Climate Variability Effects On Rising Dengue Incidence In Jakarta Province

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Abstract. The incidence of Dengue Hemorrhagic Fever (DHF) in Jakarta fluctuates throughout the year. During 2017-2020, the municipality of West Jakarta was the second-highest contributor to the incidence of DHF in DKI Jakarta Province, namely 5,301 cases. Subsequently, Kalideres district has the highest incidence of DHF in the West Jakarta municipality area. Currently, globally, the world is experiencing climate change. The transmission of dengue fever is highly dependent on climatic factors. This study aimed to analyze the impact of climate change on rising dengue fever incidence in Jakarta, especially in the Kalideres District, in 2019-2020. The study design was cross-sectional. The variables analyzed were climate change, assessed from weather climate, rainfall, wind speed, and air humidity obtained through recording data from the Meteorological, Climatological, and Geophysical Agency website. Data on the incidence of DHF used daily DHF case report data obtained from the Kalideres District Health Center. Data analysis used simple linear regression analysis. Based on the bivariate analysis obtained, rainfall (p-value = 0.031; r = 0.211) and air humidity (p-value = 0.001; r = 0.413) were associated with the incidence of DHF. The regression coefficient value indicates that the direction of the relationship between rainfall and humidity is appropriate and in the same direction as the incidence of DHF. Meanwhile, air temperature and wind speed were not related to the incidence of dengue fever (p-value> 0.05). Early detection through dengue surveillance and mosquito vector control during high rainfall is highly recommended.

1 Introduction

Dengue Hemorrhagic Fever (DHF) is a disease caused by the dengue virus through the Aedes aegypti mosquito vector. The World Health Organization (WHO) states that dengue cases have made more than 100 countries endemic including the Africa, Americas, East Mediterranean, Southeast Asia, and West Pacific Regions with a tendency for cases to increase every year. In 2008 and 2010, the number of DHF cases was more than 1.2 million and 2.3 million cases in America, Southeast Asia, and the Western Pacific. WHO also stated that from the annual DHF case data worldwide, Asia ranks first. There are eight

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countries in Asia with the highest dengue cases, namely Indonesia, Myanmar, Bangladesh, India, Maldives, Sri Lanka, Thailand, and Timor Leste. Indonesia is a country with the highest dengue cases in Southeast Asia (1)

The emergence of DHF can be caused by an imbalance between various factors such as host, agent, and environmental factors. Host factors are related to human characteristics such as the immune system and nutritional status, agent factors are related to the characteristics and virulence ability of the dengue virus, while environmental factors are related to vector capacity, one of which can be affected by climate change (2). This is because the impacts that occur due to climate change can be felt directly and indirectly, especially by humans in the field of human health. Climate change can affect land and ocean ecosystems, so it can be related to patterns of infectious diseases due to the proliferation of certain disease vectors such as Aedes, Anopheles, and others whose diseases are called vector-borne diseases, one of which is Dengue Hemorrhagic Fever (DHF). Climate change can include changes in air temperature, rainfall, air humidity, and wind speed which can be related to the mechanism and life cycle of mosquito vector breeding (3–5).

Currently, globally, the world is experiencing climate change. Climate change is a change in the average and or variability of climate elements, such as air temperature, humidity, rainfall, air pressure, and wind, which can be identified in the long term either due to nature or human activities. According to the Intergovernmental Panel on Climate Change (IPCC), the current climate change is happening so fast, mainly because of greenhouse gases and global warming which are closely related to human activities. One of the climate changes that can occur is marked by an increase in the earth's temperature. The average earth temperature from 2006-2015 increased by 0,87°C compared to 1850-1990. The IPCC also states that at the beginning of the 21st century, the earth's surface temperature will continue to increase in the range of 1,4°C hingga 5,8°C. In addition to an increase in temperature, other climate changes that can also occur are changes in the intensity of extreme weather such as increased rainfall, changes in air humidity, and wind speed (6).

Along with the increase in population activity and accompanied by increasing population growth, the number of sufferers and the area of the spread of DHF disease is increasing. Data from 2014 stated that DHF had spread in 433 of 511 districts/cities in 34 provinces in Indonesia. The very high and uncontrolled population growth will cause the population density to increase. One area with a high population density is Jakarta. In Jakarta, there are 10,075,300 inhabitants, which means that the population density in Jakarta reached 15,173 people/km^2 in 2014. With such a high density, Jakarta is one of the provinces that are prone to various diseases including DHF (7,8). DHF cases in Jakarta fluctuate throughout the year. The latest data shows that during 2017-2020, the West Jakarta Municipality was the second highest contributor to DHF cases in DKI Jakarta, with 5,301 cases after the first highest was in East Jakarta Municipality with 6,649 cases. In West Jakarta Municipality, Kalideres district is the district with the highest dengue cases throughout 2017-2020 with a total of 1,549 cases and followed by Cengkareng sub-district with the second highest with 1,483 cases. Because of the problems described above, the authors want to know more about the climate variability effects and the rising incidence of DHF in the Kalideres District from 2019-2020.

2 Methods

This study used an ecological study using a cross-sectional approach. The research was located in DKI Jakarta Province by selecting one sub-district with the highest incidence of DHF, namely the Kalideres District. The data collected was sourced from weekly climate data (air temperature, rainfall, air humidity, and wind speed) and weekly data on the incidence of DHF in Kalideres District in 2019-2020. Weekly data on climate variability (air temperature, rainfall, air humidity, and wind speed) was obtained through secondary data collection through recording data from the Meteorological, Climatological, and Geophysical Agency website or the online site of BMKG Kemayoran, Central Jakarta. Weekly data on the incidence of DHF in the Kalideres District was obtained through recording reports from the Kalideres District Health Center.

Data analysis used a simple linear regression statistical test and using STATA 17 software. This analysis aimed to measure the relative effects of the predictor factors on a specific outcome (9,10). A simple regression model has just one independent (explanatory) variable, X_i, for $i = 1, \ldots, n$ subjects, and is linear about both the regression parameters and the dependent variable. The associated dependent (outcome) variable is identified by a label. The model is expressed in the form:

$$Y_i = a + bX_i + e_i \tag{1}$$

Regression parameter a is the intercept (on the y axis), and the slope of the regression line is regression parameter b (11). Before performing statistical analysis with simple linear regression, the normality test was first performed. A normality test was used to determine whether the data were normally distributed or not. It is said to be normally distributed when the significance value is more than 0.05. Based on the normality test, the significance value was 0.165 (p-value > 0.05), and it can be said that the data were normally distributed.

3 Results

This research was carried out from November to December 2021 by recording weekly climate data (air temperature, rainfall, air humidity, and wind speed) and weekly data on DHF incidence in Kalideres District from 2019-2020. So that obtained 104 samples on each of the variables studied. Trends and developments in the incidence of DHF and climate every week were presented in Figure 1.

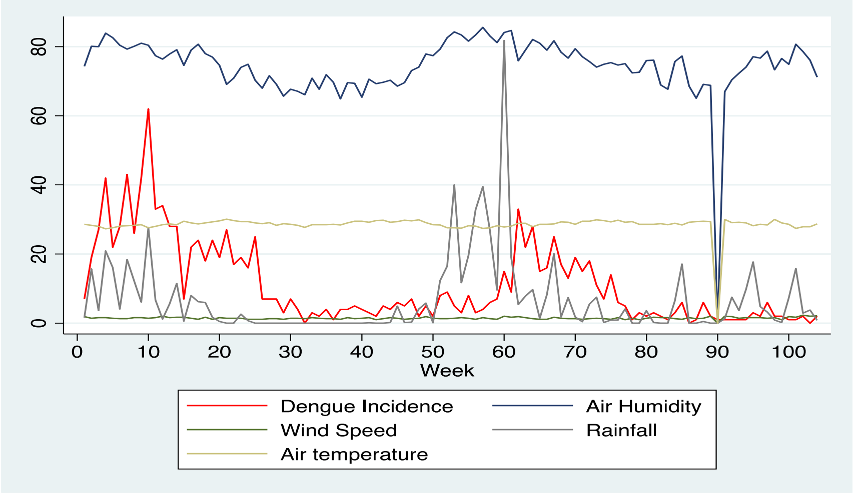

Fig. 1. Climate variability and Dengue Incidence in 2019-2020

Table 1. Simple linear regression analysis between independent and dependent variables, correlations, and their p-value

Climate variability	Intercept	Slope	r	R^2	P-value	CI
Air temperature	6.991	0.145	0.036	0.0013	0.719	-0.656-0.947
Rainfull	9.659	0.222	0.212	0.0450	0.031	0.021-0.424
Air humidity	-20.110	0.419	0.321	0.1033	0.001	0.177-0.663
Wind speed	9.447	1.178	0.031	0.0009	0.757	-6.342-8.699

a. Air temperature and the incidence of DHF

Based on table 1, it is known that the correlation coefficient (r) in the results of this analysis is 0.036 which means that the correlation strength is very weak. This is in line with the p-value of 0.719, which is greater than 0.05, indicating that air temperature is not related to the incidence of DHF. The regression coefficient of the relationship between these variables is 0.145 in a positive direction, in other words, the relationship between these two variables is unidirectional, the greater the air temperature, the greater the incidence of DHF. The formula for simple linier regression is : Y = 6.991 + 0.145X

b. Rainfall and the incidence of DHF

The results of the analysis in table 1 show that the p-value is 0.031, which means it is smaller than 0.05. Indicates that rainfall is related to the incidence of DHF. The correlation coefficient (r) in the results of this analysis is 0.212 which means the strength of the correlation is weak. The regression coefficient of the relationship between these variables is 0.222 with a positive direction indicating that the relationship between the two variables is unidirectional, ie the greater the rainfall, the greater the incidence of DHF. The formula for simple linear regression is : Y = 9.659 + 0.222X

This means that every time there is an increase in the value of X (rainfall) it can increase the value of Y (incidence of DHF) by 0.222.

c. Air humidity and the incidence of DHF

In the analysis of the air humidity variable with the incidence of DHF, the correlation coefficient value (r) is 0.321 which means that the correlation strength is weak. The p-value shows the result of 0.001 which indicates that the air humidity is related to the incidence of DHF. The regression coefficient of the relationship between these variables is 0.419 with a positive direction which also indicates that the relationship between the two variables is unidirectional, i.e. the greater the humidity, the greater the incidence of DHF. The formula for simple linear regression is : Y = -20.110 + 0.419X

This means that every time there is an increase of one unit of X (air humidity) it can increase the value of Y (incidence of DHF) by 0.419. Another explanation is that if the air humidity is equal to zero (0) then the incidence of DHF will decrease.

d. Wind speed and the incidence of DHF

Based on the results of the analysis in table 1, it is known that the correlation coefficient (r) is 0.031 which means that the correlation strength is very weak. This is in line with the p-value of 0.757 where the value is greater than 0.05 which indicates that wind speed is not related to the incidence of DHF. The regression coefficient of the relationship between these variables is 0.910 with a positive direction indicating that the relationship between these two variables is unidirectional, ie increasing wind speed can also increase the incidence of DHF. The formula for simple linear regression is : Y = 9.447 + 1.178X

4 Discussion

The pattern of rain that occurred in Kalideres Subdistrict in 2019 and 2020 has a pattern that tends to be high at the end and beginning of the year, namely in the weeks from December to February and decreases in the weeks from March to September, and in October the rainfall begins to increase again until its peak in December to February. Based on the results of this study, it was found that there was a relationship between rainfall and the incidence of DHF. This is seen based on the significant value of 0.031, which is smaller than 0.05. Rainfall can create puddles of water which can be a breeding ground for Aedes aegypti mosquitoes. Rainfall is also one of the climate elements that can affect mosquito breeding. High rainfall is indeed associated with several infectious diseases based on studies in Vietnam and Singapore over several periods, including one of them is DHF (12,13).

Based on the data that has been collected, the highest incidence of DHF in Kalideres District is in the first week of March 2019 with 27.7mm of rainfall, and the second most were 43 cases in the second week of February 2019 with 18.4mm of rainfall, and the third most was 42 cases in the fourth week of January and February 2019 with 20.9mm and 6.1mm of rainfall. Based on this data, it shows a positive and unidirectional relationship between rainfall and the incidence of DHF, which is evidenced by the increased rainfall will be followed by an increase in the number of DHF incidences. This is in line with research conducted in Tomohon City, the eastern part of Indonesia, which said that there was a relationship between rainfall and the incidence of DHF (p-value = 0.019). The number of eggs laid by a female Aedes mosquito can range from 100-300 grains, this is what can cause the mosquito population to increase rapidly. Mosquitoes need to find human prey to ripen their eggs, so the tendency to bite humans will increase. This also causes the number of mosquito bites to increase along with the increase in rainfall. In An area with an unsanitary environment, there are empty storage containers that if filled due to continuous rainfall can become a breeding ground for the Aedes aegypti mosquito which is it can increase the incidence of DHF (14).

The relationship between rainfall and the incidence of DHF in this study shows a weak strength relationship. This may occur due to the characteristics of the rainfall that occurs related to the intensity of rainfall. It is said that high-intensity and continuous rainfall that causes flooding can actually wash away the breeding site and cause the population to decrease. Throughout 2019-2020, the highest dengue cases were 62 cases which occurred in the first week of March 2019 with heavy rainfall of 27.7mm of rain. However, when referring to the time when the highest rainfall occurred, then it occurred in the first week of January 2020, namely 40mm of rainfall but was not followed by an increase in the incidence of DHF because the incidence of DHF found at that time only amounted to 5 cases. This can be the cause of the relationship between the two variables between rainfall and the incidence of DHF in this study tends to be weak. Researchers also believe that there are other factors outside the climate that also affect the number of dengue cases, such as the role of community habits or interventions that have been carried out by the government.

Air humidity can be affected by the influence of rainfall. Along with increasing rainfall, it can be followed by an increase in air humidity. The tendency of increasing air humidity in Kalideres District occurs in the weeks at the end and beginning of December to February, along with increasing rainfall. Air humidity will begin to decrease in the following months as rainfall begins to decline. Based on this study, air humidity has a relationship with the incidence of DHF, with a p-value of 0.001 with a weak strength correlation coefficient of 0.316. The strength of the weak correlation in this study could be caused by an inconsistency in the direction of the correlation between air humidity and the incidence of DHF (15). Air humidity of 60-90% is conducive humidity for Aedes larvae to breed. As seen in the first week of January 2019, with a humidity of 74.3%, there were 7 cases of DHF. In the second week of January 2019 humidity of 80.1% increased cases to 19 cases. In the fourth week of January 2019, with 83.9% humidity further increased the number of cases to as many as 42 cases. This clearly shows a positive or unidirectional relationship between air humidity and the incidence of DHF. However, in the third week of May 2019 with a lower humidity of 69.1%, 27 cases were found, which indicates a fairly high number of cases. The existence of this inconsistency can be the cause of the weak relationship between these two variables. This weak relationship between air humidity and the incidence of DHF can be caused by factors outside the climate, such as government intervention with the implementation of the DHF control program.

Air humidity can affect the lifespan of the Aedes aegypti mosquito. Air humidity above 60% makes the lifespan of the Aedes aegypti mosquito longer, spreads quickly, and has the potential to breed. This condition creates a great opportunity for mosquitoes to become infected and infect humans. Dry air humidity, below 60% as the optimal air humidity limit for mosquitoes will affect the breathing of mosquitoes using a tracheal tube with a spiracle air estuary. When the air is not humid, there will be evaporation of water from the mosquito's body so that a lot of mosquito body fluids come out. There is the evaporation of water in the mosquito's body which results in the short life of the mosquito (16). This is in line with some studies in Vietnam, there were significant correlations between monthly DF/DHF cases with monthly relative humidity ($r = -0.358$, $P < .05$) in Hanoi, and there were strong correlations between monthly DF/DHF cases within that period with average rainfall ($r = 0.70$), humidity ($r = 0.59$) in Ba Tri District, Ben Tre Province during 2004 to 2015 (17,18).

The wind speed in Kalideres District has an average of 1-2 m/s, it doesn't fluctuate too significantly. There was no significant correlation between wind speed and the incidence of DHF in this study. The insignificant result between wind speed and the incidence of DHF in this study could be due to other influences that can also affect the ability of mosquitoes to fly. Mosquito flight distance can be shortened or extended depending on the wind direction field (19). This is in line with research conducted in Bone Province which also stated that wind speed had no effect on the occurrence of DHF due to the relatively constant wind speed over time, but the others said that wind speed has the most significant effect on DHF (20,21). The air temperature also has no effect on the incidence of DHF. This is in line with research conducted in Bone Province which stated that air temperature had no effect on the occurrence of DHF. Air temperature is indeed related to the acceleration of mosquito development from eggs to adult mosquitoes, but there may be an increase in mosquito vectors but not infective. So that the possibility of transmission is low. Variations in temperature that do not fluctuate much can also affect a non-significant relationship between air temperature and the incidence of DHF(20).

5 Conclusion

Rainfall and air humidity correlated with the incidence of DHF. Rainfall and air humidity have a weak effect on the incidence of DHF, while air temperature and wind speed are not related to the incidence of DHF. Early detection through dengue surveillance and mosquito vector control during high rainfall is highly recommended.

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