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Article review

Impact of the Rainy Season to the Incidence of Leptospirosis : A Literature Review

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Abstract

Leptospirosis is a zoonotic disease with high morbidity and mortality, particularly in tropical regions. Rainfall and floods are key drivers of transmission. Eligible studies include observational and review articles addressing rainfall or floods in relation to leptospirosis. Data was synthesized narratively and thematically. This study reviews the relationship between the rainy season and leptospirosis incidence to inform effective prevention strategies. A systematic search was performed in PubMed, Scopus, Web of Science, and Google Scholar for articles published between 2019–2025. The PRISMA framework guided study selection. Eligible studies included observational and review articles addressing rainfall or flood in relation to leptospirosis. Data were synthesized narratively and thematically. Findings consistently show that rainy seasons increase leptospirosis cases through prolonged *Leptospira* survival in moist environments and heightened human exposure to contaminated water. Populations at greatest risk include agricultural workers, fishermen, and residents of flood-prone areas with poor sanitation. Studies emphasized that rainfall patterns correlate with outbreak peaks, often overwhelming local health systems. The rainy season significantly elevates leptospirosis incidence in endemic regions. Comprehensive interventions combining environmental management, risk communication, and health system readiness are crucial to reduce disease burden and mortality.

INTRODUCTION

Leptospirosis, a leading zoonotic disease in terms of morbidity and mortality in humans, is a bacterial infection caused by Leptospira that most commonly occurs in tropical regions.[1] According to the International Leptospirosis Society (ILS), Indonesia is a country with a high incidence of leptospirosis and ranks third in the world for mortality rates.[2] Leptospirosis is caused by Leptospira bacteria that can infect humans and animals. Leptospirosis cases are usually associated with conditions such as flooding, tidal flooding in coastal areas, swamps, or peatlands.[3] The incubation period for leptospirosis is 2 to 30 days, but symptoms usually begin within 5 to 14 days after exposure.[4] Most victims are asymptomatic or have mild flu-like

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symptoms with fever, headache, myalgia, conjunctivitis, abdominal pain, vomiting, diarrhea, cough, skin rash, and jaundice. In severe cases, kidney and liver failure, pulmonary hemorrhage, aseptic meningitis, cardiac arrhythmia, pulmonary insufficiency, and hemodynamic disorder.[5]

Humans and animals can become infected with this bacterium through contact between the skin or mucous membranes and water or soil containing the urine of animals infected with this bacterium. Leptospira bacteria enter the human body through wounds on the skin, mucous membranes (nose, mouth, and eyes), or even through drinking water. Once inside the human body, these bacteria enter the bloodstream and attack tissues and organs. The disease carrier or infectious microorganism of leptospirosis is a spiral-shaped bacterium belonging to the Leptospira genus. Transmission of leptospira to humans occurs through contact with urine, blood, or organs from infected animals, as well as contact with environments (soil, water) contaminated with leptospira. The ideal climate for leptospira development is warm air 25°C, moist/humid soil, and soil pH of 6.2-8.[6]. People at risk include those who frequently come into contact with animals or water, mud, soil, and plants contaminated with the urine of animals infected with leptospirosis.[7] Some high-risk occupations include rice farmers, slaughterhouse workers, livestock farmers, miners, fisheries workers, and sugarcane and banana farmers[8]. Certain hobbies that involve contact with contaminated water or soil can also transmit Leptospirosis, such as camping, gardening, hiking in the forest, rafting on rapids, and other water sports.[9]

Leptospirosis transmission occurs due to poor environmental conditions in residential areas. Poor environments can increase the availability of food, shelter, nesting, and breeding grounds for rats, which are reservoirs of Leptospirosis.[10] In addition, poor environmental conditions can cause flooding, which can increase the risk of Leptospirosis[11]. In this situation, people living in densely populated areas with poor sanitation are more vulnerable to exposure, as their daily activities often involve direct contact with contaminated water.[12] This relationship shows that climate and environmental factors interact closely in shaping the epidemiology of leptospirosis.

Several recent studies support this association. DS et al. (2025) confirm that community behaviors involving direct contact with contaminated water or soil, especially without protective equipment, increase the risk of exposure[1]. Janah et al. (2021) show that leptospirosis cases form clusters in areas with high density and proximity to rivers, even during low rainfall[12]. Research by Safera, Kusnanto, Ramadona, and Lestari (2022) shows a temporal relationship between climate factors and leptospirosis cases, particularly temperature, humidity, and rainfall with a certain time lag.[10] Meanwhile, studies by Ramadhan et al. (2020) and Nugroho, Adi, and Nurjazuli (2023) confirm that climate factors (temperature, humidity, rainfall) and abiotic factors (water and soil pH) are the main predictors of leptospirosis transmission, with global climate change potentially expanding its distribution.[9,6]

The increase in leptospirosis cases not only affects individual health but also triggers widespread public health problems. Hospitals and health facilities in endemic areas are often overwhelmed by the surge in patients during the rainy season, while limited medical resources can worsen the fatality rate.[13] Socioeconomic impacts are also unavoidable, as many patients come from the productive age group who lose workdays, and the high costs borne by families and the government for patient care.[14]

This situation underscores the importance of more in-depth research on the impact of the rainy season on the increase in

leptospirosis cases. Evidence-based understanding enables the formulation of more effective mitigation strategies, whether in the form of public education, strengthening environmental sanitation systems, or preparing health facilities before the rainy season arrives. A systematic literature review on this topic is expected to provide a comprehensive overview of risk factors, patterns of spread, and the most relevant interventions to be implemented.

METHODS

The literature search was conducted through several major electronic databases, including PubMed, Scopus, Web of Science, and Google Scholar, covering publications from the last five years (2019–2025). The keywords used in the search included a combination of the terms "leptospirosis," "rainy season," "flood," "precipitation," and "incidence," with adjustments to Boolean operators ("AND," "OR") to broaden or narrow the results. The search was also supplemented with *manual searching* of the bibliographies of relevant articles to ensure that no important literature was overlooked.

Literature selection was conducted in stages using the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) approach. The first stage involved screening titles and abstracts to identify relevance to the topic. Articles that were not related to the rainy season or leptospirosis, or that were not available in full text, were immediately eliminated. In the second stage, the remaining articles were reviewed in full to assess their suitability for inclusion criteria, namely: (1) observational, analytical, or review studies highlighting the relationship between the rainy season or climatic factors and the incidence of leptospirosis; (2) publication period between 2019 and 2025; (3) available in English or Indonesian. The exclusion criteria included duplicate articles, single case reports, editorials, opinions, and publications that did not undergo peer review. Articles that met the criteria were then included in the analysis stage. The overall selection process will be presented in a PRISMA flow chart to show the number of articles at each screening stage. This chart contains information on the number of literature obtained from the initial search, the number eliminated at the screening stage, and the final number of studies analyzed.

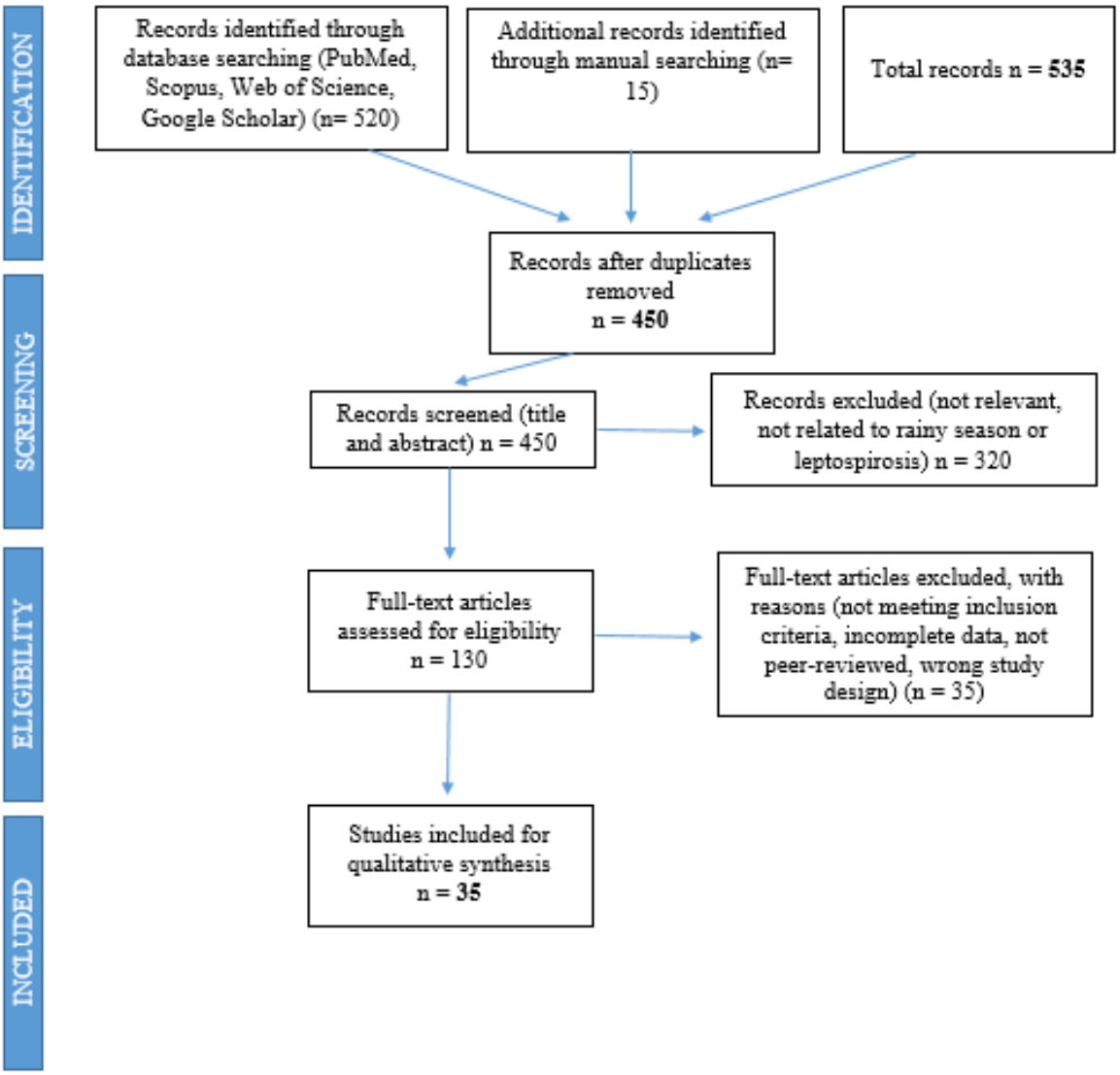


Figure 1. PRISMA Flow Diagram

The analysis method was conducted through *narrative synthesis* with a thematic approach. Each article was reviewed to extract key information, including the location of the study, study design, sample size, climate variables observed, and key findings related to the relationship between the rainy season and leptospirosis. The findings were then compared, grouped, and analyzed to identify patterns of similarity, differences, and gaps in knowledge between studies. This analysis aimed to produce a comprehensive picture of the effect of the rainy season on the increase in leptospirosis cases and to provide a basis for public health policy recommendations.

RESULTS

The results of the literature review show that the rainy season has a significant effect on the increase in leptospirosis cases in various regions. Increased rainfall triggers the formation of puddles and higher soil moisture, creating an ideal environment for *Leptospira* bacteria to survive and spread. Several studies confirm that the spike in leptospirosis cases generally occurs a certain amount of time after the peak of the rainy season, in line with increased community contact with contaminated environments. To illustrate these findings in more detail, the results of relevant previous studies are presented in the following table.

Table 1. Summary of Literature Review Findings

Author and Year	Title	Method	Research Findings
Gita Shanida Putri DS, Hariati Lestari, Listy Handayani (2025) [1]	Overview of Environmental Factors and Behavioral Incidence Of Leptospirosis in The Working Area of Blud UPTD Puskesmas Benu-Benua in 2022-2024	Cross-sectional methodology and quantitative descriptive techniques	Based on the results of the investigation conducted in the work area of BLUD UPTD Puskesmas Benu-Benua in 2022-2024, it can be concluded that environmental and behavioral factors play an important role in leptospirosis incidence. Respondents aged
Miftakhul Janah, Dwi Sarwani Sri Rejeki, Sri Nurlaela (2021) [12]	Analysis of Environmental Conditions in Leptospirosis Incidence in Banyumas District Using a Spatial Approach	Observational study with a cross-sectional spatial analysis design	Spatial analysis results show that 77.14% of patients reside in residential areas, 70% in areas with moderate population density (5.00-1,249 people/km^2), 62.85% at elevations of 0–199 meters above sea level, 63.57% in areas with low rainfall of 500 millimeters, and a statistically significant cluster pattern was identified with a p-value of 0.009. The primary clusters were located in Cilongok and Ajibarang. Leptospirosis tends to spread in residential land use, moderate population density, low altitude, low rainfall, no flooding, within a 500-meter radius of rivers, and clusters occur in Cilongok and Ajibarang. The location of leptospirosis prevention and control interventions can be prioritized in these areas.
Karina Mutia Safera, Hari Kusnanto, Aditya L. Ramadona, Wiwik Dwi Lestari (2022) [10]	Temporal and Spatial Analysis of Weather Factors with Leptospirosis Cases in Semarang City from 2012 to 2021	Quantitative research with a time-based ecological study design	Statistical analysis shows that 1-month lag temperature, 1-month lag humidity, 2-month lag rainfall, and 1-month lag flooding are associated with leptospirosis cases in Semarang City.
Sunardi, Yudied Agung Mirasa, Moh Alimansur (2023) [16]	Environmental Determinants Of Leptospirosis Incidence In Klaten District	Quantitative research with a case control study	Journal findings stagnan water in the home environtment has a risk of developing leptospirosis disease.
Salsabila, Moh Hafiyusholeh, Hani Khaulasari, Dian Candra R.N, Yubiarti D.N (2024) [17]	Implementation Of K-Means Clustering In Mapping Leptospirosis Prone Areas In East Java	Quantitative research using the K-Means Clustering	K-Means Clustering divides the vulnerability level of leptospirosis in East Java into five regional cluster, divided into a very safe cluster (C1) of 4 district/cities, a safe cluster (C2) of 7 districts/cities, a fairy safe cluster (C3) of 13 districts/cities, a vulnerable cluster (C5) of 3 districts/cities and very vulnerable cluster (C4) of 11 districts/cities with a Silhoutte coefficient accuracy value of 0.65 in the good category

The findings from the articles in Table 1 were then reviewed to assess the quality and relevance of each piece of literature found. The data obtained from the articles was then summarized and presented in a conclusion table. The analysis was made narrative and presented in Table 2.

Table 2. Conclusion Matrix

No	Main Findings	Similarity of results	Literature
1	Rainfall intensity	Existing research results show that leptospirosis cases occur in areas with low to moderate rainfall intensity	Sources 4 and 5
2	Temperature	Existing research results show that the abiotic factor of temperature supports the survival of Leptospira bacteria	Sources 2, 3, and 4
3	pH	Existing research results show that the abiotic factor pH supports the survival of Leptospira bacteria.	Sources 2, 3, and 4
4	Air humidity	Existing research results show that the abiotic factor of air humidity supports the survival of Leptospira bacteria	Sources 1, 2, and 3

DISCUSSION

Leptospirosis is a zoonotic disease whose transmission is complexly influenced by environmental, climatic, and human behavioral factors. Water and soil are important media for Leptospira bacteria to survive after being excreted through the urine of reservoir animals, especially rats. A study by Putri, Lestari, and Handayani

(2025) confirms that community behavior directly related to contaminated environments, such as activities in puddles or muddy soil without protection, increases the risk of infection. This research also shows that behavioral dimensions cannot be separated from environmental factors, as both interact in shaping exposure risk. This emphasizes the need for a preventive approach based on public health education, especially among productive age groups who are most often active outside the home.

The management of leptospirosis requires a multidisciplinary approach, including promotional, preventive, curative, and rehabilitative efforts. Prevention strategies can be implemented through rat population control, improved environmental sanitation, the use of personal protective equipment when working in high-risk areas, and public education on clean living and healthy. On the other hand, early diagnosis and appropriate antibiotic therapy are key to reducing morbidity and mortality from this disease.

Epidemiologically, leptospirosis shows an increasing pattern of cases closely related to climate change and natural disasters, requiring greater vigilance and a stronger surveillance system. Collaboration between the health sector, government, and community is essential in building resilience to the threat of leptospirosis. Thus, leptospirosis is not only a medical problem but also an environmental and social issue that requires the involvement of various parties. If prevention, environmental control, and clinical management are carried out in an integrated and sustainable manner, the negative impact of leptospirosis on public health can be minimized.[15]

Spatially, Janah, Rejeki, and Nurlaela (2021) found that leptospirosis cases were highly concentrated in densely populated areas with low elevation and proximity to rivers. The distribution of cases forming significant clusters in Cilongok and Ajibarang confirms that leptospirosis transmission does not occur randomly but follows specific environmental conditions that support rat reproduction and Leptospira survival. Low rainfall is actually a predictor of cases in these areas, contrary to the classical assumption that high rainfall always increases risk. This indicates that small puddles or stable soil moisture, even during low rainfall, can still maintain the survival of the bacteria.

Research by Safera, Kusnanto, Ramadona, and Lestari (2022) in Semarang City shows a close temporal relationship between climate factors and leptospirosis cases. Their analysis shows that temperature and humidity with a 1-month lag, as well as rainfall with a 2-month lag, have a significant relationship with an increase in cases. This indicates the existence of an environmental incubation period where suitable climatic conditions allow Leptospira to multiply before eventually triggering an increase in human cases. These findings are crucial for planning weather-based early warning systems, as interventions can be directed before the peak of cases occurs.

A case control study by Sunardi et al. (2023) in Klaten has several risk factors for leptospirosis. Risk factor number one is stagnant water in the home environtment, wich has a risk 7.667 times greater compared to respondents who do not have stagnant water in their home environtment. Poor gutter cleanliness has a risk of contracting leptospirosis 4.889 times greater and the presence of a rat population has a risk of contracting leptospirosis 5.537 times greater.

The findings of Nugroho, Adi, and Nurjazuli (2023) expand our understanding by showing that rainfall, temperature, humidity, and pH are the main predictors of leptospirosis transmission in Indonesia. This study emphasizes that global climate change, particularly the intensification of extreme rainfall and rising temperatures,

has the potential to expand the geographical distribution of leptospirosis. On the other hand, aspects of community behavior that do not maintain environmental hygiene are reinforcing factors. For example, puddles around homes due to poor drainage are often not managed properly, increasing community exposure to water contaminated with Leptospira.

From these five main studies, it can be concluded that leptospirosis is an environmentally-based disease whose transmission is influenced by multifactorial interactions: the presence of reservoirs (rats), physical environmental conditions (water, soil, climate), spatial factors (population density, proximity to rivers, land use), and community behavior. The variation in research results confirms that the pattern of leptospirosis spread is highly contextual, depending on local, temporal, and ecological conditions. Therefore, prevention strategies cannot be singular but must combine environmental control, climate monitoring, and public health education. The integration of spatial, climate, and behavioral data is crucial for developing sustainable, evidence-based control policies.

CONCLUSION

The results of the study show that the rainy season plays an important role in the increase in leptospirosis cases. Increased rainfall causes puddles to form, high soil moisture, and environmental conditions that support the survival of *Leptospira* bacteria. This factor is exacerbated by direct contact between the community and contaminated environments, whether through activities in flooded areas, waterways, or muddy soil. Several studies have found a lag time between peak rainfall and a spike in leptospirosis cases, indicating an environmental incubation period for the bacteria before it causes cases in humans. This explains why leptospirosis cases tend to increase immediately after the rainy season. Thus, it can be concluded that the rainy season is the main trigger for the increase in leptospirosis cases. Effective prevention strategies should be directed at the period leading up to and during the rainy season through environmental control, weather-based early warning systems, and education on clean and healthy living behaviors for the community.

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