Rainfall Intensity - Dengue Fever Incidents Relationship During Rainy Season in Bantul Regency, Yogyakarta, Indonesia

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Abstract.

Dengue Hemorrhagic Fever (DHF) is a disease caused by dengue virus (DENV) infection. Dengue fever is spread through the bite of the female Aedes aegypti mosquito. Rainfall intensity plays a role in creating a suitable environment for vectors, thus potentially increasing the number of DHF cases. Rainfall intensity is not the same throughout the rainy season. This study aims to determine the relationship between rainfall intensity and DHF incidence at the beginning, middle, and end of the rainy season in Bantul Regency. This study is an observational analytical study with a cross-sectional design. Monthly rainfall and DHF incidence data per sub-district from 2019-2023 were obtained from the Climate Agency of Yogyakarta Province and the Bantul Regency Health Office, respectively. The results of the Spearman rank test showed a positive correlation between rainfall and DHF incidence in the middle (p = 0.005) and end (p = 0.000) of the rainy season, but no correlation at the beginning of the rainy season (p = 0.181). Thus, the control of dengue fever must be increased from the beginning of the rainy season, considering the tendency of a lag effect and the significance of rainfall with dengue fever at the peak and end of the rainy season.

Keywords: *DHF; climate; dengue risk factors; epidemiology and Aedes.*

I. INTRODUCTION

Dengue Hemorrhagic Fever (DHF) remains a health problem in Indonesia and even globally. Indonesia is one of the Southeast Asian countries with the highest number of reported DHF cases (1). Dengue fever can be fatal due to shock syndrome which is characterized by ascites, pleural effusion, hepatomegaly and lethargy (2).In Indonesia, there are two seasons throughout the year: the rainy season and the dry season. The rainy season occurs between October and March (3), while the dry season occurs between April and September. At the start of the rainy season (October-November), water pools and humidity increase, leading to an increase in mosquito populations and the onset of dengue transmission.The middle of the rainy season (December–January) is the peak of the rainy season, marked by high rainfall. During this period, cases spike in several regions in Indonesia, and at the end of the rainy season (February–March), dengue fever cases decline as rainfall intensity decreases. Several studies in Indonesia have shown a positive correlation between rainfall and dengue fever incidence ((4,5). Bantul Regency is one of the dengue-endemic areas in the Special Region of Yogyakarta (DIY) Province, with a high incidence rate. Located on the southern coast of Java, Bantul Regency has a tropical monsoon climate with relatively consistent air temperatures throughout the year, averaging 30°C (6).

These conditions are thought to directly influence mosquito breeding (7). Tropical climates receive the most rainfall during the west monsoon, which blows from Asia to Australia and carries large amounts of water vapor (8) and typically occurs between December and March. The water vapor carried by the monsoon condenses in the atmosphere and, when it collides with mountains or land, causes heavy rainfall, especially in the western and central regions of Indonesia. Bantul Regency is located in the western region of Indonesia, so it generally follows the seasonal patterns of Indonesia, namely rainy and dry seasons.Differences in rainfall at the beginning, middle, and end of the rainy season can lead to differences in environmental characteristics that support dengue transmission. Mosquito populations depend on the number of breeding sites, which increases during the rainy season. Increased mosquito populations likely increase dengue transmission (9). Studies on the influence of rainfall generally use year-round data (10), but do not address the effect of rainfall during the rainy season. This study aims to reveal the effect of rainfall during different periods within a rainy season on dengue fever incidence. It is assumed that rainfall characteristics at the beginning, middle, and end of the rainy season can influence mosquito density, thus impacting dengue transmission.

It is known that rainfall can have both a positive and a negative correlation with mosquito population numbers. Very high rainfall can result in the washing away of many mosquito larvae, thus reducing mosquito populations (11). Prolonged rainfall will lower environmental temperatures, thereby reducing mosquito reproduction and blood-feeding frequency (12). Sunshowers, namely rain accompanied by sunlight, may cause momentarily warm surfaces due to direct sunlight. The ongoing rain contributes to higher humidity, and any subsequent evaporation or interaction with cloud cover can further influence local temperature and humidity dynamics (13). This is thought to support the life of mosquito vectors and therefore influence dengue fever incidence. The results of this study are expected to provide new information on how rainfall intensity influences the number of dengue fever cases during the rainy season. Practically, the results can be used as a basis for raising awareness of the increase in dengue fever cases during the peak of the rainy season, and theoretically, they can be developed to study the mechanisms underlying the dynamics of dengue fever incidence during the rainy season.

II. METHODS

This study was conducted using an analytical observational quantitative design with a cross-sectional approach to analyze whether there is a relationship between rainfall intensity and dengue fever incidence at the beginning, middle, and end of the rainy season in Bantul Regency. Data for the dependent variable, namely dengue fever incidence, was obtained from the Bantul Regency Health Office. Data required for the analysis are data on dengue fever incidence per sub-district per month for the period 2019-2023. Data were excluded if the dengue fever patient did not reside in Bantul Regency. Data for the independent variable, namely monthly rainfall per sub-district during the same period, was obtained from the Climatology Agency of Yogyakarta Province. The data were divided into three periods: the beginning of the rainy season (October-November), the middle of the rainy season (December-January), and the end of the rainy season (February-March).Non-parametric Spearman Rank correlation statistical analysis was used to determine the significance and direction of the correlation between rainfall and dengue fever incidence across the three predetermined periods.This study has received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Muhammadiyah Yogyakarta, under the registration number 001/EC-EXEM-KEPK FKIK UMY/I/2024.

III. RESULT AND DISCUSSION

Data on dengue fever incidents and rainfall based on the early, middle and late rainy season periods in Bantul Regency are shown in Figure 1. Figure 1 shows the relationship between rainfall (in millimeters) and the number of Dengue Hemorrhagic Fever (DHF) cases, divided into three periods of the rainy season: early (October–November), mid (December–February), and late (March–May) from 2019 to 2023.

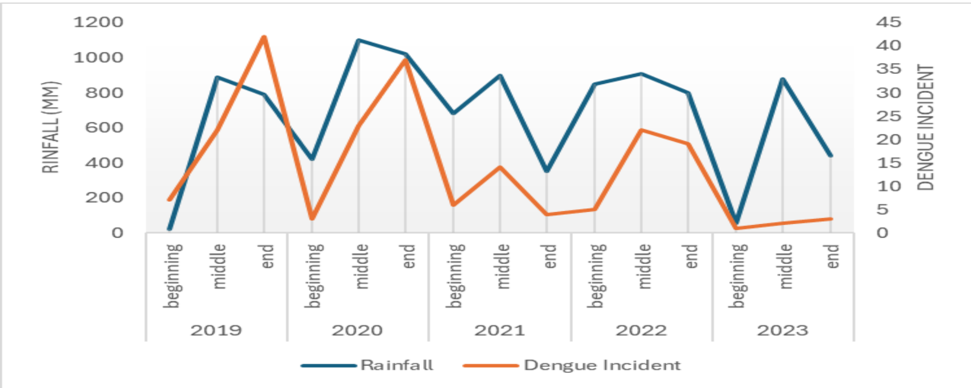

Fig 1. Graph of Dengue Fever Incidents and Rainfall at the beginning, middle and end of the rainy season in Bantul Regency 2019-2023

At the beginning of the 2019–2020 rainy season, DHF cases were low, in line with low rainfall. However, in mid-season (mid-2019), a large spike in DHF cases occurred, despite high rainfall. A similar pattern continued in 2020, with high rainfall in mid-season followed by a correspondingly high number of DHF cases. This indicates a lag effect, where rainfall at the beginning or middle of the season begins to impact the increase in DHF cases several weeks later, in line with the time required for mosquitoes to develop and transmit the virus and the incubation process of the virus in the human body.In 2021, there was a significant decline in dengue fever cases, despite relatively high rainfall, particularly in the middle and end of the season. This was likely due to the peak of the COVID-19 epidemic in 2021, resulting in very low reporting of dengue cases, or perhaps due to confusion between COVID-19 and dengue fever (14).In 2022, dengue fever cases increased significantly again, particularly at the end of the rainy season, in line with the peak of high rainfall. Increased rainfall appears to have significantly contributed to the increase in dengue fever cases, again demonstrating a positive relationship between the two, particularly at the end of the rainy season. However, in 2023, dengue fever cases were very low at the beginning and middle of the season, despite relatively high rainfall in the middle. This suggests that high rainfall does not always directly correlate with an increase in dengue fever. Very high rainfall can result in the washing away of breeding sites, which can actually reduce mosquito populations.

Table 1. Results of the Correlation Analysis between Rainfall per rainy season period and DHF incidents

Rainy season periods	Average		P value	Correlation coefficient
	Rainfall (mm)	DHF (cases/ periods)		
Early period	405.2	4.4	0.181	0.147
Mid-Period	936.2	16.6	0.005	0.299
End of Period	680	21	0.000	0.731

Correlation Test

The results of the Spearman Rank Correlation test between rainfall and dengue fever incidence at the beginning of the rainy season (October-November) showed no correlation between the two (p=0.181; r=0.147). Meanwhile, in the middle period (December-February), rainfall was shown to be positively correlated with dengue fever incidence with a weak correlation strength (p=0.005; r=0.299). However, at the end of the rainy season (March-May), rainfall had a positive and strong correlation with dengue fever incidence (p=0.000; r=0.731). At the start of the rainy season, dengue fever cases began to increase along with increasing rainfall, but the correlation was not significant. This is likely because rainfall was not yet sufficient to significantly increase dengue fever cases. The number of breeding sites was not yet sufficient to increase the Aedes population, resulting in effective dengue transmission (15). It could also be due to the time lag required for extrinsic and intrinsic incubation. Extrinsic incubation (EIP) takes 8-12 days at a temperature of 25-28 ^{O} C (16). The EIP can be shorter at higher temperatures, increasing the proportion of infectious individuals before they die. While intrinsic incubation (IIP) takes 3-10 days regardless of the dengue virus serotype (17).

Thus, it is estimated that it takes 2-3 weeks from the start of the rainy season until dengue cases appear. In addition, for dengue transmission to occur, many factors influence it besides rainfall, including air temperature and humidity, community behavior, and body immunity. Air temperature affects the frequency of biting, resting and mating behavior, distribution, and the duration of the mosquito gonotrophic cycle (18,19).During the mid-rainy season, outdoor breeding sites increase, and indoor environments with limited sunlight, resulting in darkness and humidity, can become favorable breeding and resting sites for mosquitoes (20), thus increasing the mosquito population. Furthermore, many people's immune systems decline during the mid-rainy season. Colder temperatures force the immune system to work harder. Reduced exposure to sunlight leads to a decrease in vitamin D production, which is essential for optimal immune function (21). The combination of environmental influences on mosquito life and population immunity caused the number of cases to increase to an average of 16.6 per period from 4.4 cases per period at the start of the rainy season.

Toward the end of the rainy season, there was a strong correlation between rainfall and dengue fever incidence (r=0.731), although rainfall intensity began to decrease (680 mm). The accumulation of standing rainwater during the rainy season maintains a high mosquito population, while the population's immunity remains low (21), and the time lag for the EIP and IIP processes (16) contribute to the high number of dengue cases during this period, even exceeding the mid-season (21 cases/period).The results of this study require further investigation to uncover the threshold rainfall level significantly correlated with dengue fever incidence, the time lag between rainfall and dengue fever incidence, the population's immunity during the transmission season, and the most effective model for preventing the increase in cases during the rainy season.

IV. CONCLUSION

There is a significant relationship between rainfall and dengue fever cases in the middle and end of the rainy season in Bantul Regency. During the middle and end of the rainy season, the public should be more vigilant due to an increase in dengue fever cases in the area.

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