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CONTRIBUTION OF CLIMATE FACTORS TO THE INCIDENCE OF DENGUE FEVER IN TOBELO CITY, NORTH HALMAHERA DISTRICT, 2017-2021

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Abstract

Climate change is a primary driver in accelerating certain regions' Dengue Hemorrhagic Fever (DHF) pandemic. Key climate factors, such as temperature, humidity, and rainfall, significantly contribute to mosquito vectors' spread and infection of the dengue virus. This study was conducted in Tobelo City, North Halmahera Regency, using data from the "DHF Cases and Climate Factors over the Last 5 Years in Tobelo City". The climate factors examined were rainfall, humidity, and air temperature. A path analysis was utilized to observe the relationship between DHF cases and Climate Factors (rainfall, air humidity, air temperature) in Tobelo City. The climate factors studied are rainfall, humidity, and air temperature. Path analysis was used to see the relationship between dengue fever cases and climate factors (rainfall, air humidity, air temperature) in Tobelo City. The research results show that rainfall (X2) has a direct effect on the incidence of dengue fever (Y1) through temperature (3X) = 0.0816, with a significant contribution of = 0.8046. Humidity has no direct effect on dengue fever (Y) incidence. Meanwhile, indirectly through temperature (X3) = 0.028. There was a positive relationship between humidity and temperature in dengue cases, but the relationship was fragile (29.8%).

Keywords: Climate Factors, DHF Cases in Tobelo City.

INTRODUCTION

Climate factors are critical parameters in Dengue Hemorrhagic Fever (DHF) in a particular region. These factors include temperature, humidity, rainfall, and wind [1]. Several factors that influence the incidence of DHF are climate-related, such as temperature, humidity, rainfall, and wind. Climate change triggers the acceleration of the DHF pandemic [2]. Bahtia et al., 2022, explained that temperature, humidity, and rainfall are the main climate factors causing the spread and infection of the dengue virus by mosquito vectors [3]. Climate factors are indicators in predicting the occurrence of dengue fever, including air pressure, temperature, and humidity measurements [2].

Climate factors are often used to predict the incidence of DHF in a region [4]. Sabbir et al., 2022, explained that the prediction of DHF disease development is based on 1) Socio-demographic factors significantly influence the transmission of DHF, and socio-demographics are a significant challenge in predicting the occurrence of DHF transmission and 2) The estimation of DHF can use climate change indicators, such as rainfall and air humidity [5].

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Dininta et al., 2021, stated that climate is a part of the physical environment that significantly influences the incidence of DHF [6]. Air temperature affects mosquito bite rates, mosquito reproduction, the extrinsic incubation period of the virus, and mosquito distribution [7]. Meanwhile, high rainfall and humidity can influence the formation of mosquito breeding sites, thereby increasing the density of the female mosquito population [8]. Climate change contributes significantly to the transmission of the dengue virus, causing DHF. Climate change is believed to be the leading cause of global transmission of virus infection and the development of *Ae. Aegypti* mosquitoes are the primary vector of DHF [9].

The incidence of DHF in Indonesia varies from year to year. In 2017, there were 68,407 cases of DHF, and in 2018, there were 65,602 cases. In 2019 (January-July 2020), there were 71,663 patients with DHF in Indonesia spread across 34 provinces and 459 deaths. The number of DHF cases from 2009 to December 2019 reached 110,921 [10], whereas in 2020, there were 108,303 cases, and in 2021, there were 73,518 cases and 705 deaths [11].

DHF case data at the Tobelo City Health Office in 2017 was 2 cases; in 2018, there were 60 cases; in 2019, there were 462 cases; in 2020, there were 51 cases; and in 2021, there were 68 cases [12]. This shows that Tobelo City is still not safe from DHF cases; the Tobelo City Health Office has made many efforts to suppress the surge in DHF cases in the future. However, the efforts are still insufficient to reduce the number of DHF cases. This research was conducted to analyze the contribution of climate factors influencing the occurrence of DHF cases in Tobelo City as an anticipatory step in controlling DHF in Tobelo City.

MATERIAL AND METHODS

This research was conducted in Tobelo City, North Halmahera Regency. The source of the DHF case data used came from the Tobelo City Health Office over five years (reporting period 2017-2021). The observed climate factors include rainfall, humidity, and air temperature, obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG) of North Halmahera for five years. Path analysis examined the relationship between DHF Cases and Climate Factors (Figure 1).

The stages of path analysis were performed using an analysis model presented by Yamin and Kurniawan in 2010, which involved checking multivariate data normality assumptions, testing model feasibility, and decomposing tables and path diagrams resulting from the significance test of the path coefficient [13] The structural model of the path coefficient is explained as follows:

$$X2 = pX2X1\ X1 + eX2 \text{ (substructural 1)}$$

$$X3 = pX3X1\ X1 + pX3X2\ X2 + eX3 \text{ (substructural 2)}$$

$$Y1 = pY1X1X1 + pY1X2X2 + pY1X3\ X3 + pY1 \text{ (substructural 3)}$$

The determination of standardized correlation can be explained structurally (causally) and non-structurally (non-causally) using the theory explained in a path diagram [14].

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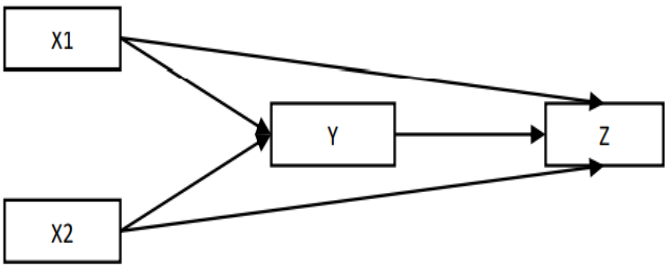

Figure 1: Path Diagram in Path Analysis Method (Sarwono, 2014 in Yanto, 2022)

RESULTS

1. Climate Conditions in Tobelo City

The climate conditions over five decades (2017-2021) can be explained in Figure 2

Based on the climate data of Tobelo City, the average Rainfall ranged between 86.2-312.82nm, Humidity 88-89.6%, and Air Temperature 24.08-26.88°C. The highest average rainfall occurred in January (312.92%), while the highest air humidity was in January (89.6%), with the air temperature at 26.88°C and rainfall (312.92nm).

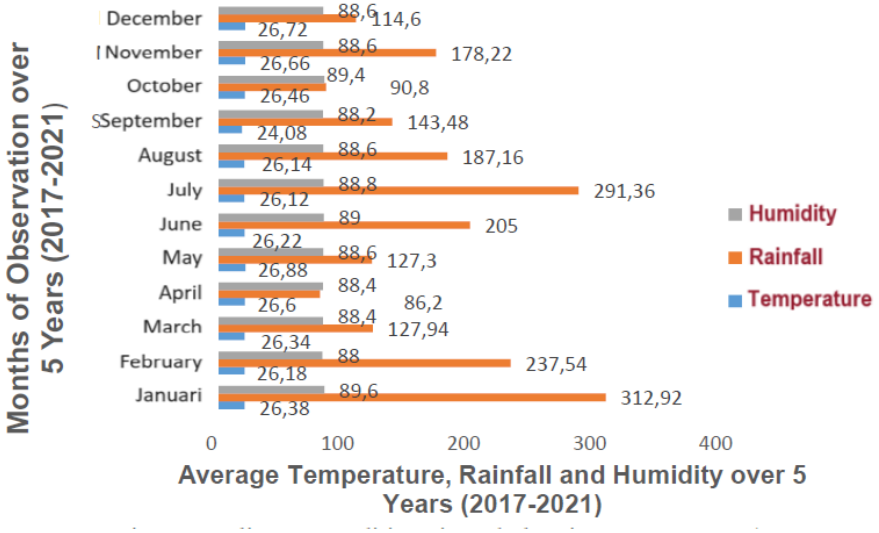

Figure 2: Climate Conditions in Tobelo City over 5 Years (2017-2015 Periods)

2. DFH Cases

DHF cases in Tobelo City fluctuated and tended to vary from year to year from 2017 to 2021. The case increase occurred from January to June 2019, and the highest number of cases occurred in June 2019. This happened at the end of the rainy season and the beginning of the transition. In 2020, the cases occurred from January to July. In 2021, DHF cases occurred every month for one year, except in September, when there were no DHF cases (Figure 3).

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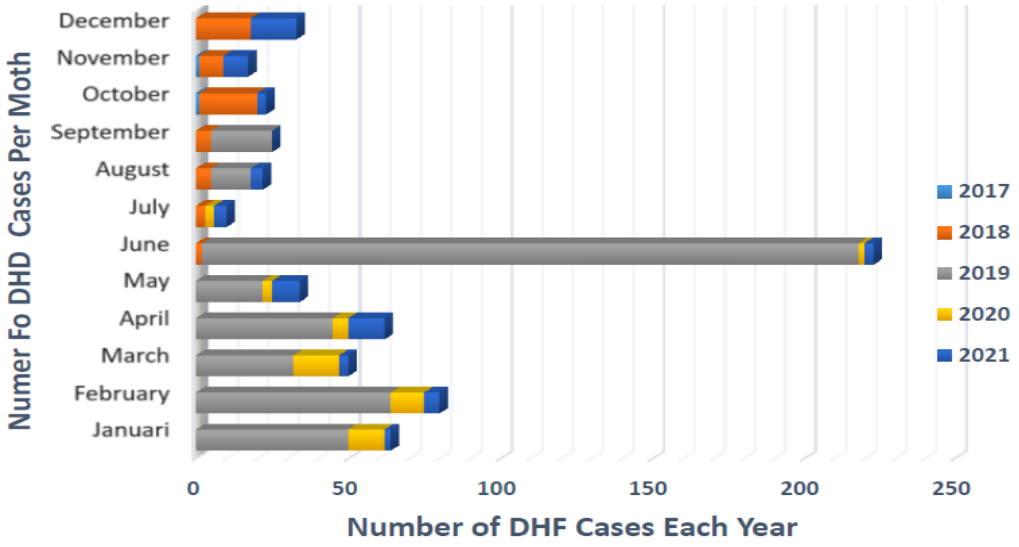

Figure 3: Number of DHF cases in 2017 - 2021 in Tobelo City

The climate changes in Tobelo City significantly affect the density of DHF vector larvae with an ABJ value in the moderate category (67%). Meanwhile, the relationship between climate changes such as rainfall, humidity, and temperature with the presence of DHF vector larvae in Tobelo City can be seen in Table 1.

Table 1: Path coefficient of the effect of humidity, temperature, and rainfall on the presence of DHF vector larvae in Tobelo City

Model		Unstandardized Coefficients		Standardized Coefficients	P
		B	Std. Error	Beta	
1	(Constant)	46.143	108.223		.311
	Temperature	.024	.286	.017	.023
	Humidity	.032	1.011	.102	.061
	Rainfall (X1)	.000	.012	.017	.005
	Temperature (X2)	.015	.022	.523	.000
	Humidity(X3)	.025	.025	1.101	.000

**Dependent: DHF_Cases (Y1)*

Statistical analysis results in Table 1 show that the variables of humidity and temperature have a positive value with a B value = 0.024 (temperature) and B value = 0.032 (humidity), with a P value = 0.023 (temperature) and P value = 0.061 (humidity). From these data, it is evident that there is a significant relationship between temperature and humidity and the occurrence of DHF in Tobelo City. Meanwhile, if there is an increase in the temperature and humidity variables by 1 unit, it will increase the rainfall by 0.017, affecting the increase in humidity by 0.102 units.

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The case explained in Table 2 (number 2) shows that the rainfall (X1), temperature (X2), and humidity (X3) variables have a positive value for unstandardized coefficients (B) of X1=0.00, X2=0.015, and X3=0.025, with P values = 0.005 (X1), 0.00 (X2) and 0.00 (X3). From these data, it is evident that the temperature, humidity, and rainfall factors significantly affect the occurrence of DHF. If there is an increase in each of the humidity, temperature, and rainfall factors by 1 unit, it will increase the incidence of DHF by 0.017 (X1), 0.523 (X2), and 1.101 (X3). The contribution of each humidity, temperature, and rainfall variable partially to each other can be explained in Table 2.

Table 2: Parameter model estimation results

Model	Path Coefficient	T	P	R^2	e
Sub structural 1 (X1 X1 to X3					
X1 Humidity	.035	.118	.023	0,76	0,80
X2 Rainfall	.102	.462	.061		
Sub structural 1 (X1 X1 X3 to Y1)					
X1 Humidity	.027	.146	.005	0.85	0,053
X2 Rainfall	.723	20.543	.000		
X3 Temperature	1.101	31.255	.000		

The path analysis results in Table 2 and Figure 4 explain that the climate factors in this study contribute to the occurrence of DHF in Tobelo City. Rainfall affects the contribution of humidity and air temperature to DHF cases. The results show that there is an indirect influence of humidity (X1) on the occurrence of DHF (Y) that occurs through Temperature (X3) = 0.035 x 0.80 = 0.028, so it is evident that the contribution of humidity and temperature to the occurrence of DHF cases is = 0.27 +0.028 = 0.298. Meanwhile, the indirect effect of rainfall (X2) on DHF cases (Y1) that occurs through temperature (X3) = 0.102 x 0.80 = 0.0816, with a total value of = 0.723 + 0.0816 = 0.8046. According to the results of the path diagram analysis, humidity, and temperature have a positive effect. Still, the relationship is fragile on the occurrence of DHF cases, which is 29.8%, while rainfall (X2) and temperature (X3) have a positive effect and are strongly related (80%).

DISCUSSIONS

The Dengue Hemorrhagic Fever (DHF) cases in Tobelo City over the five years (2017-2021) occurred in fluctuations. The highest average number of DHF cases occurred in June 2019 and subsequently decreased and fluctuated until 2021. Meanwhile, climate factors, exceptionally high rainfall, started in January, then decreased until April, and increased again from May to June, reaching its peak in July, and then decreased in August, with fluctuations until December, as observed for temperature and humidity. Changes in rainfall contribute to fluctuations in temperature and humidity, which in turn affect the presence of mosquitoes in the field. According to Yanto (2022), humidity is associated with an increase in the eating patterns of *Aedes aegypti* mosquitoes, which affects the increase in mosquito populations in Denpasar City [15].

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Based on research findings, it is known that rainfall directly contributes to the occurrence of DHF cases. In contrast, temperature and air humidity do not directly contribute to the development of DHF. However, rainfall does affect the creation of temperature and humidity that support the development of the vector. However, the research results of Tomia et al., 2019, reported that rainfall can cause a decrease in the mosquito vector population due to the loss or destruction of mosquito vectors habitats in the field as a result of heavy rainfall [7] Rainfall reduces the habitat of DHF vector in the field, as the water washes away mosquito larvae when it overflows [16]. Based on the survey results, the ABJ value in Tobelo City is 67%, indicating that there is still the potential for DHF cases to occur in the city.

The path analysis results in Tobelo City show that humidity (X1) through temperature (X3) influence is significant for DHF cases and vice versa. The same applies to rainfall (X2) through temperature (X3), which is significant for DHF cases or vice versa. The same analysis was also conducted in the study by Yanto in 2022, using path analysis, which resulted in the significant effect of temperature (X1) through rainfall (Y) on the number of DHF cases (Z) and vice versa [17]. However, unlike humidity (X2) through rainfall (Y), it does not have a significant effect on the number of DHF cases (Z), and vice versa. This may be because not all climate factors are related to DHF cases [18].

The research conducted by Nisa in 2018 in Karanganyar Regency explains that rainfall significantly affects the occurrence of DHF, and an increase in the number of DHF cases can occur when rainfall is high, and vice versa; a decrease in DHF cases is in line with a decrease in rainfall [19]. Bone et al. explain that in 2021, there will be an increase in rainfall in DHF cases [20]. Naish et al. explained in 2014 that based on epidemiological data in various countries, every case of DHF is always identified with the rainy season, and an increase in rainfall mutually affects each other [21]. However, a positive relationship can occur because rain can reduce the population of larvae and DHF cases, as rain can eliminate the habitat of DHF mosquito larvae, thus affecting the number of DHF cases [16, 22]

The temperature in Tobelo City ranges from 24.08-26.88˚C, which can affect the behavior of mosquitoes, such as changes in biting behavior, average number of bites, and maturity of mosquito parasites. An increase in temperature can also shorten the incubation period of dengue fever (DHF) [23]. In general, climate factors such as temperature and humidity significantly affect the biology of vectors and the interaction between vectors and viruses, the age and resistance of vectors, mating, spread, feeding behavior, oviposition, and faster virus replication [24]. Temperature affects the extrinsic incubation period (EIP), which ranges from 25-28˚C and lasts about 8-12 days [25].

The optimal temperature for mosquito activity is in the range of 25-30°C, while the average temperature of Tobelo City is in the range of 24.08-26.88˚C. Temperature can affect the life cycle and metabolic processes of mosquitoes. Mosquito development occurs within the temperature range of 25˚C-27˚C; if the temperature exceeds 40˚C, mosquito growth will stop [26]. The temperature range in Tobelo City during the study can affect the activity of mosquito vectors in search of food, thereby accelerating the transmission of the virus.

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Based on the research, it is observed that humidity in Tobelo City does not have a significant effect, but there is a weak positive relationship. The humidity range in Tobelo City is between 88-89.6%, indicating that within that temperature range, it is the optimal temperature for DBD vectors to be active. Using correlation tests, bone et al. in 2021 showed no significant relationship between humidity and the occurrence of DBD (p = 0.299). Still, it forms a positive correlation with a feeble correlation strength (r = 0.124), with a humidity of 82%. Furthermore, it is stated that an increase always follows an increase in the occurrence of DBD in humidity levels [27]. The research conducted in Bitung City also does not show a significant relationship between humidity and the occurrence of DBD, although the relationship is positive [28].

CONCLUSIONS

The cases of Dengue Hemorrhagic Fever (DHF) in Tobelo City over five years (2017-2021) occurred in fluctuations. The highest average number of DHF cases occurred in June 2019 and subsequently declined. The survey results of DHF vectors in each region of Tobelo City still have the potential to cause DHF cases, with an ABJ value of 67%. These results indicate that there is an indirect influence of humidity (X1) on DHF cases (Y) that occurs through temperature (X3) = 0.028, resulting in a contribution of humidity and temperature to the occurrence of DHF cases = 0.298.

Meanwhile, rainfall (X2) directly affects DHF cases (Y1) that occur through temperature (3X) = 0.0816, with a contribution of = 0.8046. The analysis of the path diagram shows a positive but fragile relationship between humidity and temperature with DHF cases, which is 29.8%.

On the other hand, the relationship between rainfall (X2) and temperature (X3) is positively and strongly related (80%). It is recommended to monitor the risk of increasing DHF cases early based on temperature, humidity, and rainfall data. To reduce the population of DHF vector mosquitoes, PSN activities with 3M Plus can be carried out in areas with DHF cases.

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