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Climate Factors with the Incidence of Dengue Hemorrhagic Fever in Semarang, Indonesia

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Abstract

In Indonesia, Dengue Hemorrhagic Fever (DHF) remains a public health issue that can lead to extraordinary events. Indonesia ranks fourth in the world for the highest incidence of DHF. This is evident from the fluctuating morbidity and mortality rates due to DHF in Indonesia, including in Semarang. The purpose of this study is to determine the relationship between climatic factors and the incidence of DHF in Semarang from 2018 to 2022. This type of research is descriptive observational with an ecological study design. The data sources for the study are secondary data from the Semarang City Health Office and the Semarang City Meteorology, Climatology, and Geophysics Agency (BMKG) from 2018 to 2022. Data analysis was conducted using the Spearman Rank test. The results showed that rainfall (p= 0,004; r= 0,37), air humidity (p= 0,0001; r= 0,47), temperature (p= 0,016; r= -0,31), wind speed (p= 0,0001; r= -0,48), and duration of sunshine (p= 0,015; r= -0,31) were associated with the incidence of DHF. The conclusion of this study indicates a correlation between climatic factors, such as rainfall, air humidity, temperature, wind speed, and duration of sunshine, and the incidence of DHF in Semarang from 2018 to 2022.

INTRODUCTION

Dengue Hemorrhagic Fever (DHF) is one of the infectious diseases caused by the Dengue virus, which belongs to the Flaviviridae family and the Flavivirus genus. This virus has four main serotypes: DENV-1, DENV-2, DENV-3, and DENV-4. DHF is transmitted by vector mosquitoes, with the main vector species being Aedes aegypti and Aedes albopictus (Wang et al., 2020). According to WHO, the incidence of dengue fever has increased rapidly worldwide in recent decades. In 2000, there were 505,430 reported cases, which sharply increased to 5.2 million reported cases in 2019. This disease is endemic in more than 100 countries, including regions in Africa, America, the Eastern Mediterranean, Southeast Asia, and the Western Pacific (World Health Organization, 2023). The European Centre for Disease Prevention and Control (ECDC) stated that in 2022, there were 4,110,465 cases of dengue fever worldwide. The countries with the highest number of cases were Brazil (2,363,490 cases), Vietnam (367,729 cases), Philippines (220,705 cases), Indonesia (125,888 cases), and India (110,473 cases) (World Health Organization, 2023). In Indonesia, DHF remains a public health issue that can lead to extraordinary events (Susilowati & Cahyati, 2021). It is evident from the fluctuating morbidity and mortality rates due to DHF in Indonesia. In 2022, the number of dengue cases in Indonesia reached 143,000, with the highest incidence occurring in three provinces, namely West Java, East Java, and

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Central Java (Kementerian Kesehatan Republik Indonesia, 2022).

DHF situation in Semarang shows a fluctuating trend in cases. According to the Semarang City Health Office, there were 103 cases of DHF in Semarang in 2018 (IR = 6.17; CFR = 0.97%). In 2019, the incidence of DHF increased to 441 cases (IR= 26.37; CFR= 3.18%). In 2020, the incidence of DHF decreased to 320 cases (IR= 19.16; CFR= 1.25%). In 2021, the incidence of DHF increased to 322 cases (IR= 19.88; CFR= 2.71%). In 2022, the incidence of DHF increased to 864 cases (IR= 51.7; CFR= 3.82%) (Kementerian Kesehatan Republik Indonesia, 2022). Based on the epidemiological triangle, Dengue Hemorrhagic Fever (DHF) is associated with three main factors. They are agent, host, and environment. The vector requires a suitable environment to breed (Ghaisani et al., 2021; Cahyati et al., 2023; Cahyati & Fitriani, 2020). The vector that causes DHF is closely related to climate change. Climate change can affect the increased risk of disease transmission and cause the mosquito population to rise.

The spread of the DHF virus is closely related to climate change patterns. Several studies indicate that climatic factors such as temperature, rainfall, humidity, wind speed, and sunshine duration are associated with the incidence of DHF in a region. A study conducted in Sleman, Indonesia, found that humidity, temperature, rainfall, and the number of rainy days are the climatic factors that most significantly influence DHF incidence (Kesetyaningsih & Fauzan, 2021). Research conducted in Dhaka, Bangladesh, indicated that wind speed has a positive relationship with dengue fever (Hossain et al., 2023). A study conducted in Hanoi found a correlation between monthly relative humidity and total sunshine hours with DHF incidence (Thi Tuyet-Hanh et al., 2018). Rainfall contributes to the incidence of DHF because high rainfall can increase the potential breeding places for Aedes aegypti and Aedes albopictus mosquitoes, thereby increasing the mosquito vector population (Ghaisani et al., 2021). Temperature can affect virus replication and mosquito breeding (Arsin et al., 2020). Humidity also contributes to the incidence of DHF, as it influences mosquito breeding, resting, lifespan, and biting habits (Kesetyaningsih & Fauzan, 2021).

Sunshine significantly affects mosquitoes when resting and biting (Minarti et al., 2021). Aedes aegypti mosquitoes look for shaded places to rest, have adequate humidity, and protected from the sun. Abundance of sunshine increase air temperature, which can heat water temperature and reduce humidity, thereby disrupting mosquito survival. Wind speed can affect the range of mosquito flight. A wider flight range increases the possibilities of contact with humans (Arsin et al., 2020). Based on the above explanation, the researcher considers it important to study the data related to climatic factors and the incidence of DHF in Semarang from 2018 to 2022. Therefore, this study is conducted to determine the correlation between climatic factors and the incidence of DHF in Semarang from 2018 to 2022. Understanding the relationship between climatic factors and DHF incidence is expected to help take preventive measures to reduce the incidence of DHF.

METHOD

The type of research used in this study is descriptive observational with an ecological study design. An ecological study examines the relationship between independent and dependent variables, along with the strength and direction of the relationship. The population in this study consists of the total number of DHF cases in Semarang from 2018 to 2022. Data collection for DHF and climate used secondary ones. DHF data was obtained from the Semarang City Health Office recorded in the TUNGGAL DARA application from January 2018 to December 2022. Climate data was sourced from the Central Java Province BMKG Station in Semarang recorded in BMKG's official central database application from January 2018 to December 2022.

In this study, the dependent variable is the incidence of DHF. The independent variables include rainfall, air humidity, temperature, wind speed, and duration of sunshine. The units for the independent variables are as follows: rainfall (mm), air humidity (%), temperature (°C), wind speed (m/s), and duration of sunshine (hours). The

measurement of distribution is conducted to describe the mean, median, standard deviation, and min-max of the incidence of DHF, rainfall, air humidity, temperature, wind speed, and duration of sunshine. In this study, the bivariate analysis uses the Pearson Product Moment test if the requirements are met, such as the measurement scale being numerical and the data being normally distributed. Alternatively, the Rank Spearman test is used if the data is not normally distributed. The correlation strength parameter (r) is as follows: 0.0 - < 0.2 very weak; 0.2 - < 0.4 weak; 0.4 - < 0.6 moderate; 0.6 - < 0.8 strong; and 0.8 - 1 very strong. The direction of correlation can be positive or negative. The p-value parameter is > 0.05 for non-significant and < 0.05 for significant correlation. Ethical approval for this research was obtained from the Health Research Ethics Committee (KEPK) of the Faculty of Medicine, Universitas Negeri Semarang, with No. 018/KEPK/FK/KLE/2024.

RESULTS AND DISCUSSION

Based on Table 1, the average monthly incidence of DHF in Semarang from 2018 to 2022 was 35 cases, with a minimum of 2 cases and a maximum of 94 cases. The monthly rainfall in Semarang from 2018 to 2022 ranged from 0 to 694.2 mm, with an average monthly rainfall of 181.7 mm. The monthly air humidity in Semarang from 2018 to 2022 ranged from 66.2% to 91.4%, with an average monthly humidity of 79.5%. The monthly temperature in Semarang from 2018 to 2022 ranged from 26.7°C to 30.1°C, with an average monthly temperature of 28.3°C. The monthly wind speed in Semarang from 2018 to 2022 ranged from 1.5 to 3.2 m/s, with an average monthly wind speed of 2.2 m/s. The duration of sunshine per month in Semarang from 2018 to 2022 ranged from 3 to 9.9 hours, with an average of 6.6 hours.

Based on Table 2, the bivariate results indicate that rainfall has a significant relationship with the incidence of DHF, with a weak correlation strength and a positive correlation direction (r= 0.37; p= 0.004). Air humidity also has a significant relationship with the incidence of DHF, with a moderate correlation strength and a positive correlation direction (r= 0.47; p= 0.0001). Temperature has a significant relationship with the incidence of DHF, with a weak correlation strength and a negative correlation direction (r= -0.31; p= 0.016). Wind speed has a significant relationship with the incidence of DHF, with a moderate correlation strength and a negative correlation direction (r= -0.48; p=0.0001). The duration of sunshine also has a significant relationship with the incidence of DHF, with a weak correlation strength and a negative correlation direction (r= -0.31; p= 0.015).

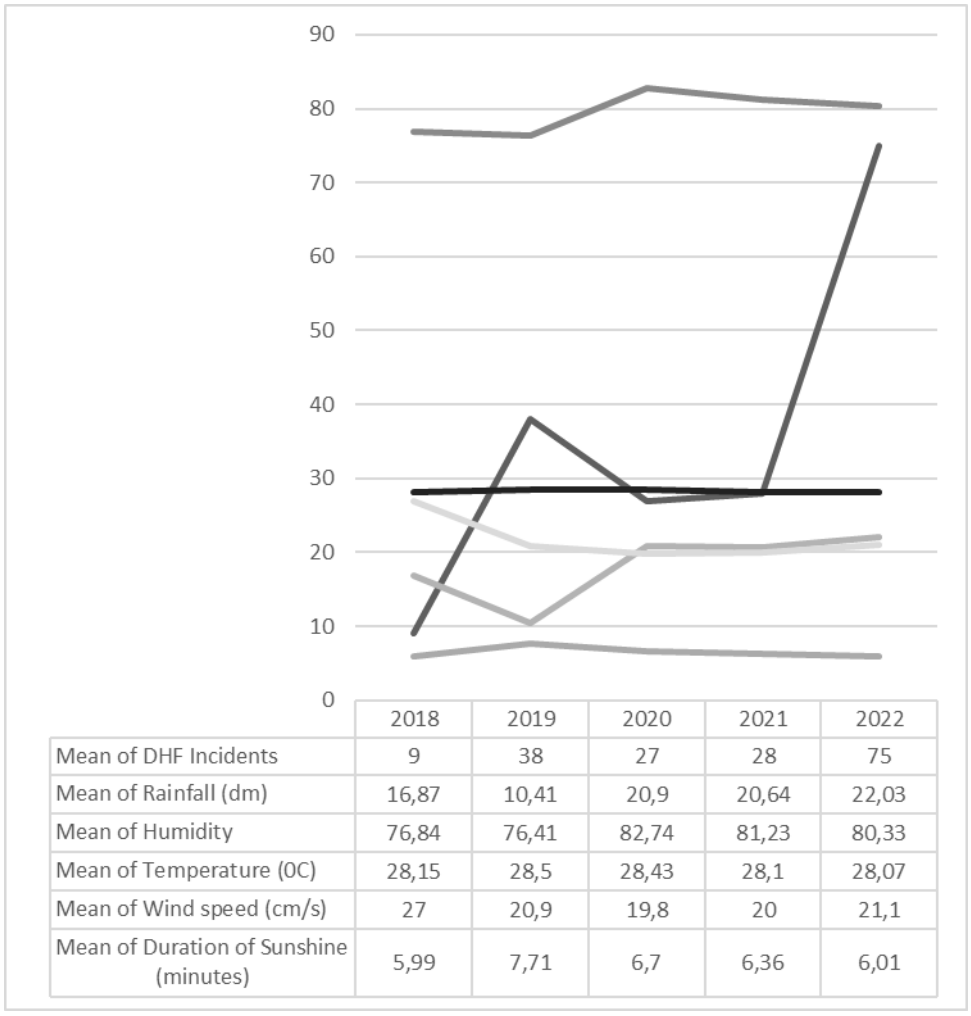
Based on the diagram 1, the increase in rainfall is also accompanied by an increase in the incidence of dengue fever. The incidence of dengue fever also follows trends in other variables. Thus, it can be concluded that the incidence of dengue fever can be influenced by several climate variables, including rainfall, humidity, temperature, wind speed, and duration of sunshine.

The results of this study indicate that rainfall, air humidity, temperature, wind speed, and duration of sunshine are related to the incidence of DHF. These findings are consistent with a study conducted in Sleman, Indonesia, from 2008 to 2015, which showed that rainfall is significantly related to the incidence of DHF (Kesetyaningsih & Fauzan, 2021). A study in Bangkok stated that a 1% increase in rainfall would result in a 3.3% increase in monthly dengue fever incidence (Polwiang, 2020). Research in Lampung, Indonesia, from 2007 to 2018 found that rainfall had a 19% impact on the incidence of DHF (Rusli & Yushananta, 2020). Rainfall is a crucial factor in the transmission of

Table 1 Distribution of DHF Incidence and Climatic Factors in Semarang from 2018 to 2022

Variables	n (Months)	Mean	Minimum	Maximum
DHF Incidence	60	35	2	94
Rainfall	60	181,7	0	694,2
Air Humidity	60	79,5	66,2	91,4
Temperature	60	28,3	26,7	30,1
Wind Speed	60	2,2	1,5	3,2
Duration of Sunshine	60	6,6	3	9,9

Sources: Tunggal Dara Application (Kementerian Kesehatan Republik Indonesia, 2022)



	2018	2019	2020	2021	2022
Mean of DHF Incidents	9	38	27	28	75
Mean of Rainfall (dm)	16,87	10,41	20,9	20,64	22,03
Mean of Humidity	76,84	76,41	82,74	81,23	80,33
Mean of Temperature (0C)	28,15	28,5	28,43	28,1	28,07
Mean of Wind speed (cm/s)	27	20,9	19,8	20	21,1
Mean of Duration of Sunshine (minutes)	5,99	7,71	6,7	6,36	6,01

Diagram 1. Climatic Factors and DHF Incidence in Semarang from 2018 to 2022 (Kementerian Kesehatan Republik Indonesia, 2022)

DHF. High rainfall intensity leads to increased water puddles, which become breeding grounds for adult mosquitoes, facilitating their egg-laying and increasing mosquito populations. Rainfall can also affect air humidity, and increased humidity can extend the lifespan of adult mosquitoes (Wulandari et al.,2023). However, a study conducted in Surabaya from 2007 to 2017 showed contrasting results, indicating that there is no relationship between rainfall and the incidence of DHF. This is due to the possibility of heavy rains being detrimental to mosquitoes, as they can destroy mosquito eggs and larvae (Ghaisani et al., 2021).

Dengue fever cases are more frequent during the rainy season when humidity is relatively higher. High humidity during the rainy season supports mosquito breeding, which can lead to an increase in the number of infected mosquitoes (Sutriyawan et al., 2023). The average air humidity based on the study results was 79.5%, which is consistent with research conducted in Hanoi from 2008 to 2015, indicating that air humidity is related to the incidence of DHF, with an average air humidity of 80.1% (Thi Tuyet-Hanh et al., 2018). A study conducted in Manado also stated that there is a relationship between air humidity and the incidence of DHF (r=0.873; p= 0.0001) (Monintja et al., 2021). Air humidity can affect the respiratory system and physiological processes of Aedes aegypti mosquitoes. The optimal air humidity for mosquito survival is more than 60%, while low air humidity, less than 60%, can shorten the mosquito's lifespan due to body fluid evaporation. Conversely, high air humidity, more than 85%, can extend the mosquito's

Table 2 Correlation Analysis Results between Climatic Factors and DHF Incidence in Semarang from 2018 to 2022

Variables	Dengue Hemorrhagic Fever (DHF) Incidence		
	Correlation Coefficient (r)		Description
Rainfall	0,37	0,004	Weak correlation strength, positive correlation direction, and significant correlation
Air Humidity	0,47	0,0001	Moderate correlation strength, positive correlation direction, and significant correlation
Temperature	-0,31	0,016	Weak correlation strength, negative correlation direction, and significant correlation
Wind Speed	-0,48	0,0001	Moderate correlation strength, negative correlation direction, and significant correlation
Duration of Sunshine	-0,31	0,015	Weak correlation strength, negative correlation direction, and significant correlation

Source: Primary data

lifespan (Wulandari et al., 2023). Additionally, mosquitoes prefer to lay eggs in humid places, so increased air humidity can potentially increase Aedes aegypti larvae (Kesetyaningsih & Fauzan, 2021). The relationship between air humidity one month prior and the incidence of DHF is very strong. It is because high air humidity causes mosquitoes to lay more eggs, leading to an increased mosquito population and faster DHF transmission (Amelinda et al., 2022). However, a study conducted at RSUD Palembang Bari, Indonesia showed contrasting results, indicating no relationship between air humidity and the incidence of DHF (Indawati et al., 2021).

Based on this study, temperature correlates with the incidence of DHF, with an average temperature of 28.3°C. This is in line with research conducted in Surabaya, Indonesia, which found a statistical relationship between average temperature and the incidence of DHF (r= -0.603; p= 0.01) (Tang et al., 2020). A study in Central Java, Indonesia observed that the temperature with the lowest risk of dengue fever is around 27°C. The risk of dengue fever decreases as the temperature increases (Wibawa et al., 2024). Research conducted in Kelantan, Malaysia, stated that dengue fever cases increase when the average temperature ranges between 26°C and 28°C. The dengue fever cases are predicted to decrease when the average daily temperature rises above 28°C (Masrani et al., 2021). Temperature is a climatic factor that can affect the life cycle of mosquito vectors and virus replication. The optimal temperature for mosquito vectors is around 26-30°C. Therefore, dengue transmission is higher in tropical and subtropical regions. It is because extremely high or low temperatures can disrupt mosquito growth and can be fatal to them (Amelinda et al., 2022). Temperature can also affect the biting activity of female mosquitoes, with optimal temperatures potentially increasing the spread of DHF (Minarti et al., 2021). Research conducted in Surabaya, Indonesia, showed contrasting results, indicating no relationship between temperature and the incidence of DHF (Ghaisani et al., 2021).

Based on the results, wind speed is related to the incidence of DHF, with an average wind speed of 2.2 m/s. This study aligns with research conducted in Makassar, Indonesia, which found a relationship between wind speed and the incidence of dengue fever, with a negative correlation. The research in Makassar indicated that strong winds could reduce mosquito density, making it difficult for mosquitoes to find their hosts (Susilawaty et al., 2021). Wind speed can affect mosquito flight and dispersion. When the wind speed is 11-14 m/s or 25-31 mph, it can hinder mosquito flight. Wind speed when mosquitoes fly in and out of houses is one of the factors that determines the amount of contact between mosquitoes and humans (Amelinda et al., 2022).

Aedes aegypti mosquitoes fly about 30-50 meters per day, but this distance depends on the availability of breeding places. When the breeding site is in or around the house, they will not fly far. Female mosquitoes have an average

flying capability of 40 meters and a maximum of 100 meters. Wind speed influences the range of Aedes aegypti mosquitoes while flying. The wider the range of the mosquitoes, the greater the chances of contact with humans. If the wind speed is faster, mosquitoes find it more difficult to fly. Therefore, mosquitoes find it hard to move long distances, which can reduce the chance of DHF transmission (Arsin et al., 2020). Research conducted in Kendari, Indonesia, showed a contrasting result, indicating no correlation between wind speed and the incidence of DHF (Arsin et al., 2020).

Research results indicate a relationship between the duration of sunshine exposure and the incidence of dengue hemorrhagic fever (DHF), with an average sunshine duration of 6.6 hours. This study aligns with research conducted in Hanoi, which found a relationship between the average monthly sunshine duration and the incidence of DHF (Thi Tuyet-Hanh et al., 2018). Research in Bangladesh stated that shorter sunshine duration is more conducive to the transmission of dengue fever, as mosquitoes are more active in dark environments, increasing the frequency of mosquito bites (Hossain et al., 2023). When resting, Aedes aegypti mosquitoes tend to seek shaded areas with adequate humidity, protected from sunshine (Kementerian Kesehatan Republik Indonesia, 2022). The mosquito movement in searching for food or resting places is greatly influenced by sunshine (Minarti et al., 2021). Research conducted in Palembang, Indonesia, showed a contrasting result, indicating no correlation between sunshine duration and the incidence of DHF (Minarti et al., 2021).

This study has limitations due to the ecological study design, resulting in aggregate data analysis. In this research, bias cannot be controlled as the validity and reliability of the data are unknown, given the use of secondary data. Additionally, this study cannot accurately measure the risk impact and predictive value of DHF incidence because the analysis is only bivariate when the data is not normally distributed. Moreover, this study is limited by its focus solely on climatic factors, suggesting a need for further research on other potential factors related to the incidence of DHF.

CONCLUSION

Based on the results of bivariate analysis using the Rank Spearman correlation analysis, climatic factors that have a relationship with the incidence of DHF in Semarang from 2018 to 2022 include rainfall (r= 0,37; p= 0,004), air humidity (r= 0,47; p= 0,0001), temperature (r= -0,31; p= 0,016), wind speed (r= -0,48; p= 0,0001), and duration of sunshine (r= -0,31; p= 0,015). This study has shown that climatic factors are important elements that can influence the incidence of DHF in Semarang. It is expected that the Semarang City Health Office implements an early warning system regarding the risk of increasing DHF incidence related to climatic factors by using data from the Meteorology, Climatology, and Geophysics Agency (BMKG) at the Semarang City Climatology Station. It would allow for timely intervention in monitoring DHF. Additionally, it is hoped that this research can strengthen environmental management and raise awareness of DHF in society.

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