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Assessing Meteorological Variables, Larvae Free Rate and Dengue Incidence in Yogyakarta, Indonesia

Juhrati Raodatul Zannah[1] and Sulistyawati Sulistyawati[1*]

[1]Department of Public Health Universitas Ahmad Dahlan, Yogyakarta, Indonesia.

Authors' contributions

This work was carried out in collaboration between both authors. Authors JRZ and SS designed the study. Author JRZ wrote the protocol, collected the data and performed the statistical analysis as well as wrote the first draft of the manuscript. Author SS supervised and checked the analyses of the study. Author SS finalized the manuscript before submitting. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: Dengue is a disease closely related to the environment, including several climatic variables such as temperature, humidity, and wind speed. This research attempted to illustrate the relationship between dengue fever incidence and climatic factors, larva free rate (LFR) or Angka Bebas Jentik (ABJ) in Yogyakarta city, Indonesia.

Methodology: Secondary data from meteorological agency and district health office were collected and analyzed using Spearman Rank Test and Multiple Linear Regression Test.

Results: Temperature, air humidity and wind speed were associated with dengue incidence in Yogyakarta city during 2016-2018. Correlation between rainfall and dengue was r = 0.27 and p value = 0.11; temperature and dengue r =0.62 and p value = 0.000; humidity and dengue r=0.38 and p value 0.02; wind speed and dengue r=-0.36 and p value = 0.03; r = -0.36. Larvae free rate and dengue r=0.04 and p value = 0.77.

Conclusion: Climate variables are an important factor affecting the incidence of dengue fever. To decrease the incidence, it is necessary to educate the community on improving awareness related to the mosquito breeding place.

**Corresponding author: E-mail: sulistyawati.suyanto@ikm.uad.ac.id;*

Keywords: Dengue incidence; meteorological variable; larva free rate.

1. INTRODUCTION

The principal cause of dengue incidence was related to the increase of mosquito breeding places. The number of dengue increased from 0.4 million to 1.3 million cases from 1996 to 2005 and continued to grow after then. During 2013-2015, recorded 3.2 million severe cases with 9,000 deaths. The incident occurred mostly in Asia, America, and Africa [1], in the tropical and sub-tropical country. Dengue transmitted to humans through mosquito biting into the human body. The primary vector for dengue is Aedes aegypti, and the secondary vector is Aedes albopictus who carries one among four dengue virus serotypes DEN 1-4. Dengue virus belongs to the family and genus new Flaviridae virus [2].

Although dengue receives serious attention from the Indonesia government by doing several programs, however, the number of cases is inconsistent, and some years increase significantly. In 2014, it found 100.347 cases of dengue fever, with 907 deaths among the cases or equal with incidence rate (IR) 39.8 per 100,000 population. It indicated the target of Strategic Plan Ministry of Health in 2014, where dengue IR of <49 per 100,000 population had been reached. However, in 2015 the IR increased significantly with 129,650 dengue cases with 1,071 mortality or equal with IR 50.75 per 100,000 people, meaning that the Strategic Plan target of 2015 by IR at <49 per 100,000 population has not been achieved [3]. Yogyakarta is one district in Indonesia that contributed to the national dengue case. In 2014, reported 418 dengue cases in this city, with three death among them (CFR 0.72%).

The increase of dengue incidence closely associated with many aspects, one of them is climate and environmental change that influences the mosquito behavior and the breeding places. Recent studies demonstrate the association between climate variables and dengue. A research in Surabaya, Indonesia stated there was relationship between dengue incidence and rainfall (p-value = 0.042) and (r = 0.230) [4]. In Taiwan, the temperature, rainfall, and sunshine were influencing dengue transmission [5]. Quite the same finding was established in the Western Brazilian Amazon region [6].

Larvae free rate (LFR) indicates dengue transmission in a particular area by knowing the existence of larvae in the household level. LFR is the number of houses not discovered larvae inside during the inspection [7,8]. Having high LFR implies that a particular area is safer from dengue transmission [9,10].

Indonesia's government has set up the minimum LFR by making some effort, such as 3M movement, Friday cleaning, and Jumantik [11]. However, dengue transmission still occurs in some areas of Indonesia. Even though, LFR can be an essential indicator when climate and environment have changed recently.

This study aims to examine the relationship between climate variable, larvae free rate, and dengue incidence in Yogyakarta city, Indonesia.

2. MATERIALS AND METHODS

2.1 Research Data

This study was conducted using a cross-sectional design to determine a relationship between variable involved and dengue incidence during 2016-2018. Climate data consist of rainfall, temperature, wind speed, and humidity were collected from the meteorological agency of Yogyakarta. Larvae free rates and dengue cases were gathered from the Yogyakarta city health office. For meteorological data versus dengue incidence were analyzed in monthly aggregate. While larva free rate versus dengue incidence calculated based on the sub-district unit of analysis.

2.2 Statistical Analysis

In this study, we employed the Spearman Rank Test to see the association between dengue incidence versus rainfall, temperature, wind speed, humidity, and larva free rate, indicated with p-value and correlation (r). Multiple Linear Regression Test was used in multivariate analysis to assess the most associate variables compare to others by looking at the p-value and R.

All the analysis was conducted in SPSS version 24.0 (IBM, Armonk, NY, USA) by considering the statistical significance level at p-value< 0.05.

3. RESULTS AND DISCUSSION

Climatic and non-climatic variables can influence dengue transmission. Currently, many pieces of research that predict dengue incidence according to climate information. However, studies that were involved in climatic variable and mosquito situation at once analysis were rare. Identification, the relationship between climate variable, larvae indices, and dengue incidence, will facilitate the prevention development and may improve to currently available programs.

3.1 Descriptive Data Characteristic

The dengue case in Yogyakarta during 2016-2018 reduced significantly. We can see from Table 1 that in 2016, reported more than 1,700 dengue case. This year was called a dengue peak in this area. In 2018, the number of cases reduced by 93%. However, at the beginning of 2019, the case increases gradually compared to 2018 in the same period [12]. During the three years, June was a month with a maximum case of August had the lowest cases.

Between 2016 to 2018, the peak of dengue cases occurred in 2016. The highest rainfall occurred between January-March every year (Fig. 1) and (Table 1). Meanwhile, regarding temperature, during the three years of observation, the temperature in Yogyakarta City looked stable between 26-27°C (Fig. 2).

Regarding the humidity, it was unstable during the three years of observation. The highest humidity occurred in 2016, and the lowest humidity was in 2018 (Fig. 3). During the three years, wind velocity was between 3.1-3.5 knots, which was quite stable (Fig. 4).

In Yogyakarta City, Larvae free rate not reached the target of standard minimum LFR that is 95% [13]. Tegalrejo is a sub-district with the highest LFR during the three years; however, they also had quite high dengue cases in 2016.

In this study, we measured the association between meteorological variables and larva free rate to dengue incidence. We found that through bivariate analysis, we found that temperature, humidity, and wind velocity were significantly correlated with dengue incidence. While in multivariate analysis, the only temperature serves as a predictor. The surrounding environment's temperature is an essential factor for an insect's life [14], including Aedes aegypti as the primary vector and Aedes albopictus as the secondary vector for dengue transmission. Our result is consistent with the previous study in Southwestern Nigeria demonstrated that mosquito abundance was significantly associated inversely with temperature [15]. However, a significant correlation between temperature and vector abundance reported in Ekiki State of Nigeria [16].

Table 1. Annual distribution of dengue incidences and meteorological variable in Yogyakarta city, 2016-2018

Period	Dengue incidences	Average temperature (°C)	Average rainfall (mm)	Average humidity (%)	Average wind velocity (knots)
2016	1705	27	234.3	84.5	3.1
2017	414	26	174.8	83.6	3.25
2018	113	26	148.5	79.4	3.5

Source: Meteorological agency region Yogyakarta, 2019

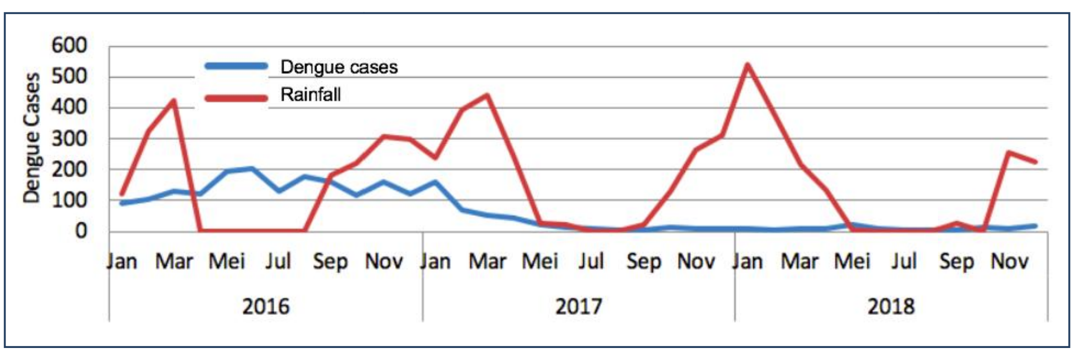

Fig. 1. Relationship between monthly dengue cases and average monthly rainfall in Yogyakarta city, 2016-2018

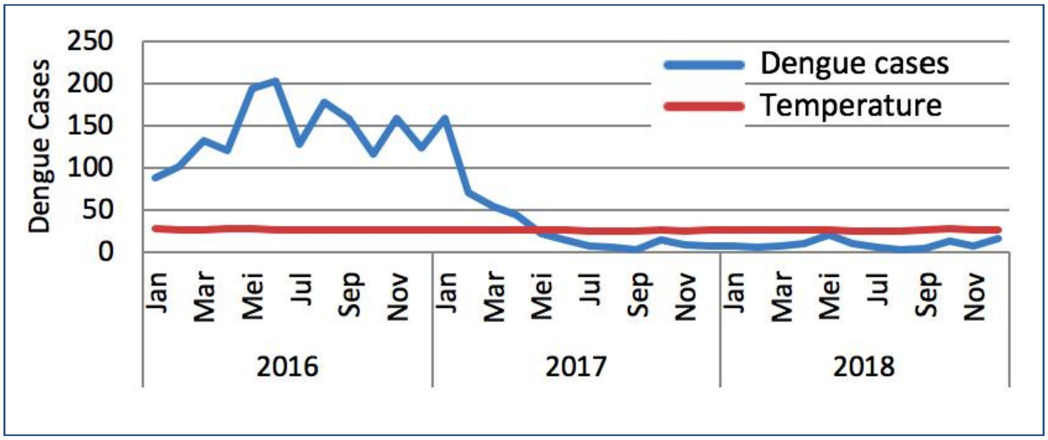

Fig. 2. Relationship between monthly dengue cases and average monthly temperature in Yogyakarta city, 2016-2018

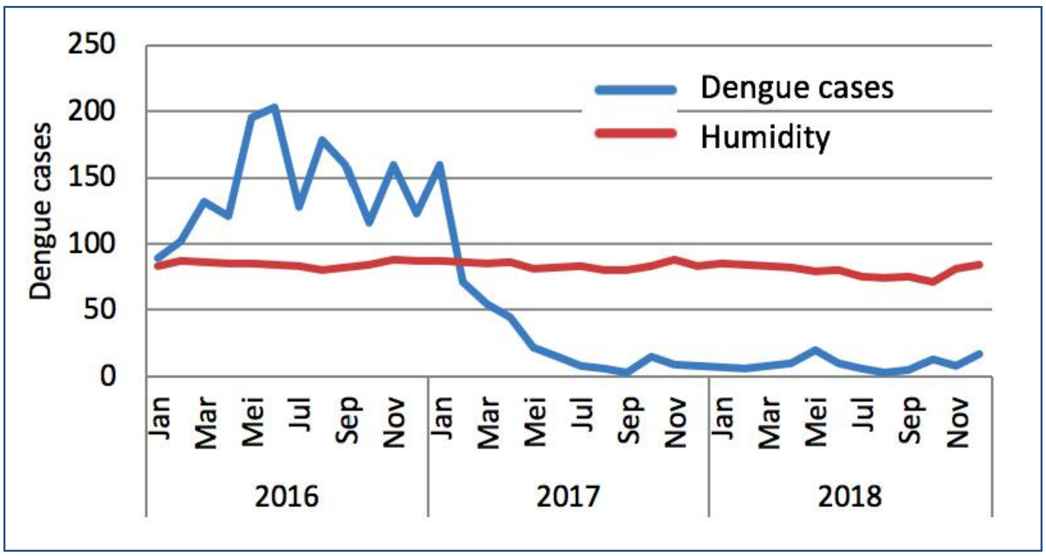

Fig. 3. Relationship between monthly dengue cases and average monthly humidity in Yogyakarta city, 2016-2018

Temperature influencing vector in several ways, such as:1) vector abundance and 2) mosquito development. Nowadays, the increase of dengue incidence expected highly correlated with the increasing mosquito density. This may attributed to the climate change phenomenon, which is changing the environmental condition such as the temperature. A prior study said that the optimum temperature for mosquito development is 25–27°C [17]. In comparison, another study reported at 24-25°C the hatching eggs of Aedes aegypti is 95% after 24 hours and 98% at 48 hours [18]. Based on these data, we propose that shifting of temperature is a significant influencer for Aede's development.

3.2 Spearman Correlations Coefficient between Meteorological Data, Larva Free Rate and Dengue Incidence

Spearman correlation analyses were conducted relating monthly dengue incidence to monthly meteorological data. While larvae free rate to dengue incidence was analyzed by subdistrict. Monthly average temperature and monthly average humidity were significantly positive-correlation with monthly dengue incidence. In contrast, the monthly average of wind velocity was significantly negative-correlation with monthly dengue incidence. Among the meteorological data, the monthly average temperature most strongly correlated to monthly dengue incidence (r = 0.62, $P < 0.05$). The monthly average of wind velocity was related to the monthly dengue incidence (r = -0.36, $P < 0.05$) (Table 2).

An unexpected finding was found in this research regarding larva free rates. We discovered that the larva free rate did not associate with dengue incidence in Yogyakarta. Table 2 presents that in some subdistricts who had high LFR, they also had high dengue incidence. We guest this finding related to the validity of LFR data. Larva free rate calculates from some sources of data collection, one of them is from larva observation by Jumantik. Jumantik is a volunteer that frequently inspects larva presence in the community [19]. However, our recent study elaborated that Jumantik faced some challenges when examining the household's larva's existence, such as society's refusal. Accordingly, Jumantik, in some cases, wrote the larva number by guessing it (Sulistyawati, 2019, not published). This situation also experienced by Jumantik in other regions [20,21].

3.3 Multivariate Analysis of Significant Variable in Bivariate Analysis

Among the variables involved in multivariate analysis, namely wind velocity, temperature, and humidity, they together contributed to dengue incidence of 0.26 (26%). In the next step, the only temperature independently associated with dengue incidence (Table 3).

There may be some possible limitations in this study. First, the association of meteorological variable and dengue are based on the secondary data, which was represented by one nearest station measurement that located not in the city centre. Our calculations may be overestimated. However, we believe it is still acceptable since there is no other station source. Second, we did not include mosquito density on this analysis.

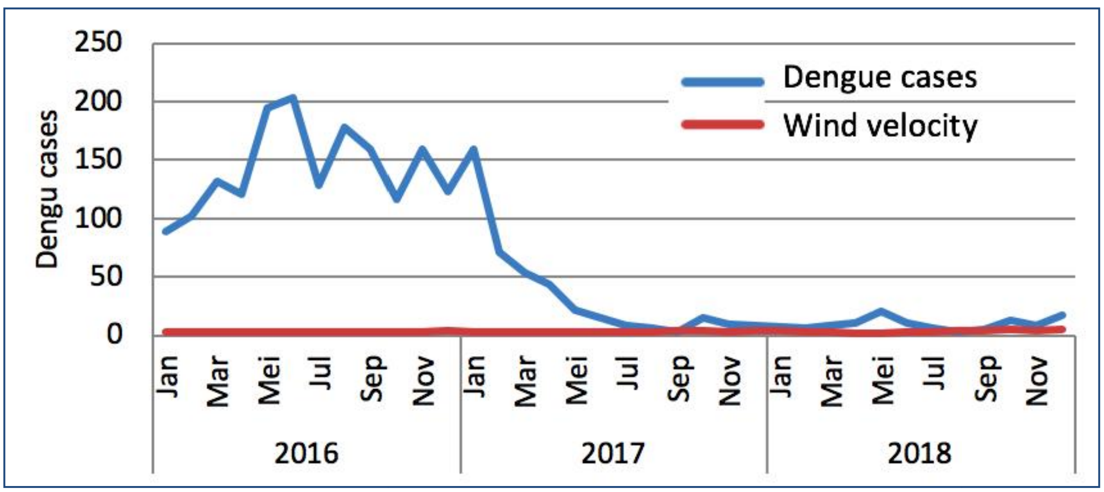

Fig. 4. Relationship between monthly dengue cases and average monthly wind velocity in Yogyakarta city, 2016-2018

Table 2. Correlation between meteorological variable, larva free rate and dengue incidence in Yogyakarta, 2016-2018

Variables	**Dengue incidence**	
	Correlation coefficient	***p*-value**
Monthly average of rainfall	0.27	0.11
Monthly average of temperature	0.62	0.00*
Monthly average of humidity	0.38	0.02*
Monthly average of wind velocity	-0.36	0.03*
Larvae free rate by subdistrict	0.04	0.77

*Significance of correlation coefficient: * = P < 0.05*

Table 3. Multivariate linear regression analysis among meteorological variable and dengue incidence in Yogyakarta, 2016-2018

Explanatory variables	Adjusted R^2	ß (SE)	t-value	*p*-value
Wind velocity		-0.26 (14.6)	-1.84	0.07
Temperature	0.26	0.49 (13.1)	3.38	**0.02**
Humidity		-0.16 (0.7)	-1.12	0.27

4. CONCLUSION

Globally, dengue is a disease that is difficult to eradicate because of the existence of 3 components that are not easily controlled simultaneously: agent, environment, and host. Considering the result of this study, we propose in the next coming research assesses the meteorological variable and dengue by referring to other data sources to support perforated data such as by using remote sensing data. We recommend including vector density in the analysis because this variable is proven related to climate variables.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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