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Environmental Factors linked to the Presence of *Aedes aegypti* Larvae and the Prevalence of Dengue Hemorrhagic Fever

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Abstract

AIM: This study aimed to examine the effect of environmental factors and the presence of Aedes aegypti larvae on the prevalence of Dengue Hemorrhagic Fever (DHF) in Bukittinggi. In particular, the study was conducted to reduce the prevalence of DHF through vector control (A. aegypti) guided by the mosquito larvae free rate by proposing a model for environmental management in an A. aegypti larva-free area in Bukittinggi.

METHODS: Precipitation, air temperature, and humidity in 2015–2019 in Bukittinggi were measured to analyze their effect on the prevalence of dengue fever. Samples of data on the prevalence of dengue cases were carried out in total population against data on the prevalence of dengue cases, which amounted to 686 cases, and data on mosquito larvae free rates during 2015–2019. Pearson correlation analysis was used.

RESULTS: The results show that the average air temperature in Bukittinggi over the past 5 years allows mosquitoes to survive because they have an average air temperature that functions as an optimum breeding vector. High precipitation can be expected to increase the breeding places of the A. aegypti so that the population will increase also has an impact on increasing cases in that month and several months later. Furthermore, the results confirm that there is no significant relationship and also no correlation between physical environmental factors, such as air temperature, humidity, and precipitation with the prevalence of dengue cases in Bukittinggi during the 2015–2019 periods.

CONCLUSION: Based on the pattern of distribution of DHF cases in Bukittinggi during the 2015–2019 periods, controlling the prevalence of DHF cases needs to focus on activities in areas/villages that are endemic for DHF, without neglecting areas/villages where the prevalence of DHF cases is low, both at the temperature of the air and the mosquitoes will cause dengue fever experience optimal development, low, medium, and high precipitation, as well as in humidity where mosquitoes will experience ideal development.

Introduction

The vector of dengue hemorrhagic fever (DHF) is the *Aedes aegypti* mosquito. The *A. aegypti* lives in the lowlands with tropical to sub-tropical climates. In areas that are too high (> 1000 m) above sea level, dengue fever mosquitoes are usually not found [1]. According to Hadid *et al*. [2] stated that there was a significant relationship between knowledge, attitudes, and prevention of DHF with the presence of *Aedes* sp. According to Prasetyowati *et al*. [3] stated that the number of containers is significantly related to the presence of larvae. Nurrochmawati and Dharmawan [4] stated that the occurrence of DHF is possible with the presence of live mosquito larvae. There is a significant relationship between pH, temperature, and water and air humidity with the presence of *A. aegypti* larvae [5]. On the other hand, air temperature does not have a significant relationship with the presence of *A. aegypti* larvae. According to Dinata and Dwantara [6], the existence of containers plays a very important role in increasing the density of the *A. aegypti* vector, because the more the number of containers in an area, the more places are used for breeding *A. aegypti* mosquitoes, The social environment conditions have a fairly important role in the transmission of dengue disease, which refers to education, population mobility, employment, income, the presence of DHF care groups, and activities. According to another study, Getachew *et al*. [7] stated that *A. aegypti* breeds in various artificial containers. To control these mosquitoes, the integration of various methods should be considered. The DHF control model can be used for early precautions by controlling DHF in the period from January to June. In that month, the rainy season will end, but there will be puddles of water as a breeding ground for the *A. aegypti* and an increase in air temperature that increases the transmission of DHF [8].

The program for preventing and reducing the high prevalence of DHF is closely related to the community participation in planning and implementing program activities [9]. Darwin *et al*. [10] stated that the integrated control model for DHF vectors in Salatiga was conducted through integrated control through the application of M. aspericornis and curtains with the insecticide cypermethrin 10EC, a dose of 0.5-gram ba/m plus 0.1% ethyl cellulose could increase the larval free rate and lowering ovitrap index. In addition, other researcher, Fidayanto *et al*. [8] stated that the dengue control model is divided into several node management, namely, node one management regarding control of the source of the disease such as dengue patients by actively searching for cases and establishing cases in promotive and preventive efforts because it prevents cases from occurring, there is no further transmission in the community. Halasa *et al*. [11] stated that from 2002 to 2010, the aggregate annual cost of DHF was an average of $38.7 million, of which 70% was for adults (aged 15+ years). Hospitalized patients accounted for 63% of the cost of dengue fever. Households funded 48% of the cost of dengue fever, government funded 24%, insurance funded 22%, and entrepreneurs funded 7%. Including dengue surveillance and vector control activities, the overall annual cost of dengue fever was $46.45 million ($12.47/capita).

DHF cases began to appear in Bukittinggi in 2005 and were designated as endemic areas. This incident was caused by climate change and global warming, and in 2012 Bukittinggi was designated as an extraordinary event area with the discovery of fatalities due to dengue fever. In 2014, there were 139 DHF patients with IR/Prevalence Rate = 115.36/100,000 population with no deaths. There was an increase in 2015 found 141 cases of DHF with IR = 114.99/100,000 population with no deaths. In 2016, it found 106 cases of DHF, the IR dropped to 84.99/100,000 population but there were two deaths with a CFR of 1.8%. It is still far from the target of the Ministry of Health for the morbidity rate IR <55/100,000 population and CFR <1% so that dengue cases in Bukittinggi are categorized as high [12]. Based on these problems, this study was conducted in order to reduce the prevalence of DHF through vector control (*A. aegypti*) which is guided by the Mosquito Larvae Free Rate by proposing a model for environmental management of *A. aegypti* larvae-free areas in Bukittinggi.

Methodology

Research design

This type of research is survey research, namely research that takes secondary data collected in the form of data on cases of dengue fever, data related to the presence of *A. aegypti* larvae, risk factors for dengue prevalence including, free rate of mosquito larvae, physical environment, namely, precipitation, air humidity, and air temperature.

This research method will be used to answer the formulation of the problem with the intention of explaining (explanatory or confirming) the causal relationship and testing hypotheses or explanations. The research was conducted in Bukittinggi in 2020, which consists of three sub-districts: Guguk Panjang, Tigo Baleh, and Mandiangin Koto Selaya sub-districts.

Sampling and inclusion criteria

The population in this study includes a collection of data on the prevalence of dengue cases in Bukittinggi and climate data including: Precipitation, air temperature, and humidity in 2015–2019 in Bukittinggi, as well as secondary data for other phenomena that already exist and can be measured. Data on the prevalence of dengue cases from 2015 to 2019, as many as 686 cases of dengue fever and mosquito larvae-free rate, spread over three sub-districts, and 24 sub-districts. Climatic data include precipitation, air temperature, and humidity in 2015–2019 in Bukittinggi. Samples of data on the prevalence of dengue cases were carried out in total population against data on the prevalence of dengue cases, which amounted to 686 cases, and data on mosquito larvae free rates during 2015–2019. Climate data samples include data on average precipitation, average air temperature, and average air humidity taken for the total population from 2015 to 2019.

To get the desired sample, it is necessary to set the criteria. Inclusion criteria were set on the basis that all data on the prevalence of dengue cases occurred from 2015 to 2019, and all climate data included data on average precipitation, average air temperature, and average air humidity from 2015 to 2019. The exclusion criteria were data on the prevalence of DHF cases were incomplete with their addresses, and data were not available.

Data retrieval of all cases of DHF, larvae-free rate data from 2015 to 2019, which is available at the Puskesmas and at the Bukittinggi Health Office, based on surveillance reports. Collecting physical environmental data (precipitation, humidity, and air temperature) for 2015–2019 in the form of a recap of the climate data, we need through the assistance of Climatology station of Sicincin, Padang Pariaman Regency.

Data analysis

The data collected in this study were secondary data. The data on the prevalence of dengue cases obtained from all Puskesmas and the Bukittinggi Health Office, and climate data obtained from the climatology office in Sicicin, Padang Pariaman Regency. The data analysis technique was carried out with the aim of answering the research problem formulation and research hypothesis. This researcher will analyze the data in accordance with the objectives and research hypotheses, using statistics. To determine the effect of climate factors on the prevalence of dengue cases and free-rate with the prevalence of dengue cases, the data analysis technique used was multivariate statistics.

Results

Changes in physical environmental factors include changes in the average air temperature, changes in the average air temperature in an area can be caused by air pollution, either naturally occurring or due to human activities, and this will have an impact on the emergence of a disease in the area, an area or region. For Bukittinggi, whether or not there is a relationship between air temperature and the prevalence during the past 5 years is shown in Table 1.

Table 1: Average air temperature and prevalence of DHF in Bukittinggi, 2015–2019

Year	Variable	Dengue cases		
		N	p-value	r
2015	Average Air Temperature	12	0.228	−0.376
2016	Average Air Temperature		0.031	0.621
2017	Average Air Temperature		0.064	0.550
2018	Average Air Temperature		0.064	0.031
2019	Average Air Temperature		0.633	0.154

Table 1 shows the results of the analysis of the correlation between the average air temperature and the prevalence of dengue cases for 5 years (2015–2019). The results of statistical test analysis using the Pearson correlation test showed that there was a relationship between the average air temperature and the prevalence of DHF cases in 2016 with p value (0.031) with a positive correlation degree (r = 0.621) meaning that the average air temperature and the prevalence DHF is moderately correlated. Furthermore, in 2017 showed a moderate and positive relationship (0.550) but the prevalence of dengue cases did not have a significant relationship with air temperature. Meanwhile, the highest prevalence of DHF cases occurred in 2019, and there was no correlation (0.154), and there was also no significant relationship between the prevalence of DHF cases and air temperature with a p-value (0.633).

Furthermore, with respect to the relationship between air humidity and the prevalence of DHF cases, Table 2 shows the results of the analysis of the average correlation of air humidity with the prevalence of DHF cases in 5 years (2015–2019). Based on the results of statistical analysis using the person correlation test, there is no significant difference between the average humidity and the prevalence of dengue cases, but it does show a correlation. The closeness of the strongest degree of influence occurred in 2016, with a value of (r = 0.553) meaning that there was a moderate degree of correlation with a positive moderate correlation, then in 2017 there was an influence with a weak correlation and in 2017 there was no degree of correlation between the average humidity with dengue cases (r −0.198).

Table 2: Average air humidity and the DHF prevalence in Bukittinggi, 2015–2019

Year	Variable	Dengue cases		
		N	p-value	r
2015	Average Air Humidity	12	0.164	−0.429
2016	Average Air Humidity		0.062	0.553
2017	Average Air Humidity		0.538	−0.198
2018	Average Air Humidity		0.442	−0.245
2019	Average Air Humidity		0.496	0.218

Statistical test of correlation regarding the relationship between average precipitation and the prevalence of DHF cases is shown in Table 3. Based on the results of statistical test analysis with the person correlation test, there is 1 year that has a significant relationship between the average precipitation and the prevalence of DHF cases, namely, in 2018 has a p-value (0.004), with a correlation value (r = 0.759), meaning that the average precipitation in Bukittinggi is strongly correlated. There are 2 years that have a moderately positive correlation, namely in 2016 with a value (r = 0.422) and in 2019 a moderate and negative correlation with a value (r -0.468), but there is no significant difference between the average precipitation and the prevalence of cases DHF in Bukittinggi.

Table 3: Average precipitation with the DHF prevalence in Bukittinggi, 2015–2019

Year	Variable	Dengue cases		
		N	p-value	r
2015	Average Precipitation	12	0.611	0.164
2016	Average Precipitation		0.171	0.422
2017	Average Precipitation		0.611	0.164
2018	Average Precipitation		0.004	0.759
2019	Average Precipitation		0.125	−0.468

Precipitation and the prevalence of DHF cases in Bukittinggi during the 2015–2019 periods, there was a significant relationship between precipitation and the prevalence of DHF cases, namely in 2018, which was included with the degree of a strong positive correlation (r = 0.759). This condition can be caused by the position of Bukittinggi which is at an altitude and is in the equatorial area which has two peaks in October, November, and March-May. The average rain every month is quite high, which is more than 150 mm. This pattern is influenced by shifts to the north and south of the ITCZ or the solar equinox. The peak of the rain usually occurs when the position of the Sun is above an area which is the Inter-Tropical Convergence Zone.

The absence of a relationship between precipitation and the prevalence of dengue cases is assumed because high precipitation does not have a direct relationship, although precipitation is high but rainwater is not supported by the availability of a container, the rainwater will not affect the breeding of *A. aegypti* mosquitoes. Furthermore, Table 4 shows the results of the correlation analysis of several physical environmental factors with the prevalence of dengue cases for 5 years (2015–2019).

Table 4: Physical environmental factors with the DHF prevalence, 2015–2019

Variable	Dengue cases		
	N	p-value	r
Average Air Temperature	60	0.799	0.034
Average Air Humidity		0.582	0.072
Average Precipitation		0.529	−0.083

Based on the results of statistical test analysis with the person correlation test, there is no significant relationship and there is also no correlation between physical environmental factors and the prevalence of dengue cases. The analysis of the average air temperature with the prevalence of DHF cases has a p-value of 0.799, and an r-value (0.034), it can be concluded that there is no relationship and there is no correlation between the average monthly air temperature and the prevalence of DHF cases. Analysis of the average humidity with the prevalence of DHF cases obtained p-value of 0.582, and the value of r (0.072), it can be concluded that there is no significant and uncorrelated relationship between the average humidity per month and the prevalence of DHF cases. Analysis of the average precipitation per month with the prevalence of dengue cases obtained p-value of 0.529), and the value of r (−0.083), the results of this analysis can be concluded that there is no relationship and no correlation between the average precipitation per month with the prevalence of dengue cases. Based on the analysis of the data in Table 5 in Bukittinggi during the 2015–2019 periods, it was concluded that the physical environmental factors including air temperature, humidity, and precipitation did not have a significant and uncorrelated relationship with the prevalence of dengue cases in Bukittinggi. The analysis of the effect of the larvae free rate with the prevalence of dengue cases is shown in Table 5.

Table 5: Risk level of the *Aedes aegypti* with the DHF prevalence

Year	Variable	Dengue cases		
		N	p-value	r
2015	Mosquito free-rate	12	0.087	−0.515
2016	Mosquito free-rate		0.106	0.106
2017	Mosquito free-rate		0,040	−0.599
2018	Mosquito free-rate		0.669	−0.138
2019	Mosquito free-rate		0.014	−0.684

The results of the correlation analysis of the free-rate of the *A. aegypti* with the prevalence of DHF cases in 6 (five) years (2015–2019) showed that there were 2 years which had a significant relationship between the free-rate of the *A. aegypti* and the prevalence of DHF cases, namely, in 2017 and in 2019, with a P-value of 0.040, and 0.014. In 2017, the results of the analysis showed that there was a weak and negative correlation (r = −0.559), and in 2019 the results of the analysis showed that there was a moderately correlated relationship (r = −0.684) and negative, meaning that the higher the *A. aegypti* free-rate, the higher the *A. aegypti* free-rate, the lower the prevalence of dengue cases. However, in 2015, the results of the analysis showed that there was a weak correlation (r = −0.515) and was negative, there was no significant relationship between the level of risk of the *A. aegypti* and the prevalence of dengue cases in Bukittinggi.

Discussion

The results showed that the humidity in Bukittinggi did not show an increase in the prevalence of dengue cases over the past 5 years. During the past 5 years (2015–2019) only in 2016, there was a relationship between the average air temperature and the prevalence of DHF cases with a p-value of 0.031 and the degree of drag a positive relationship (r = 0.621) meaning that the average air temperature with the prevalence DHF is moderately correlated. The test results show that for the last 5 years (2015–2019), there is no significant relationship between the average humidity and the prevalence of DHF cases. However, it shows that there is a correlation. The strongest degree of closeness occurred in 2016, the value (r = 0.553) means that there is a degree of relationship with the moderate correlation being positive. In 2017 there was an influence with a weak correlation and in 2017 there was no degree of correlation between the average air humidity and DHF cases (r −0.198). This research is in line with research conducted by Kurniawati and Yudhastuti [13]. The results of the correlation test show that there is a moderate, positive relationship strength. The existence of this relationship can be estimated because the position of Bukittinggi is at an altitude and is based on the Equatorial area (zone B) which experiences two peaks of rain. This incident also indirectly affects the temperature change. Humidity is one part of the climate that has an important role in the life of microorganisms such as viruses, fungi, mites, mosses, and bacteria that trigger allergies for asthmatics will grow rapidly. The spread of a disease transmitted by vectors is also influenced by humidity, and the spread of mosquitoes, depending on relative humidity, determines the level of disease transmission [14]. Meanhwile, Alizkan [15] found that there was a relationship between air humidity and the prevalence of DHF in Serang Regency, while in line with this study, they both had their respective correlations (r = 0.48) and (r = 0.553). This study is not in line with Sumi *et al*. [16] that relative humidity is correlated with the Dengue Fever (DF) epidemic, this is due to differences in research conducted which focuses more on laboratory activities.

Furthermore, the results show that the precipitation index (RI) does not have a direct impact on mosquito breeding. The RI is the product of precipitation and rainy days divided by the number of days in the month. Precipitation is an interesting climate-related issue to study. This is because not all regions of Indonesia have the same precipitation pattern. In addition, precipitation is a climatic parameter that most influences people's life patterns. According to Aldrian *et al*. [17], Indonesia's precipitation pattern is divided into three main areas with a transitional area as follows:

The changes in precipitation have direct consequences on infectious disease outbreaks, due to growing large larval heights and generating new breeding grounds [18]. This supports Kurniawati and Yudhastuti [13]. The correlation test results show that precipitation with the prevalence of DHF has a weak relationship strength (r = 0.141) and a positive relationship direction. However, Nisaa [19] found no significant relationship between precipitation and DHF.

Moreover, it can be seen that the pattern of rainy days is not significantly followed by the pattern of changes in the prevalence of DHF. This study is in line with Dini *et al*. [20] stated that there was no relationship between precipitation and the prevalence of dengue fever in Jakarta (1999–3003). Because the results of the researchers' research are both unrelated, this can be due to high precipitation which will have an impact on flooding which brings small water storage containers carried away by water, and it can also be caused that the water storage containers do not exist, so there is no. There are puddles of water that mosquitoes can use to breed. Dini *et al*. [20] also found no significant relationship with the prevalence of DHF during 2007–2008, with r and p values of 0.212 (p = 0.321); 0.331 (p = 0.114); and −0.016 (p = 0.941). The result supports previous research conducted by Xu *et al*. [21] indicating no significant relationship between the prevalence of DHF and relative humidity. This also supports Kurniawati and Yudhastuti [13], the results of the study show that there is a weak and positive relationship strength (r = 0.078). This shows that if the free-rate is high, the prevalence of dengue cases will also be high. The findings underscore previous studies that found a close correlation between mosquito-borne diseases such as dengue fever and environmental factors such as temperature [22], [23], 24], rainfall [16], [24], [25], humidity [26], [27], [28], [29], and highlighting the important aspect of environmental factors in the emergence of vector-borne diseases [21], [30], [31].

Conclusion

The results found that average air temperature in Bukittinggi allows mosquitoes to survive and functions as an optimum breeding vector. The statistical test also revealed significant relationship between precipitation and the prevalence of DHF cases in 2018. The results confirmed that there was no significant relationship and also no correlation between physical environmental factors, such as air temperature, humidity, and precipitation with the prevalence of dengue cases in Bukittinggi during the 2015–2019 periods. The results showed a correlation between mosquito free-rate and the prevalence of DHF cases in 2017 and 2019, highlighting a moderate and negative correlation, meaning that the higher the *A. aegypti* free-rate, the lower the prevalence of DHF cases.

Practical recommendations are outlined that to control the prevalence of dengue cases, activity managers need to focus their attention on endemic areas of dengue fever. Moreover, mosquito larvae monitoring activities for the prevalence of dengue cases need to be considered. Finally, the programs to carry out larval monitoring activities and other activities such as larval eradicating program are needed.

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