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Climate Variability Effects On Rising Dengue Incidence In Jakarta Province: A Case Study in Kalideres District

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Abstract In Jakarta, the frequency of dengue hemorrhagic fever (DHF) varies throughout the year. The municipality of West Jakarta contributed 5,301 cases, or the second-highest amount, to the incidence of DHF in the Daerah Khusus Indonesia (DKI) Jakarta Province between 2017 and 2020. The West Jakarta municipality's Kalideres district has the greatest incidence of DHF as a result. Globally, climate change is now taking place. Climate plays a significant role in the spread of dengue illness. The goal of this study was to examine how increased dengue fever incidence in Jakarta, particularly in the Kalideres District, in 2019-2020 was impacted by climate change. The study was cross-sectional in design. Climate change was evaluated using weather conditions, rainfall, wind speed, and air humidity recorded by the Meteorological, Climatological, and Geophysical Services. A daily report of DHF is used to collect the incidence of DHF obtained from the Kalideres District Health Center. Multiple linear regression is used to analyze the data. All independent variables (air temperature, rainfall, air humidity, wind speed) simultaneously have a significant effect on the incidence of DHF ($p<0.05$). R= 0.436 indicates how well the model predicted the occurrence of DHF. R^2= 0.190 indicates how well the model explained the variance in the dependent variable. By examining these coefficients, it can be concluded that the model's predictions of the dengue incidence or DHF shown here are weak. Early detection, preparedness, and responses through strengthening dengue surveillance and mosquito vector control are highly recommended.

Keywords Climate Variability, Dengue, Incidence, Multiple Linear Regression

1. Introduction

An illness known as dengue hemorrhagic fever (DHF) is brought on by the dengue virus and spread by the Aedes aegypti mosquito. The World Health Organization (WHO) states that dengue cases have made more than 100 countries endemic, including Africa, the Americas, the East Mediterranean, Southeast Asia, and the West Pacific Regions, with a tendency for cases to increase yearly. In 2008 and 2010, DHF cases were more than 1.2 million and 2.3 million cases in America, Southeast Asia, and the Western Pacific. WHO also stated that Asia ranks first in the annual DHF case data worldwide. There are eight countries in Asia with the highest dengue cases, specifically, Timor Leste, Indonesia, Myanmar, Bangladesh, India, the Maldives, Sri Lanka, and Thailand. The country with the most dengue cases in Southeast Asia is Indonesia [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, and agent factors are related to the characteristics and virulence ability of the dengue virus. In contrast, environmental factors are related to vector capacity, one of which can be affected by climate change [2]. This is because the impacts of climate change can be felt directly and indirectly, especially by humans in 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 specific 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].

Globally, climate change is now taking place. 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 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 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 from 1.4°C to 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 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 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 had the highest number of dengue cases throughout 2017-2020, with a total of 1,549 cases, followed by the Cengkareng sub-district with the second highest with 1,483 cases. Because of the problems described above, the author want to analyze 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 multiple linear regression statistical test and STATA 17 software. The extension of simple linear regression to incorporate many explanatory variables is known as multiple linear regression. This analysis aimed to measure the relative effects of the predictor factors on a specific outcome [9], [10]. Equation (1) for multiple linear regression :

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots\ldots + \beta_p x_{pi} + e_i \qquad (1)$$

When all explanatory variables are 0, the predicted value of y in the simple situation is β_0 (the constant). Each explanatory variable in a model with *p* explanatory variables has its own coefficient (β_coefficient) [11]. Before performing statistical analysis, the normality test was first performed. The data's distribution was checked using a normality test to see if it was normal. When the significance value exceeds 0.05, the distribution is referred to as being regularly distributed. The data were considered to be regularly or normally distributed because the significance value for the normality test was 0.165 (p-value > 0.05).

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 DHF and climate every week are presented in Figure 1.

Table 1. Multiple Linear Regression Analysis Result Related to Incidence of DHF

Climate variability	β	t	p	CI 95%
Air temperature	-1.895	-2.86	0.005	-3.209 – -.580
Rainfall	-.120	-0.93	0.354	-.377 – .136
Air humidity	.946	4.16	0.000	.495 – 1.398
Wind speed	-2.231	-0.57	0.570	-9.995 – 5.533
β_0= -1.313	R=0.436	R^2= 0.190	F(4,99)= 5.81	p= 0.0003

The F test result for Table 1 is 0.0003. The F test accepts H_1 at a significance level of 5% if the value is < 0.05, indicating that all independent variables—air temperature, rainfall, air humidity, and wind speed—significantly influence the incidence of DHF at the same time. R= 0.436 indicates how well the model predicted the dependent variable. R^2= 0.190 indicates how well the model explained the variance in the dependent variable or DHF. By examining these coefficients, it can be concluded that the model's predictions of the dengue incidence shown here are not strong or weak.

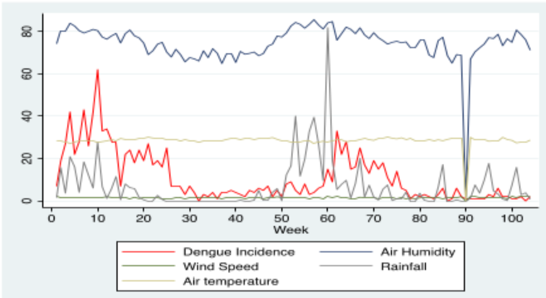

Figure 1. Climate variability and Dengue Incidence in 2019-2020

The order of significance of the independent variable is indicated by the absolute value β in Table 1. The independent variable that has the highest β value is considered to be of relative most significance. It was found that wind speed made the most significant contribution, followed by air temperature, humidity, and rainfall. The question was obtained based on the multiple regression analysis results, as shown in equation (2).

$$Incidence\ of\ DHF = -1.313 - 1.895\ Air\ temperature - 0.120\ Rainfall + 0.946\ Air\ humidity - 2.231\ Wind\ speed \qquad (2)$$

2.1. Air temperature and the incidence of DHF

We can test for the statistical significance of each independent or explanatory variable. Table 1 shows that the p-value of 0.005 is smaller than 0.05, indicating that air temperature is related to the incidence of DHF. The regression coefficient of the relationship between these variables is 1.895 in a negative direction. In other words, the relationship between these two variables is undirectional.

2.2. Rainfall and the incidence of DHF

The analysis results in table 1 show that the p-value is 0.354, where the value is more significant than 0.05. Indicates that rainfall is not related to the incidence of DHF. The regression coefficient of the relationship between these variables is 0.120 in a negative direction. In other words, the relationship between these two variables is undirectional.

2.3. Air humidity and the incidence of DHF

The p-value shows a result of 0.000, which indicates that the air humidity is related to the incidence of DHF. The regression coefficient of the relationship between these variables is 0.946 with a positive direction, meaning that the relationship between the two variables is unidirectional, i.e., the greater the humidity, the greater the incidence of DHF.

2.4. Wind speed and the incidence of DHF

Wind speed is not related to the incidence of DHF, according to the analysis results in table 1, where the p-value of 0.570, where the value is greater than 0.05, suggests. The regression coefficient for the association between these two variables is 2.231, and the fact that it is negative indicates that the link is undirectional.

4. DISCUSSION

The air temperature in Kalideres District does not fluctuate much every week. It tends to increase in the weeks of April-October and decrease in November-March. This temperature fluctuation is not more than 2 °C, so it tends to be in the same range every time. The lowest temperature was in the fourth week of January 2019, which was 27.3°C. Meanwhile, the highest temperatures are in September and November 2020, ranging from 29-30°C. According to the findings of this study, there was a relationship between air temperature and the incidence of DHF in a negative direction.

The average air temperature in Kalideres District in 2019 and 2020 was 28.9 °C with a total of 782 and 384 cases, while the average temperature for mosquitoes to breed well is around 25-27 °C. The air temperature in Kalideres District tends to be hotter than its productive temperature, so this can be a cause that makes air temperature has a negative direction with the incidence of DHF. When the air temperature is hotter, the air moisture content or humidity tends to be low. In other cases, dry air can evaporate the water content in the mosquito's body so that a lot of mosquito body fluids come out [12]. When the vector balance is disturbed and does not meet the host, agent, and environmental principles, this can be an answer related to air temperature, which does not affect the incidence of DHF. Air temperature is related to the accelerated development of mosquitoes from eggs to adult mosquitoes, but it could be the possibility of an increase in non-infective mosquito vectors. So that transmission can occur with a lower potential. Research conducted by Youngjo Choi in Cambodia states that air temperature is significantly related to the incidence of DHF in 3 provinces in Cambodia. This can be caused by differences in location and implementation of early warning systems that are well implemented [13].

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. Rain 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 DHF [14], [15].

According to the findings of this study, a negative direction between air temperature and the incidence of DHF existed. According to the data that has been gathered, the first week of March 2019 saw the greatest incidence of DHF in the Kalideres District, with 27.7mm of rainfall. The second most were 43 cases in the second week of February 2019, with 18.4mm of rain, and the third most were 42 cases in the fourth week of January and February 2019, with 20.9mm and 6.1mm of rainfall. This is consistent with a study from Tomohon City, in the east of Indonesia, which found a correlation between rainfall and the incidence of DHF (p-value = 0.019). A female Aedes mosquito can lay anywhere between 100 and 300 grains of eggs, which 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 rain, can become a breeding ground for the Aedes aegypti mosquito, increasing the incidence of DHF [16].

The relationship between rainfall and the incidence of DHF in this study shows a negative direction. This may occur due to the rainfall's characteristics related to the intensity of rainfall. It is said that high-intensity and continuous rain that causes flooding can wash away the breeding site and cause the population to decrease. Throughout 2019-2020, the highest number of dengue cases was 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 rain 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 of rainfall, and the incidence of DHF in this study tends to be weak. Researchers also believe that other factors outside the climate also affect the number of dengue cases, such as the role of community habits or interventions that the government has carried out.

Air humidity can be affected by the influence of rainfall. Along with increasing rainfall, it can be followed by increased air humidity. The 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 rain begins to decline. Based on this study, air humidity has a relationship with the incidence of DHF, with a p-value of 0.000. The weak strength of the model predicts the incidence of dengue in this study could be caused by an inconsistency in the direction of the correlation between air humidity and the incidence of DHF [17]. Air humidity of 60-90% is conducive to breeding for Aedes larvae. 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, the humidity of 80.1% increased issues to 19 cases. In the fourth week of January 2019, 83.9% humidity increased the number of instances 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 reasonably high number of cases. The existence of this inconsistency can be the cause of the weak relationship between these two variables. Factors outside the climate, such as government intervention in implementing the DHF control program, can cause this weak relationship between air humidity and the incidence of DHF.

Air humidity can affect the lifespan of 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 an excellent 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, water from the mosquito's body will be evaporated so that a lot of body fluids come out. The evaporation of water in the mosquito's body results in the mosquito's short life [18]. 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 between 2004 and 2015, there were significant associations between monthly DF/DHF cases and average rainfall ($r = 0.70$) and humidity ($r = 0.59$) in Ba Tri District, Ben Tre Province [19], [20].

The wind speed in Kalideres District has an average of 1-2 m/s, and it doesn't fluctuate significantly. 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 [21]. Research conducted in Bone Province, which also stated that wind speed did not affect the occurrence of DHF due to the relatively constant wind speed over time, but others said that wind speed has the most significant effect on DHF [22], [23].

5. CONCLUSION

Multiple regression was run to predict the incidence of DHF from air temperature, rainfall, air humidity, and wind speed. These variables simultaneously significantly affect the incidence of DHF ($p<0.05$). This study was only conducted in Kalideres District. We recommend that future studies involve larger populations with different climates and geographic locations. In addition, multi-year climate variability may play a role in dengue dynamics. Early detection, preparedness, and responses through strengthening dengue surveillance and mosquito vector control are highly recommended.

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