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Original Article

The Relationship Between Climate Factors and Leptospirosis Incidence in Central Java in 2019-2023

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Abstract

Each year, more than 500,000 cases of Leptospirosis are reported worldwide. This disease is spread globally, especially in humid tropical countries like Indonesia. Based on the 2023 Indonesian Health Profile, there were 2,554 cases with a CFR of 8%, and Central Java ranked second (884 cases). This study aims to determine the relationship between climate factors and the incidence of Leptospirosis in Central Java in 2019–2023. The study used a quantitative approach with an ecological study design. The sample includes data on Leptospirosis incidence, air temperature, humidity, rainfall, and sunshine duration for 60 months. This study utilized secondary data sourced from the Central Java Provincial Health Office, accessed through the Central Java PPID website, for Leptospirosis case data and the BMKG website for Climate data. Data processing was carried out using the Spearman rho correlation test method. The results are the relationship between air temperature and leptospirosis incidence ($p=0.053$; $r=-0.251$), the relationship between humidity and leptospirosis incidence ($p=0.000$; $r=0.546$), the relationship between rainfall and leptospirosis incidence ($p=0.022$; $r=0.295$), and the relationship between the duration of sunlight and leptospirosis incidence ($p=0.002$; $r=-0.383$). It was concluded that humidity, rainfall, and duration of sunlight were significantly related to leptospirosis incidence, while temperature was not. It is recommended that the government strengthen vector control, especially during the rainy season, that the community maintain personal and environmental hygiene, and that further research use a wider time and area coverage with more complex methods.

Keywords: climate; leptospirosis; rats

Introduction

Leptospirosis is defined as a zoonotic disease that has spread widely throughout the world and has become a public health issue with a major impact, especially in developing countries with tropical climates (Caballero Méndez et al., 2024). Leptospira sp. is a pathogen that causes leptospirosis and lives in the kidney tubules of mammals such as rats, livestock, and pets, and can survive in water and soil environments for weeks to months (Douchet et al., 2022).

According to the International Leptospirosis Society, the number of leptospirosis cases worldwide reaches more than 500,000 each year. The disease is distributed globally, but is most commonly found in endemic areas, particularly humid tropical countries. Leptospirosis outbreaks often occur after heavy rains or floods. Indonesia is considered a leptospirosis-endemic country (WHO/PAHO, 2021).

The global impact of leptospirosis is significant, reflected in the high mortality rates in several countries. Sri Lanka records over 700 deaths per year from leptospirosis, twice the rate of dengue fever. The incidence of hospitalizations has reached 52.1 patients per 100,000 population (Sykes, Haake, Gamage, Mills, & Nally, 2022). This confirms that leptospirosis is a serious threat to global public health. The high mortality rate and hospitalization burden demonstrate the need for a more comprehensive approach to its management, including improved early diagnosis and prevention efforts.

The situation in Indonesia is also showing a worrying trend. The International Leptospirosis Society states that Indonesia has a high leptospirosis mortality rate, ranging from 2.5% to 16.45%, with an average of 7.1%, ranking it third highest in the world. This disease is endemic but receives little attention, making it a serious public health issue (Setiawan, Setiyadi, & Murti, 2024).

Based on the 2023 Indonesian Health Profile, 2,554 cases of leptospirosis were recorded, with a case fatality rate (CFR) of 8%. In Central Java Province, the number of leptospirosis cases increased significantly, from 265 in 2021 to 502 in 2022 and continued to rise to 884 in 2023. This increase makes Central Java the province with the second-highest number of cases after East Java (Kementrian Kesehatan, 2024) .

Geographically, Indonesia is located along the equator (95°–141° E and 6° N–11° S), making it a tropical climate country characterized by high temperatures and high humidity throughout the year (Iswanto, 2018). This location greatly influences the climate type and is an important environmental factor in the spread of leptospirosis.

Rainfall is one of the main determinants in the survival and spread of Leptospira bacteria, which ultimately increases the risk of infection among vulnerable populations (Chiani et al., 2023). A thorough understanding of the relationship between environmental factors and leptospirosis incidence is key to disease control strategies. Furthermore, climate change is expected to exacerbate these conditions by increasing rainfall intensity and the frequency of extreme weather events, expanding the distribution of areas at risk for leptospirosis (Rohmah, Aryanto, Wiratama, & Ibrahim, 2024). Flooding due to prolonged rain can accelerate the spread of bacteria through soil contamination by rodent urine and other vectors (Rohmah et al., 2024)

Leptospirosis is spread through various routes, including direct contact with skin wounds, consumption of contaminated food or drink, and contact with contaminated water. Indonesia's tropical environment provides ideal conditions for the bacteria to survive: warm temperatures, neutral pH, high humidity, and abundant rainfall (Ariani & Wahyono, 2021). Rainy seasons accompanied by flooding often trigger a surge in leptospirosis cases. Difficulty diagnosing also leads to many cases going unreported, resulting in the disease being classified as a Neglected Infectious Disease (NTD) (Haryono, Manyullei, & Amqam, 2020).

Therefore, understanding the relationship between climate factors such as air temperature, humidity, rainfall, and sunshine duration and leptospirosis incidence is crucial. Analysis of climate data and disease incidence can be used to develop more effective early warning systems and prevention strategies.

This study was conducted to examine the relationship between climate factors and leptospirosis incidence in Central Java Province during the period 2019–2023. This period was selected based on the availability of climate and health data long enough to observe significant patterns and trends.

Method

This research employs an ecological study with a quantitative approach. The unit of analysis is monthly aggregate data, with the population encompassing all leptospirosis and climate events recorded during that period. The dependent variable in this study is the number of leptospirosis cases per month, while the independent variables consist of average air temperature, air humidity, rainfall, and sunshine duration. All data are summarized in the form of monthly time series for five years (2019–2023). The data sources used are secondary data obtained from two institutions: the Central Java Provincial Health Office (for leptospirosis case data) and the BMKG (for climate data).

The data analysis process was carried out in two stages, with the initial stage being a descriptive analysis to obtain an overview of leptospirosis cases and climate elements (temperature, humidity, rainfall, sunshine duration). The second stage is a Spearman correlation analysis, which is used to assess the relationship between climate elements and leptospirosis cases. The Spearman test was chosen because the data is not normally distributed and is non-parametric.

Results

Univariate Analysis

1. Descriptive Analysis of Leptospirosis Incidence in Central Java Province

Table 1. Leptospirosis Incidence in Central Java 2019-2023

	Leptospirosis Incident				
	2019	**2020**	**2021**	**2022**	**2023**
January	39	69	19	40	119
February	81	60	40	37	87
March	60	83	55	50	274
April	94	49	44	80	146
May	52	37	13	32	96
June	30	45	10	78	50
July	23	32	2	41	30
August	16	12	3	18	18
September	20	9	7	12	17

October	19	4	13	19	13
November	18	14	33	38	16
December	6	8	26	58	18
Total	458	422	265	503	884

Source: Central Java Provincial Health Office

Based on Table 1, there were 458 cases of leptospirosis in 2019, with the highest incidence in April (94 cases) and the lowest in December (6 cases). In 2020, there were 422 cases, with the highest incidence in March (83 cases) and the lowest in October (4 cases). In 2021, there were 265 cases, with the highest incidence in March (55 cases) and the lowest in July (2 cases). In 2022, there were 503 cases, with the highest incidence in April (80 cases) and the lowest in September (12 cases). In 2023, there were 884 cases, with the highest incidence in March (274 cases) and the lowest in October (13 cases).

2. Descriptive analysis of average air temperature in Central Java Province

Table 2. Air Temperature in Central Java 2019-2023

	Air Temperature (^{0}C)				
	2019	**2020**	**2021**	**2022**	**2023**
January	27.72	28.09	27.09	27.63	27.52
February	27.83	27.71	26.89	27.29	26.99
March	27.6	28.14	27.74	27.81	27.87
April	28.53	28.52	28.23	28.21	27.75
May	28.57	28.88	28.71	28.56	28.18
June	27.43	28.19	28.03	26.67	27.73
July	26.96	27.99	27.21	27.72	27.41
August	27.04	28.06	28.12	28.00	27.51
September	27.66	28.18	28.30	28.41	28.23
October	28.94	28.44	28.68	27.56	28.94
November	29.40	28.52	27.83	27.78	28.81
December	28.70	27.50	27.45	26.93	28.69
Avarage	28.03	28.19	27.86	27.71	27.97

Source: BMKG

Based on table 2. The average air temperature in 2019 was 28.03°C with the highest temperature in November (29.40°C) and the lowest in July (26.96°C). In 2020, the average temperature was 28.19°C with the highest temperature in May (28.52°C) and the lowest in December (27.50°C).

In 2021, the average temperature was 27.86°C with the highest temperature in May (28.71°C) and the lowest in January (27.09°C). In 2022, the average temperature was 27.71°C with the highest temperature in May (28.56°C) and the lowest in June (26.67°C). In 2023 the average temperature was 27.970C with the highest temperature in October (28.940C) and the lowest in February (26.990C).

3. Descriptive analysis of humidity in Central Java Province

Table 3. Humidity in Central Java 2019-2023

	Humidity (%)				
	2019	**2020**	**2021**	**2022**	**2023**
January	83.15	82.76	85.06	82.12	83.15
February	82.36	83.98	86.52	83.51	85.02
March	83.66	83.56	83.3	83.17	81.27
April	80.54	81.23	79.43	80.15	81.02
May	76.52	79.62	78.09	80.17	75.87
June	73.26	77.94	80.02	79.28	77.79
July	71.43	75.88	74.93	76.61	74.22
August	69.32	74.52	74.79	74.63	71.48
September	69.13	73.07	75.03	75.56	67.74
October	70.01	77.09	75.91	80.85	70.74
November	72.54	79.12	82.8	81.76	76.18
December	79.46	83.41	81.63	82.16	75.41
Avarage	75.95	79.35	79.79	80.00	76.66

Source: BMKG

Based on table 3. Air humidity in 2019 averaged 75.95% with the highest humidity in March (83.66%) and the lowest in September (69.13%). In 2020 the average humidity was 79.35% with the highest humidity in February (83.98%) and the lowest in September (73.07%). In 2021 the average humidity is 79.79% with the highest humidity in February (86.52%) and the lowest in August (74.79%). In 2022 the average humidity will be 79.99866% with the highest humidity in February (83.51%) with the lowest humidity in August (74.63%). In 2023 the average humidity will be 76.66% with the highest humidity in February (85.02%) and the lowest in September (67.74%).

4. Descriptive analysis of rainfall in Central Java Province

Table 4. Rainfall in Central Java 2019-2023

Rainfall (mm)					
	2019	**2020**	**2021**	**2022**	**2023**
January	15.27	14.91	12.51	11.47	9.75
February	12.54	16.35	23.74	10.24	11.46
March	11.9	12.96	9.06	10.51	9.14
April	9.7	9.49	7.46	9.27	7.31
May	4.24	10.18	5.74	6.81	6.18
June	0.25	3.56	8.82	8.91	4.5
July	0.37	5.35	2.28	6.48	5.07
August	0.13	1.95	4.14	3.72	0.67
September	0.45	4.91	7.13	11.67	0.26
October	0.86	11.42	5.41	11.5	1.07
November	3.98	14.21	13.88	14.68	9.14
December	12.56	16.58	10.35	12.03	8.13
Avarage	6.02	10.15	9.21	9.77	6.06

Source: BMKG

Based on table 4. Rainfall in 2019 averaged 6.02 mm with the highest rainfall in January (15.28 mm) and the lowest in August (0.13 mm). In 2020, the average rainfall was 10.15 mm with the highest rainfall in December (16.58 mm) and the lowest in August (1.95 mm). In 2021, the average rainfall was 9.21 mm with the highest rainfall in February (23.74 mm) and the lowest in July (2.29 mm). In 2022, the average rainfall was 9.77 mm with the highest rainfall in October (14.68 mm) and the lowest rainfall in August (3.72 mm). In 2023, the average rainfall was 6.06 mm with the highest rainfall in February (11.46 mm) and the lowest in September (0.259 mm).

5. Descriptive Analysis of Sunshine Duration in Central Java Province

Table 5. Sunshine Duration in Central Java, 2019-2023

Sunshine Duration (Hour/Day)					
	2019	**2020**	**2021**	**2022**	**2023**
January	4.57	4.92	2.99	4.88	4.22
February	6.00	4.48	3.50	3.73	3.22
March	4.41	5.40	5.73	5.13	6.12
April	6.67	5.88	6.83	6.57	6.28
May	7.81	6.33	6.88	6.14	7.32

June	7.71	7.17	6.18	5.48	7.22
July	8.25	7.08	7.84	6.8	7.53
August	8.32	7.70	7.60	7.34	8.34
September	8.48	7.9	6.91	6.98	8.92
October	8.69	5.9	6.59	4.21	8.62
November	7.47	5.72	3.84	4.32	6.41
December	6.02	3.93	5.57	4.11	6.44
Avarage	7.03	6.03	5.87	5.48	6.72

Source: BMKG

Based on table 5. The average sunshine duration in 2019 was 7.03 hours/day with the highest sunshine duration in October (8.69 hours/day) and the lowest in March (4.41 hours/day). In 2020, the average sunshine duration was 6.03 hours/day with the highest sunshine duration in September (7.90 hours/day) and the lowest in December (3.93 hours/day). In 2021, the average sunshine duration was 5.87 hours/day with the highest sunshine duration in July (7.84 hours/day) and the lowest in January (2.99 hours/day). In 2022, the average sunshine duration was 5.48 hours/day with the highest sunshine duration in August (7.34 hours/day) and the lowest sunshine duration in February (3.73 hours/day). In 2023, the average duration of sunshine was 6.72 hours/day with the highest duration of sunshine in September (8.92 hours/day) and the lowest in February (3.22 hours/day).

Bivariate Analysis

1. Correlation Analysis of Average Air Temperature and Leptospirosis Incidence in Central Java Province

Table 6. Relationship Between Air Temperature and Leptospirosis Incidence

Based on Table 6, the results of the correlation analysis show no significant relationship between temperature and leptospirosis incidence (P-value >0.05). This result indicates no statistically significant relationship because the P-value is greater than 0.05. This finding indicates that temperature fluctuations do not directly affect the increase or decrease in the number of leptospirosis cases in Central Java Province from 2019 to 2023.

2. Correlation Analysis of Humidity and Leptospirosis Incidence in Central Java Province

Table 7. Relationship between Humidity and Leptospirosis Incidence

	Leptospirosis Incidence (Y)		
Variable	n	r	P-value
Humidity (X2)	60	0.546	0.000

Based on table 7, the results of the correlation analysis show a significant relationship between humidity variables and Leptospirosis incidents (P-value <0.05) with a moderate relationship strength (0.4-0.6) and a positive relationship direction, meaning that the higher the humidity, the more Leptospirosis cases will increase and vice versa.

3. Correlation Analysis of Rainfall and Leptospirosis Incidence in Central Java Province

Table 8. Relationship between Rainfall and Leptospirosis Incidence

	Leptospirosis Incidence (Y)		
Variable	n	R	P-value
Rainfall (X3)	60	0.295	0.022

Berdasarkan tabel 8 hasil analisis korelasi terdapat hubungan yang signifikan antara variabel curah hujan dengan kejadian Leptospirosis (P-value<0,05) dengan kekuatan hubungan lemah (0.2- 0.4) dan arah hubungan positif yang artinya semakin tinggi curah hujan maka kasus Leptospirosis akan semakin meningkat dan sebaliknya.

4. Correlation Analysis of Sunlight Duration and Leptospirosis Incidence in Central Java Province

Table 9. Relationship between Sunlight Duration and Leptospirosis Incidence

	Leptospirosis Incidence (Y)		
Variable	n	R	P-value

Sunlight Duration (X4)	60	-0,383	0,002

Based on Table 9, the results of the correlation analysis show a significant relationship between the variable of sunshine duration and leptospirosis incidence (P-value <0.05), with a weak correlation strength (0.2-0.4) and a negative correlation direction, meaning that less sunshine leads to an increase in leptospirosis cases, and vice versa.

Discussion

Relationship between Temperature and Leptospirosis Incidence

This study found no significant relationship between air temperature and leptospirosis incidence (P-value = 0.053, r = -0.251). This result is consistent with a previous study conducted by Husni & Raharjo (2023) yang menunjukkan bahwa tidak terdapat hubungan antara suhu dan kejadian leptospirosis. Penelitian Husni di Semarang menemukan bahwa suhu memiliki nilai p value 0,098 dengan arah hubungan negatif. Temuan ini juga sejalan dengan Syakbanah dkk (2020), that there was no significant relationship between average air temperature and the incidence of Leptospirosis in Bantul in 2010-2018 (p-value = 0.117)(Syakbanah et al., 2020).

Temperature affects the survival of microorganisms, including Leptospira sp., with an optimal air temperature of 28°C-30°C (Musbir, 2021), However, Leptospira can survive across a wide temperature range, particularly in tropical regions like Indonesia, where temperatures tend to be stable throughout the year. Therefore, there are no significant temperature differences to affect the dynamics of this bacteria in the environment. One reason temperature doesn't play a significant role is because the transmission mechanism of leptospirosis relies more on stagnant, moist environments, which are ideal habitats for Leptospira bacteria (Husni & Raharjo, 2023).

The Relationship Between Humidity and Leptospirosis Incidence

This study found a significant relationship between air humidity and leptospirosis incidence (P-value = 0.000 and r = 0.546). These findings are consistent with a previous study by Syakbanah et al. (2020), which found a significant relationship between average air humidity and leptospirosis incidence in Bantul Regency from 2010 to 2018 (p-value = 0.002), with a weak relationship (r = 0.292) and a positive relationship (Syakbanah et al., 2020). This finding is also supported by research by Sekarsari, Azizah, & Mulyani, (2020) There was a significant relationship between average air humidity and leptospirosis incidence in Jakarta from 2007 to 2011 (p-value = 0.000), with a weak relationship (r = 0.244) and a positive direction.

High humidity conditions can create a more favourable environment for the survival of Leptospira bacteria and increase the likelihood of human contact with contaminated water or soil, thus increasing the risk of disease transmission. (Ramadhan, Devi, Mahrani Ismail, Mulyani, & Tosepu, 2020). Air humidity is one of the environmental factors that plays a role in the life cycle of Leptospira sp. bacteria and the survival of the primary vector, rats. These bacteria can survive for long periods in environments with humidity levels above 60% (Musbir, 2021).

The Relationship Between Rainfall and Leptospirosis Incidence

This study found a significant relationship between rainfall and leptospirosis incidence (P-value = 0.022 and r = 0.295). These results align with previous findings by Safera, Kusnanto, & Ramadona (2022) which showed a significant relationship between rainfall and leptospirosis incidence in Semarang City from 2012 to 2021. The analysis methods employed were the Spearman correlation test and the Generalised Additive Model (GAM), yielding an RMSE of 4.45%. These results indicate that rainfall can be a predictor of future leptospirosis cases.

Furthermore, research by Hutapea et al. (2024) also supports the findings of this study. The study showed a significant relationship between rainfall and leptospirosis incidence (p-value = 0.000). This study used data from 2018 to 2023 and analyzed weather factors, namely temperature, humidity, and rainfall, on the incidence of leptospirosis in Semarang City.

Rainfall will influence the spread of leptospira bacteria. The first mechanism explains that increased rainfall creates favorable environmental conditions for rats to breed, resulting in an increase in their population. This increase in rat numbers also increases the potential for leptospirosis. The second mechanism suggests that high rainfall can cause flooding, which drives rats out of their nests and into residential areas and homes.

This condition increases the chance of leptospirosis transmission to humans. The third mechanism explains that changes in rainfall patterns can increase the risk of humans coming into contact with water contaminated with Leptospira sp. Rainwater contaminated by rat urine can flow into drains or rivers, then overflow and form puddles in public areas such as streets, increasing the potential for exposure. (Ramadhan et al., 2020).

The Relationship Between Sunlight Duration and Leptospirosis Incidence

This study found a significant relationship between sunlight duration and leptospirosis incidence (P-value = 0.002 and r = -0.383). These results align with previous findings by Husni & Raharjo (2023) This study showed a relationship between lighting and rat density in residential areas around Semarang City Market (p-value 0.049). Although the study did not directly examine sunlight in the area, it does support the presence of leptospirosis vectors influenced by lighting.

Sunlight plays a role in inhibiting environmental humidity, which is an ideal breeding ground for Leptospira bacteria and their hosts. Therefore, low sunlight intensity can increase the risk of spreading the disease (Anies, 2015). Leptospirosis is an infectious disease caused by the bacteria Leptospira sp., which is transmitted through the urine of contaminated animals, especially rodents.

The transmission of this disease is greatly influenced by damp and dirty environments, where the bacteria can multiply. One factor that can influence the spread of this disease is the duration of sunlight. Adequate sunlight can help kill germs and reduce environmental humidity, as well as reduce the number of vectors, which can reduce the risk of leptospirosis transmission (Anies, 2015).

Conclusion

Based on the research results, the conclusions are Leptospirosis cases in Central Java Province increased annually from 2019 to 2023, except for a decrease in cases in 2020. There was a significant relationship between humidity, rainfall and sunlight exposure with leptospirosis incidence in Central Java Province from 2019 to 2023, with a moderate relationship and a positive direction. Over there, there was no significant relationship between temperature and leptospirosis incidence in Central Java Province from 2019 to 2023.

The government is recommended to strengthen vector control, especially during the rainy season, and for the public to maintain personal and environmental hygiene. Further research can cover a wider timeframe and area with more complex methods.

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