum temperatures occur in the southeastern region, while low minimum temperatures occur in a small part of the southern districts/cities of Central Java Province.

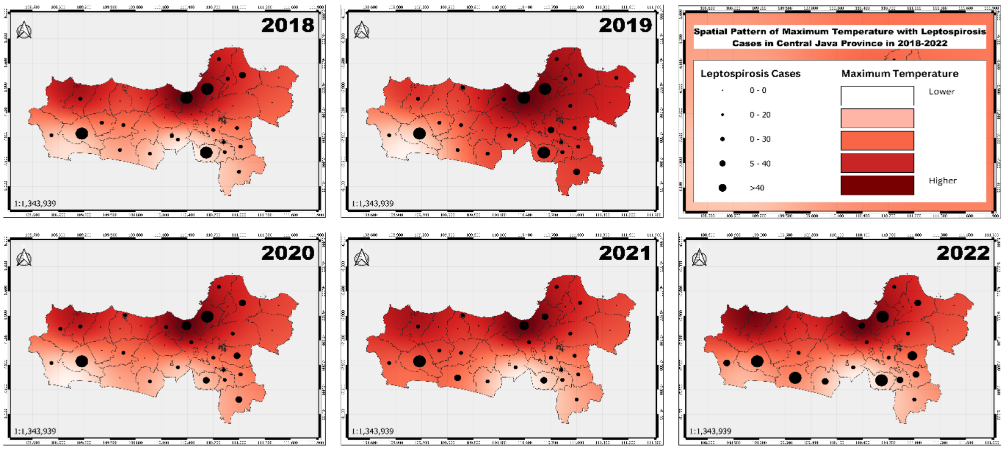
In the spatial map overlaying minimum temperature with leptospirosis cases in 2018-2022 (Figure 1), it can be seen that districts/cities with high minimum temperatures tend to have higher cases than districts/cities with low minimum temperatures. Districts/cities with high minimum temperatures show a high number of cases, such as Banyumas (56, 157, 63, 48, and 73 cases), Demak (92, 76, 107, 28, and 42 cases), and Semarang city (56, 45, 38, 34, and 30 cases).



Spatial Pattern of Maximum Temperature with Leptospirosis Cases

The spatial pattern of maximum temperature in Central Java Province each year shows a fairly consistent pattern. In Figure 2, it can be seen that during 2018-2022 high maximum temperatures dominate in most districts/cities in Central Java Province, namely in the northern, eastern and northwestern regions, moderate minimum temperatures occur in a small part of the southwestern, southeastern and southern regions, while low maximum temperatures occur in a small part of the southern and southwestern districts/cities of Central Java Province.

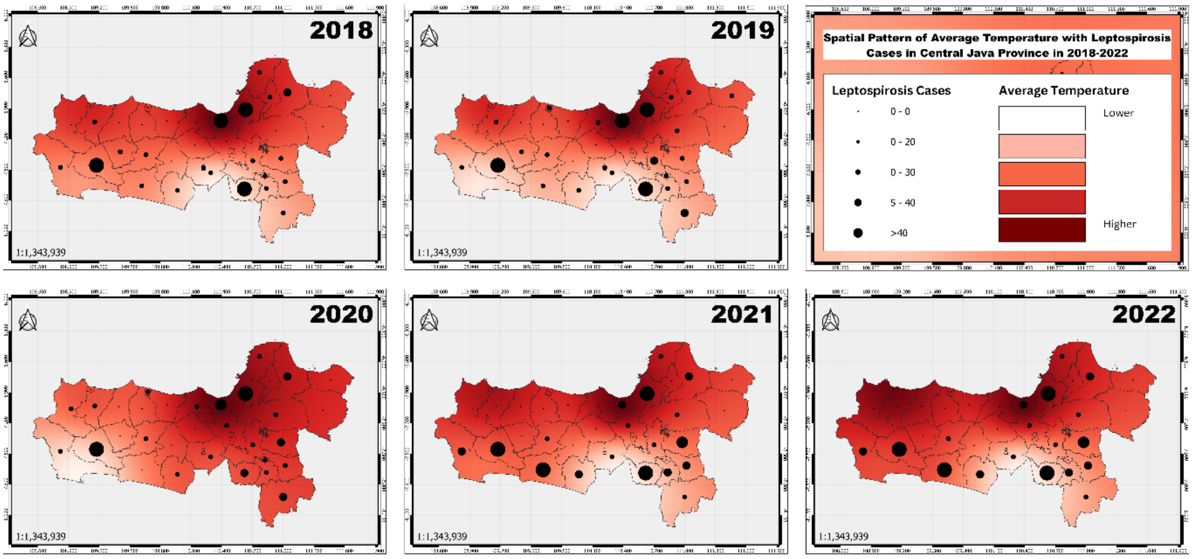
In the spatial map overlaying maximum temperature with leptospirosis cases in 2018-2022 (Figure 2), it can be seen that districts/cities with high and medium maximum temperatures tend to have higher cases than districts/cities with low maximum temperatures. Districts/cities with high and medium maximum temperatures show a high number of cases such as Banyumas (56, 157, 63, 48, and 73 cases), Demak (92, 76, 107, 28, and 42 cases), and Semarang city (56, 45, 38, 34, and 30 cases).



Spatial Pattern of Average Temperature with Leptospirosis Cases

The spatial pattern of average temperature in Central Java Province each year shows a fairly consistent pattern. In Figure 3, it can be seen that during 2018-2022 high and medium average temperatures dominate most districts/cities in Central Java Province, namely in the northern, eastern, and western regions, while low average temperatures occur in a small number of districts/cities in the southern and southwestern parts of Central Java Province.

In the spatial map overlaying average temperature with leptospirosis cases in 2018-2022 (Figure 3), it can be seen that districts/cities with high and medium average temperatures tend to have higher cases than districts/cities with low average temperatures. Districts/cities with high and medium average temperatures showed high numbers of cases, such as Banyumas (56, 157, 63, 48, and 73 cases), Demak (92, 76, 107, 28, and 42 cases), and Semarang city (56, 45, 38, 34, and 30 cases).



DISCUSSION

This study examines the relationship between ambient temperature and leptospirosis in Central Java from a spatial perspective. Regions with high and medium minimum temperature, maximum temperature, and average temperature tend to have higher cases than districts/cities with low minimum temperature. Regions with high and medium minimum temperature, maximum temperature, and average temperature such as Banyumas, Demak, and Semarang city showed a high number of cases. This finding is in line with a study conducted by Tunissea (2009) in Semarang which found the higher the air temperature, the higher the incidence of Leptospirosis. High incidence of leptospirosis is more common in areas with higher temperatures with air temperatures between 28-30ºC compared to areas with lower air temperatures (Tunissea, 2009). This is reinforced by the findings of Antima and Banerjee (2023) who stated that warm air temperature (between 28 to 30ºC) is an optimal environmental factor for the growth of Leptospira bacteria (Antima & Banerjee, 2023).

The characteristics of Central Java province with an average air temperature of 18 to 34°C make it an ideal location for Leptospira development (Antima & Banerjee, 2023; Central Java Provincial Government, 2024). The mechanism is supported by other abiotic factors such as air humidity, rainfall, solar radiation, water and soil pH, and exacerbated by flooding events (Chadsuthi et al., 2022; Cucchi et al., 2019; Nugroho et al., 2017). The resistance of leptospira microorganisms increases with air stickiness in wet or humid conditions with air humidity levels above 31.4 percent (Sumanta et al., 2015). This condition causes the spread of leptospira cases to increase, especially in areas with warm ambient temperatures in Central Java.

The mechanism of transmission to humans occurs through direct contact with urine or reproductive fluids of infected animals, contaminated water or soil, and wounds to the skin and mucous membranes (Schafer et al., 2023). Warm temperatures in sunny weather without rain increase human activity outdoors, thus increasing the risk of human contact with the causative agent of leptospirosis. Further investigation of the relationship between human activity and transmission needs to be conducted in the future.

CONCLUSION

This study showed that areas with high and medium minimum temperature, maximum temperature, and average temperature such as Banyumas, Demak, and Semarang city, tended to have higher cases than areas with low minimum temperature. These findings have important implications for public health policy, such as the development of spatial-based monitoring systems to detect areas with high risk of leptospirosis, especially areas with warm ambient temperature levels.

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CONFLICTS OF INTEREST

All author state that there is no conflict of interest.

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