Examining the Impact of rainfall patterns on leptospirosis cases in Bantul District, Indonesia: a four-year ecology study 2020-2023

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Abstract. Leptospirosis, a zoonotic illness induced by the pathogenic Leptospira bacteria, is a noteworthy public health issue, especially in regions with tropical climates. The primary objective of this investigation was to delve into the connection between precipitation patterns and the frequency of human leptospirosis cases in Bantul District, Indonesia, spanning the years 2020 to 2023. Employing an ecological approach, the study scrutinized instances of leptospirosis obtained from the Health Department of Bantul District, alongside rainfall data trends from the Meteorology, Climatology, and Geophysics Agency (BMKG) specifically from Climatology Station with the ID WMO 96851. The outcomes disclosed a total of 489 instances of leptospirosis over the specified four-year duration, with a conspicuous upsurge in recent times. Through the application of linear regression analysis, a substantial affirmative correlation between rainfall and leptospirosis occurrences was unveiled, underscoring the impact of environmental elements on disease manifestation. These findings enrich comprehension regarding the nexus between precipitation patterns and the risk of leptospirosis in tropical areas, underscoring the necessity of incorporating environmental aspects into strategies to prevent and manage diseases.

1 Introduction

Leptospirosis, a bacterial zoonotic disease, is a significant global health issue, especially in tropical areas characterized by high rainfall and humid climates [1]. The causative agent of leptospirosis is pathogenic bacteria from the genus Leptospira, which can infect humans through various routes, including direct or indirect exposure to the urine of infected animals such as rodents, livestock, and pets [2]. The transmission and prevalence of leptospirosis are

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heavily influenced by environmental factors, with rainfall patterns being a key determinant in the survival and spread of the Leptospira bacteria. The conditions can lead to increased risk of exposure and infection among susceptible populations [3].

In Indonesia, leptospirosis remains a significant public health concern, particularly in tropical regions like Bantul District in Yogyakarta. The area's high rainfall and humidity create ideal conditions for *Leptospira* bacteria to thrive and spread [4,5]. The disease is primarily transmitted through contact with water contaminated by the urine of infected animals particularly rodents, which are the main reservoirs of the bacteria. Studies have shown that standing water, poor sewer conditions, and the proximity of residential areas to open drains significantly increase the risk of leptospirosis transmission [6,7].

During the rainy season, the risk of leptospirosis increases due to flooding, which creates new habitats for the bacteria. For instance, a high incidence of leptospirosis cases has been reported in the Pacitan District during the rainy season from February to April [8]. The role of environmental factors is further highlighted by a finding from Probolinggo, where flood-prone areas have been identified as hotspots for leptospirosis outbreaks [9]. Climate change is expected to exacerbate the situation by altering precipitation patterns and increasing the frequency of extreme weather events, thereby expanding the geographical distribution of leptospirosis risk areas in regions like western Java [10].

This study aimed to investigate the relationship between rainfall patterns and the incidence of leptospirosis cases in Bantul District, Indonesia, from 2020 to 2023. By examining the correlation between these patterns, the research seeks to provide insights into the potential environmental factors influencing leptospirosis transmission in the region.

2 Materials and Methods

2.1 Participants

The study included all confirmed leptospirosis cases in Bantul District during the period of three years, starting from 2020 to 2023. Data on these cases, including the number of cases, demographic characteristics, and clinical outcomes were obtained from the Health Department Office of Bantul District.

Leptospirosis cases are defined according to the Indonesian Ministry of Health's criteria, which classify cases as suspected, probable, or confirmed based on clinical symptoms, epidemiological exposure, and laboratory confirmation. Specifically, suspected cases presented with acute fever and related symptoms such as muscle pain, weakness, and conjunctival sufficient (red eyes without exudate), along with a history of exposure to risk factors within the previous two weeks. Probable cases exhibited additional clinical signs or positive rapid diagnostic tests, and confirmed cases had laboratory evidence of Leptospira infection through culture, PCR, or serological tests [11] .

2.2 Research Design

An ecological study design with a cross-sectional approach was employed to investigate the correlation between rainfall patterns and the incidence of leptospirosis cases in Bantul District, Indonesia, from 2020 to 2023.

2.3 Data collection tools

a. Leptospirosis case data: Data on confirmed leptospirosis cases in Bantul District during the study period (2020-2023) was obtained from the Health Department Office of Bantul District.

b. Rainfall data: The rainfall data for the Bantul District region during the study period was obtained from the online central database of the Meteorology, Climatology, and Geophysics Agency (BMKG). The study utilized data from a single station, as the Climatology Station with the ID WMO 96851, in Yogyakarta with monthly aggregate rainfall data from 2020 to 2023.

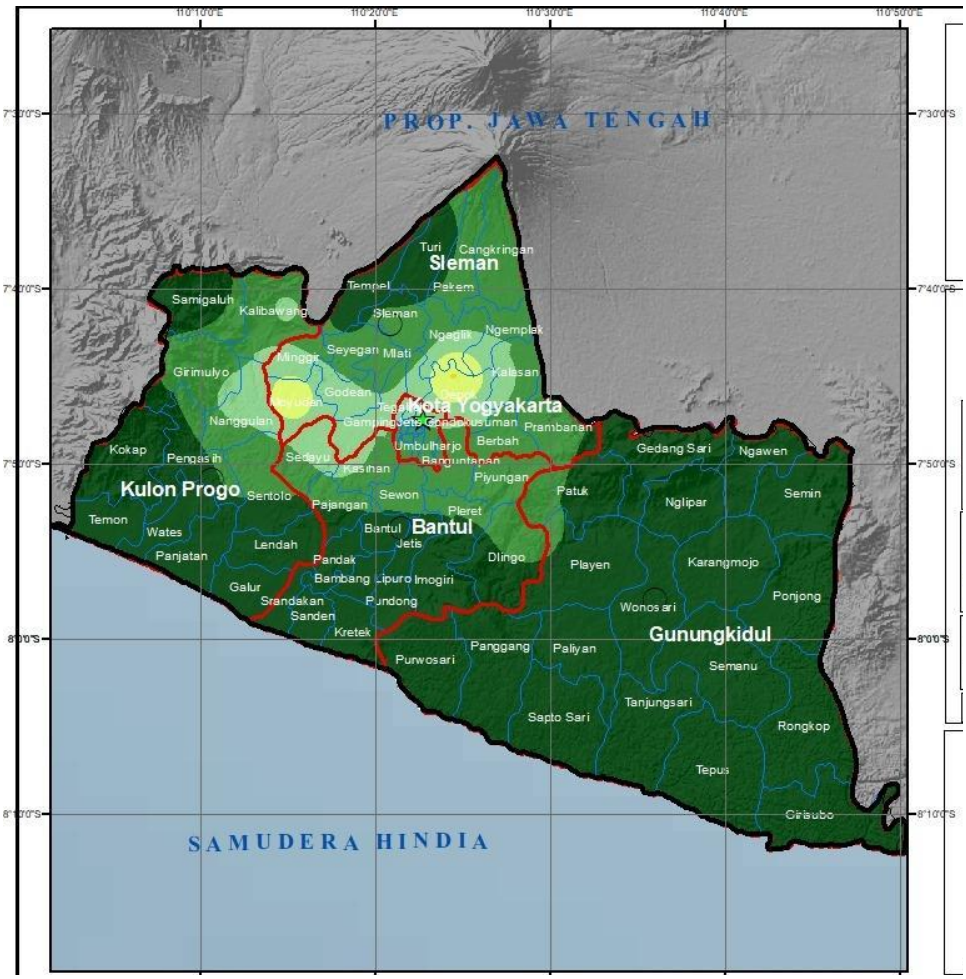

Fig. 1. Map of climatology stations in Yogyakarta ID WMO 96851 [12]

Legend:

Provincial Capital		Provincial Boundary
Regency Capital		Regency Boundary
		Sub-district Boundary

2.4 Data evaluation and statistical analysis

Statistical software was utilized to conduct data analysis. Summary statistics were employed to depict the characteristics of both the leptospirosis cases and rainfall patterns. An examination of the correlation between the quantity of leptospirosis cases (dependent variable) and rainfall quantities (independent variable) was carried out through a simple linear regression analysis. The assessment of the robustness and importance of the relationship was performed by calculating the regression coefficient, confidence intervals, and p-values.

3 Results and Discussion

The study identified a total of 489 cases of leptospirosis in Bantul District during the four years from 2020 to 2023. The distribution of cases across the years was as follows: 80 cases in 2020, 53 cases in 2021, 167 cases in 2022, and 269 cases in 2023. The majority of leptospirosis patients were male (86.91%), while females accounted for 13.09% of the cases. The age distribution showed that middle-aged individuals were most affected. While most patients recovered after receiving treatment in various healthcare facilities in the area, there were 43 recorded deaths due to leptospirosis during the study period.

The substantial rise in leptospirosis instances in Bantul District between 2020 and 2023, characterized by a significant male preponderance and a worrisome fatality rate, corresponds to global patterns observed in areas endemic to leptospirosis. Leptospirosis, a zoonotic ailment, is widespread in tropical and subtropical zones such as Southeast Asia, Latin America, and the Caribbean, where environmental circumstances promote the persistence and dissemination [13]. The ailment is frequently linked to impoverished conditions, inadequate hygiene practices, and occupational contact with polluted water and soil [14]. These observations align with results reported in different areas, like Sri Lanka, where leptospirosis is prevalent and connected to comparable environmental and occupational hazards [15].

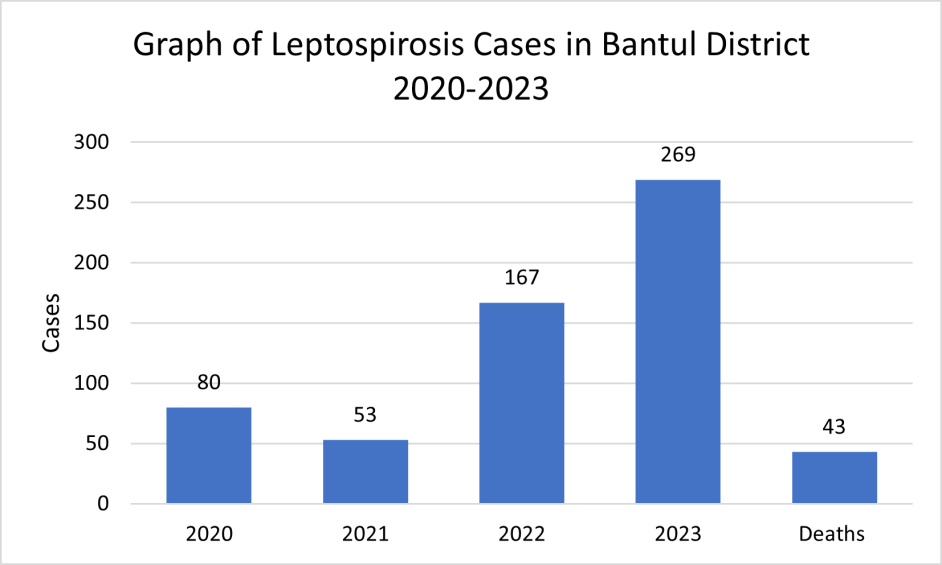

Fig. 2. Trend graph of leptospirosis cases in Bantul District, 2020-2023

The findings from Bantul District, which reported 489 cases of leptospirosis from 2020 to 2023, the age distribution showed that middle-aged individuals were most affected, aligning with trends observed in other regions and countries where leptospirosis is prevalent. For instance, in the Santa Clara municipality, a high incidence of leptospirosis was noted, particularly among males aged 15 to 59 years, with a seasonal pattern of outbreaks [16].

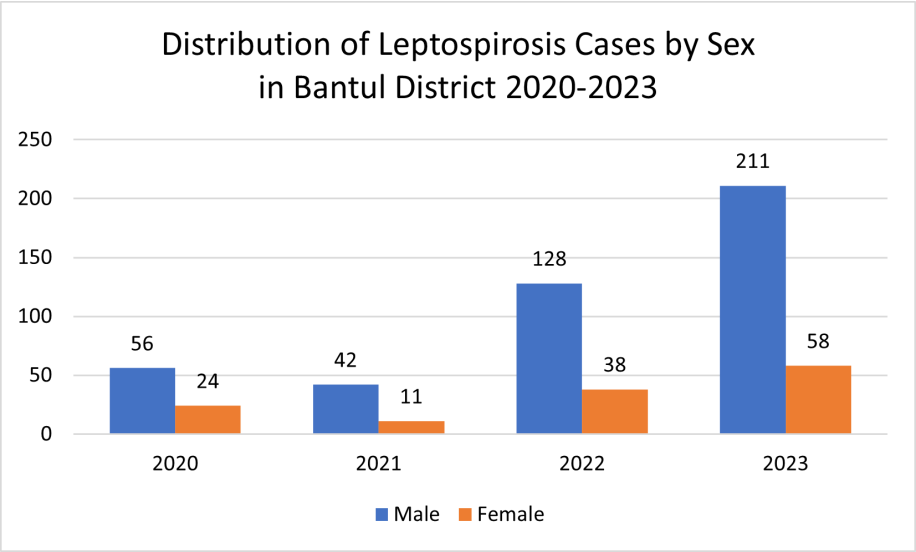

Fig. 3. Trend graph of leptospirosis cases in Bantul District, 2020-2023

The gender-based analysis of leptospirosis cases. A closer look at the annual distribution of cases by sex shows that in 2020, males represented 70% of the cases, followed by 79% in 2021, 77% in 2022, and 78% in 2023. Conversely, females made up 30% of the cases in 2020, 21% in 2021, 23% in 2022, and 22% in 2023. This consistent trend of a higher proportion of male cases.

The male predominance in Bantul District is consistent with findings from other regions, where men are more likely to engage in outdoor activities or occupations that involve exposure to contaminated environments, such as agriculture, mining, and sewer work [14,17]. For instance, in Sri Lanka, a high case fatality rate of leptospirosis was observed, with a significant number of cases among males involved in paddy farming and cinnamon cultivation, highlighting the occupational risk factors [15]. Similarly, in Indonesia, environmental risk factors such as the presence of rats, standing water, and poor sanitation have been identified as significant contributors to leptospirosis incidence, with men in occupations like farming and trading being particularly vulnerable [9,17].

The significant increase in leptospirosis cases in Bantul District from 2020 to 2023, with a notable male predominance and a concerning number of fatalities, aligns with global trends observed in regions where leptospirosis is endemic. Leptospirosis is a zoonotic disease prevalent in tropical and subtropical regions, including Southeast Asia, Latin America, and the Caribbean, where environmental conditions favor the survival and transmission of Leptospira bacteria [13]. The disease is often associated with poverty, poor sanitation, and occupational exposure to contaminated water soil [14]. This is consistent with findings from other regions, such as Sri Lanka, where leptospirosis is also endemic and associated with similar environmental and occupational risk factors [15].

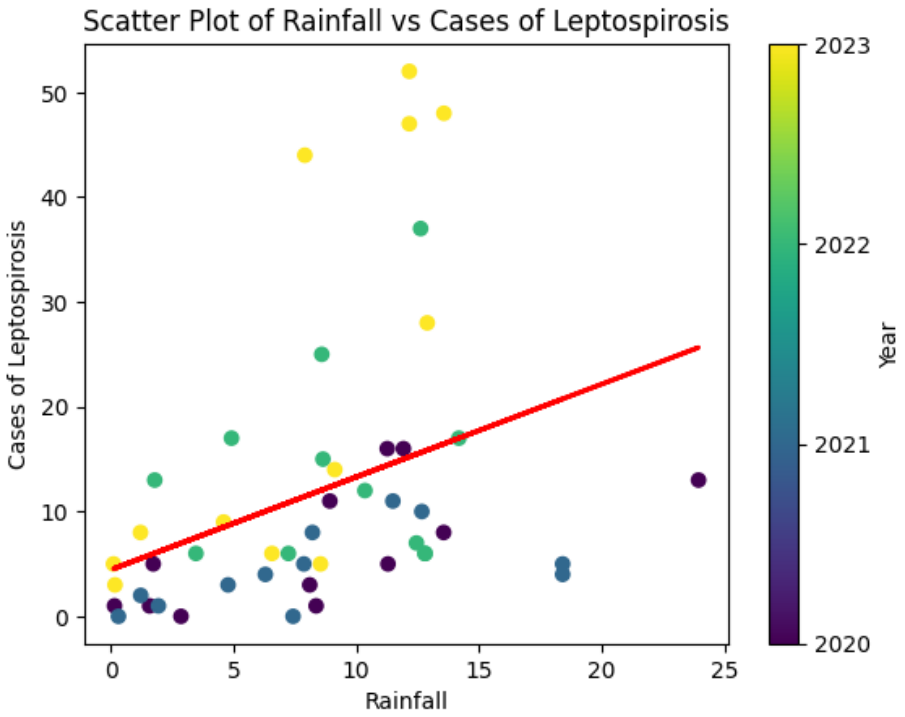

Fig. 4. Scatter plot of rainfall vs cases of leptospirosis.

The linear regression analysis revealed a coefficient of 1.3604 (95% CI: 0.758512, 2.962288) for the rainfall variable, with a p-value of less than 0.001, indicating a significant positive association between rainfall and leptospirosis cases. The multiple R-squared value was 0.3265, suggesting that approximately 32.65% of the variability in the number of leptospirosis cases could be explained by the variability in rainfall.

These findings are consistent with previous studies that have identified rainfall as a significant environmental factor contributing to the transmission and spread of leptospirosis [18]. Heavy rainfall events can create favorable conditions for the survival and dissemination of Leptospira bacteria, leading to increased exposure and infection risk. Additionally, flooding events associated with heavy rainfall can further exacerbate the problem by facilitating the spread of the bacteria in water sources and surrounding environments [19].

This study's positive association between rainfall and leptospirosis cases highlights the importance of considering environmental factors in disease prevention and control strategies. Monitoring rainfall patterns and implementing appropriate preventive measures, such as improving sanitation and water management systems, can contribute to reducing the risk of leptospirosis transmission in Bantul District and other similar tropical regions [20].

However, it is crucial to acknowledge the limitations of this study. The broad geographical coverage of the BMKG rainfall data may not accurately capture local variations in rainfall patterns within the Bantul District, as explained in Figure 1 above. Additionally, other environmental and socio-economic factors, such as urbanization, population density, and occupational exposures, which were not considered in this study, may also influence the transmission dynamics of leptospirosis.

4 Conclusion

This investigation offers further proof that rainfall patterns have an impact on the incidence of leptospirosis cases in Bantul District, Indonesia. The outcomes demonstrate a noteworthy positive correlation between the volume of rainfall and the quantity of leptospirosis cases recorded from 2020 to 2023. The findings underscore the significance of monitoring rainfall patterns as a potential prognostic factor for leptospirosis cases in tropical regions like the Bantul District.

Efforts aimed at preventing and managing leptospirosis in the region should take into account environmental elements, including rainfall, alongside other contributing factors. Implementing strategies to enhance sanitation, water management systems, and public awareness can aid in reducing the likelihood of leptospirosis transmission during periods of intense rainfall.

Although this study offers valuable perspectives, further investigation is necessary to delve into the intricate interplay among environmental factors, socio-economic circumstances, and the dynamics of leptospirosis transmission. Subsequent studies could integrate additional parameters, such as urbanization, population density, and occupational exposures, to furnish a more holistic comprehension of the determinants of leptospirosis transmission. Furthermore, examining the time delay between rainfall occurrences and the onset of leptospirosis cases could provide crucial insights for establishing early warning mechanisms and executing prompt interventions.

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