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Dengue Incidence in Relation to Environmental Factors in Sampang Regency: Analysis of Five Years Data

Hubungan Insiden Dengue dengan Faktor Iklim di Sampang: Analisis Data Lima Tahun

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ABSTRACT
In Indonesia and especially East Java, incidence of Dengue Fever (DF) and Dengue Hemorrhagic Fever (DHF) has been increasing despite various policies to mitigate or curb the burden of DF and DHF. Studies regarding when the dengue incidence rate would increase are essential for more effective policies. This study sought to analyze the relationship of monthly dengue incidence rate with various environmental factors (temperature, humidity, and rainfall) within a 5-year period at Sampang Regency, East Java, Indonesia. A retrospective cross-sectional study was conducted. Dengue incidence rate within a 5-year period from 21 primary healthcare centers and one hospital as well as data on various environmental factors were collected. The data were tabulated and analyzed using the Pearson Correlation Test. Cumulatively, there are 2.298 DF/DHF cases recorded between 2012–2016. Incidence tend to increase every year. Monthly dengue incidence rate increases after approximately three months of humidity and rainfall increase. Dengue incidence has a significant correlation with rainfall (p=0.008; p<0.05) and humidity (p=0.003; p<0.05) but insignificant correlation with minimum (p=0.653; p>0.05), maximum (p=0.999; p>0.05), and average temperature (p=0.823; p>0.05). We hope this result could help policymakers adjust their policies to anticipate dengue incidence after the rise of rainfall and humidity.

ABSTRAK
Di Indonesia dan Jawa Timur, insiden demam dengue dan demam berdarah dengue (DBD) terus meningkat meski berbagai kebijakan telah diimplementasikan untuk mencegah peningkatan dan penyebarannya. Studi mengenai kapan insiden demam berdarah akan meningkat menjadi sangat penting untuk membuat kebijakan yang lebih efektif. Studi ini bertujuan menganalisa hubungan antara angka insidens demam berdarah dengan berbagai faktor iklim (suhu, kelembapan, dan curah hujan) dalam 5 tahun di Kabupaten Sampang, Jawa Timur, Indonesia. Studi potong lintang retrospektif dilakukan. Insiden demam berdarah selama 5 tahun di 21 fasilitas kesehatan primer dan 1 rumah sakit serta data tentang faktor iklim dikumpulkan. Data tersebut di tabulasi dan dianalisa dengan uji Pearson. Secara kumulatif, terdapat 2.298 kasus demam berdarah antara 2012-2016. Insiden cenderung meningkat setiap tahunnya. Angka insidens bulanan meningkat kurang lebih 3 bulan setelah meningkatnya curah hujan dan kelembapan. Angka insidens tersebut berkorelasi secara signifikan dengan curah hujan (p=0,008; p<0,05) dan kelembapan (p=0,003; p<0,05) namun tidak signifikan dengan minimum (p=0,653; p>0,05), maksimum (p=0,999; p>0,05), dan rata-rata temperatur (p=0,823; p>0,05). Peneliti berharap pemegang kebijakan dapat menggunakan hasil studi ini untuk menyesuaikan kebijakannya untuk mengantisipasi peningkatan insidens dengue setelah meningkatnya curah hujan dan kelembapan.

INTRODUCTION

Dengue Fever (DF) and Dengue Hemorrhagic Fever (DHF) is an infection caused by arthropod born virus from genus Flaviviridae with 4 serotypes: DENV–1 until DENV–4. Recently, it was found that there are another dengue serotypes named DENV–5 which also causes DHF and DF. These viruses are transmitted through their main vector: *Aedes* aegypti and *Aedes* albopictus and their main host: humans.[1,2] Nowadays, dengue infection has spread worldwide, with the highest incidence in tropical and subtropical countries, including Indonesia.[1]

The global incidence of DF and DHF has been consistently increasing within the past few years. It is estimated that, globally, there are 50-100 million dengue cases each year which resulted in 20.000 deaths every year. The spread and incidence of dengue is exacerbated in areas at which multiple virus serotypes circulated known as hyperendemic regions which occurs in Southeast Asia and Pacific including Indonesia.[3] In East Java, dengue incidence has increased by more than 100% between 2017-2019.[4,5] The local government of Sampang has been implementing various policies only to eradicate and to reduce the burden of DF and DHF, but it has not been successful and, instead of reducing dengue's incidence, the incidence of dengue kept increasing from 271 cases to 639 cases from 2012-2015.[6]

There are various factors affecting dengue incidence, but amongst the many, environmental factors had been proven to significantly affect DF's and DHF's incidence. Based on previous literatures, there are three important environmental parameters that had been proven to increase dengue incidence significantly: temperature, humidity, and rainfall.[7–9] These factors are able to accelerate mosquito's life cycle and thus increases the number of viable mosquitoes living in the environment ready to act as a vector for DF and DHF.

To the author's knowledge there are no studies regarding relationship of environmental factors and dengue in Madura Island area. Meanwhile, the incidence of dengue infection varied widely between each country due to the difference in population, climate of each country, and the common virus serotype that infects local populace.[1]

Without proper anticipation from all healthcare providers in each area, surely dengue infection would cause significantly higher morbidity and mortality. Therefore, we sought to analyze the relationship of dengue incidence with other environmental factors, especially on temperature, humidity, and rainfall within five-year period at Sampang Regency, East Java, Indonesia.

MATERIAL AND METHOD

Retrospective cross-sectional studies were conducted. Dengue incidence monthly rate data between 2012–2016 were collected from all government health facilities in Sampang Regency, which consists of 21 Community health centers and one government hospital (Sampang General Hospital). Meanwhile, environmental factors (temperature, humidity, and rainfall) between 2012–2016 were collected from Center of Meteorology, Climatology and Geophysics at Kalianget, Sumenep (Madura Island), East Java. The monthly dengue incidence rate would be the dependent variable and environmental factors (temperature, humidity, and rainfall) would be the independent variable. We chose all population as a sample because we wanted to know the accurate depiction of the relationship between DF/DHF incidence and environmental factors within Sampang Regency.

The research Permit for this research was granted by the government of Sampang Regency (No. 072/284/434.401/2017). Definition of each variable is defined at Table 1. The data collected were tabulated and analyzed. The incidence of dengue fever by month and year is shown in the table. Incident relationships and climatic factors are presented in a graph for easy visual analysis. Frequency, average, maximum, minimum, and chi-square values were calculated and analyzed. Pearson correlation was used for non–continuous variables, p value < 0.05 was accepted as significant.

Table 1. Variable's Operational Definition

No.	Variable	Definition
1.	Dengue Incidence	Monthly incidence rate of dengue fever and dengue haemorrhagic fever recorded in all Sampang's primary health care facility and Sampang General Hospital
2.	Temperature	Monthly mean, maximum, and minimum temperature in Sampang area as noted in the Center of Meteorology, Climatology, and Geophysics (^oC)
3.	Humidity	Monthly average humidity in Sampang area as noted in the Center of Meteorology, Climatology, and Geophysics (%)
4.	Rainfall	Monthly average rainfall in Sampang area as noted in the Center of Meteorology, Climatology, and Geophysics (mm)

Source: Primary Data, 2020

RESULT

Table 2 showed DF/DHF monthly incidence rate. Cumulatively, there are 2.298 DF/DHF cases recorded between 2012–2016 in Sampang's public health facilities. Gender proportion were 52.4% (n=1.204) female and 47.6% (n=1.098) male.

Average age was 11.3 years old. The minimum age was two months old and maximum age were 68.4 years old. Most of dengue patients were within age range of 5–14 years old (57.1%). The highest incidence was in 2016 with a total of 666 patients. Meanwhile, the least was in 2014 with a total of 209 patients. From 2012– 2016 the incidence kept increasing except in the year 2014.

Comparing dengue monthly incidence rate with temperature data (figure 1), we can see that the temperature at Sampang is relatively stable throughout the years with a slight increase on February and March. Meanwhile, the overall pattern of each year's monthly dengue incidence is similar despite changes in yearly cumulative incidence of dengue. Reaching its peak in January and then decreases gradually until the lowest incidence of dengue between August and November which is a transition month from dry to rainy season. Afterward, the incidence rate surged again in January.

Quantitatively, correlation between dengue and temperature were calculated using Pearson R test. Resulting in 0.653 (p>0.05) for minimum temperature, 0.999 (p>0.05) for maximum temperature, and 0.823 (p>0.05) for average temperature.

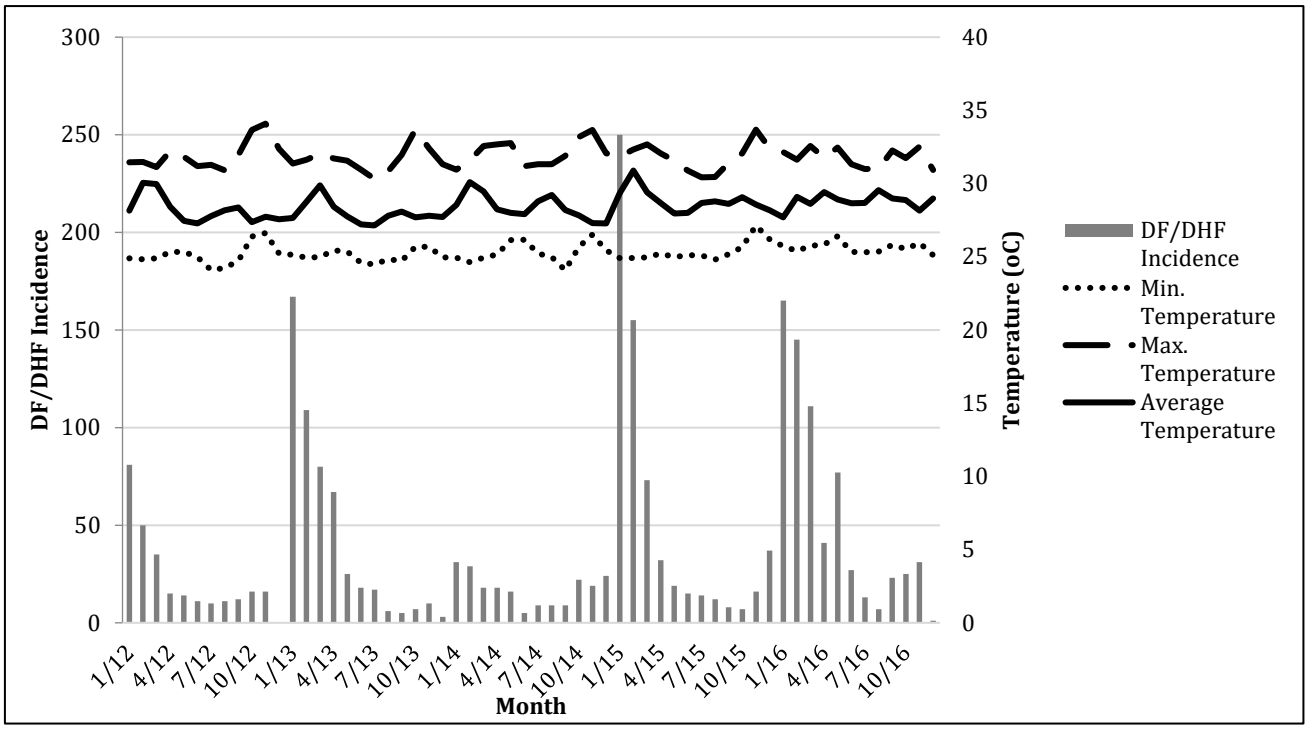
Comparing average rainfall and average humidity with the monthly dengue incidence rate (figure 2), we can see that humidity in Sampang tends to fluctuate in accordance with the rainfall but after a delay of ±3 months. The lowest humidity happened in September, four months after the lowest rainfall and the highest humidity happened in February, one month after the highest rainfall.

In relation to monthly dengue incidence rate, the rise of monthly humidity seemed to be able to predict an increase of dengue incidence rate. Dengue incidence rate would increase approximately three months after the increase in humidity. Whenever humidity remained constant, the dengue incidence rate would decrease. Meanwhile, in relation to rainfall, monthly dengue incidence rate tends to increase after the increase of rainfall either one month, two months, or three months after the increase of rainfall. Whenever the rainfall stayed constant, monthly dengue incidence rate will drop. Quantitatively, the result of dengue incidence correlation with rainfall (p=0.008; p<0.05) and humidity (p=0.003; p<0.05) are significant.

Table 2. DF/DHF Monthly Incidence Rate between 2012-2016 in Sampang Regency

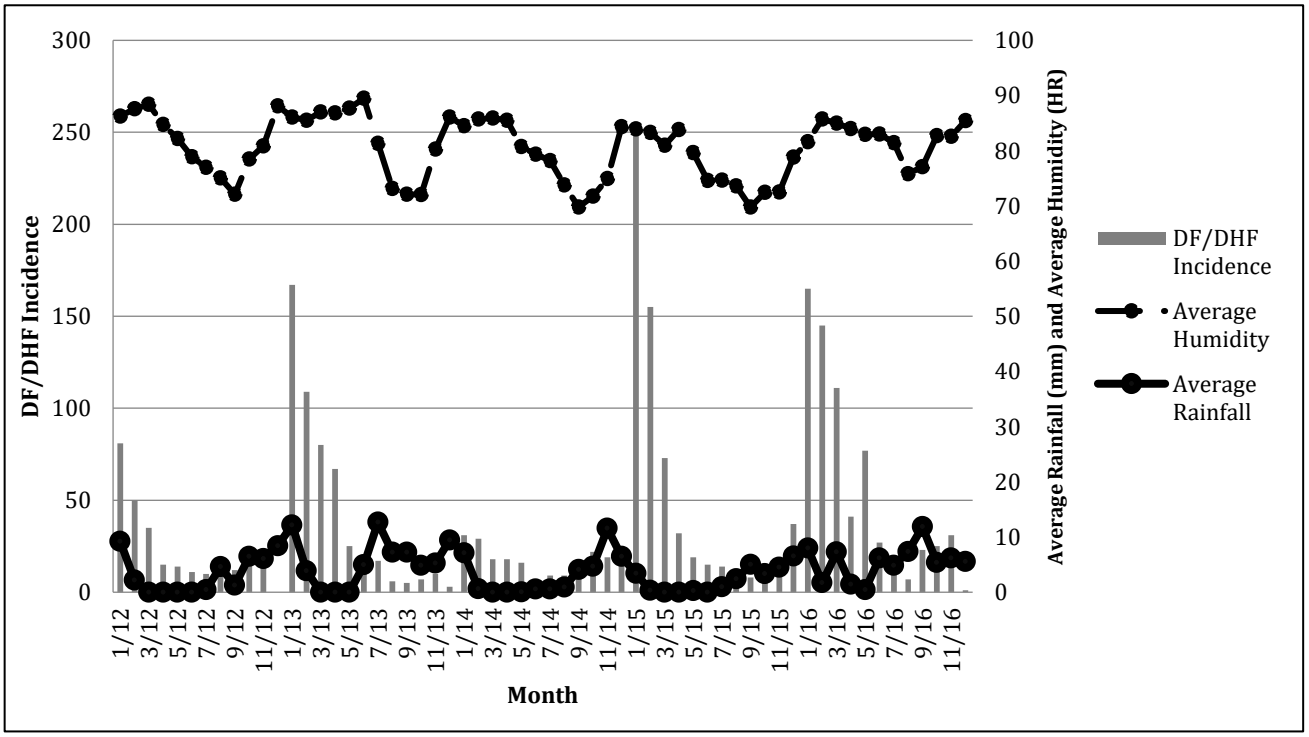
Year	Month												Total
	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Aug	Sept	Okt	Nov	Des	
2012	81	50	35	15	14	11	10	11	12	16	16	0	271
2013	167	109	80	67	25	18	17	6	5	7	10	3	514
2014	31	29	18	18	16	5	9	9	9	22	19	24	209
2015	250	155	73	32	19	15	14	12	8	7	16	37	638
2016	165	145	111	41	77	27	13	7	23	25	31	1	666
Total	**694**	**488**	**317**	**173**	**151**	**76**	**63**	**45**	**57**	**77**	**92**	**65**	**2.298**

Source: Secondary Data of *Laporan Bulanan Program P2M DBD Sampang, 2016*



Source: Secondary Data of *Laporan Bulanan Program P2M DBD Sampang, 2016 and Kabupaten Sampang Dalam Angka, 2016*

Figure 1. DF/DHF Monthly Incidence Rate and Average Temperature Progression Between January 2012 – December 2016



Source: Secondary Data of *Laporan Bulanan Program P2M DBD Sampang, 2016 and Kabupaten Sampang Dalam Angka, 2016*

Figure 2. DF/DHF monthly Incidence Rate, Average Humidity, and Average Rainfall Progression Between January 2012 – May 2016

DISCUSSION

The increase of yearly dengue incidence between 2012–2016 is also found in other countries such as Thailand, Vietnam, and Malaysia.[1,9,10] Such increase can be caused by various factors, such as: virus evolution, climate change, increase in mobilization, socioeconomic factor, and increase in urbanization. But looking at our data, over the years, no increase in average humidity, temperature, and rainfall were observed. Therefore, climate change is not likely to be the cause to this increase in incidence.

Temperature was not significantly associated with dengue incidence rate in our study meanwhile, other study's results varied.[7,10–13] Temperature is found to affect dengue incidence by increasing its transmission rate (through mosquito biting rate and mosquito population dynamics) and changing human's behavior (wearing less clothes and enacting more outdoor activities).[14,15] On further literature review, previous studies using mechanistic models over real data in China, Philipines, and Americas have found that temperature effect on dengue incidence is non-linear.[16–18] The optimal temperature for dengue transmission is between 26-29^{o}C. Above and under these levels showed less impact on incidence rate. This might explain the inconsistency of previous study's result and also explains the insignificancy found in our study. Notably the temperature at Sampang is narrow, ranging mostly between the optimal temperature: 26-30^{o}C.

Humidity and rainfall are significantly correlated with dengue incidence in our study. This result is similar to results from previous studies.[10,14,17,19–21] Humidity is also found to have optimum levels which is around 70-80%.[17,21] This optimal humidity could facilitate mosquito's longevity, egg hatching, feeding behavior, and dengue virus proliferation within *Aedes aegypti mosquitos.*[10,17] Rainfall in itself is not a prerequisite of mosquitoes breeding, but higher rainfall would result in the increase of pools of water or surface water area and thus providing larger breeding area for mosquitoes. Moreover, higher rainfall would adjust some places with higher humidity, providing optimum condition for mosquito reproduction. These explains differing impact humidity brings onto dengue incidence with inherently humid areas reporting lower impact of rainfall to dengue incidence as compared to less humid areas.[17,18]

Aside from the significant correlation, the timing at which dengue incidence rate would increase is also similar to previous studies which are between one to three months after increase in rainfall and humidity.[7,10,13,19] *Aedes* mosquito are expected to increase in population starting on day 8–10 after the start of rainy season. After breeding, dengue virus will go through incubation period within *Aedes* mosquito for 8-10 days before the virus could be transmitted to another human by *Aedes* mosquito.[22] Lastly, time between exposure and onset of symptoms in human bodies ranges from 4-7 days.[22] Therefore, an approximately one month delay before a rise in dengue incidence rate is as expected.

Errors in diagnosis in the primary health care facility and the use of old guidelines for diagnosis might cause under and/or over-diagnosis. Other factors such as: virus evolution, climate change, increase in mobilization, socioeconomic factor, and increase in urbanization that affect dengue incidence also contributes in the fluctuation of dengue incidence. These factors are not assessed in this study and are the limitation of this study.

CONCLUSION AND RECOMMENDATION

Monthly dengue incidence rate is significantly correlated with rainfall (p=0.008; p<0.05) and humidity (p=0.003; p<0.05) but not with minimum temperature, maximum temperature, and average temperature. Governments should use rainfall and humidity as a basis for improving the strategy and policies in managing dengue fever.

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