Conference Paper

Developing an Early Warning System Based on Correlation Analysis For Dengue Haemorrhagic Fever

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Published: 25 March 2021

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ISMoPHS 2020 Conference Committee.

Abstract

Several cities in Indonesia have been declared as Dengue Haemorrhagic Fever (DHF)-endemic areas, including East Jakarta, an administrative city of DKI Jakarta Province. Surveillance is the most important activity in controlling and monitoring the development of DHF. This ecological study was conducted to assess the correlation between DHF cases, vector density (Larva Free Index [LFI]) and climate (rainfall and humidity). While the DHF cases were collected from hospitals report, vector density data were obtained from public health centres and climate data were obtained from the Meteorological, Climatological, and Geophysical Agency (BMKG). The correlations between DHF cases, vector density, and the climate were analysed based on weekly data, from week 1 to week 33 of 2019. This study showed a consistent trend of increasing and decreasing DHF cases with rainfall and LFI. DHF cases and LFI had a strong negative correlation (r = –0.72) at a time lag of six weeks. LFI and rainfall also showed a strong negative correlation (r = –0.86) at a time lag of five weeks. The strongest correlation between DHF cases and rainfall was found at week 8 (r = 0.87). Humidity, also an indicator of climate, had a strong positive correlation (r = 0.80) with DHF cases at the 11th-week time lag. However, contrarily, humidity had a strong negative correlation with LFI at the 5th-week time lag. These findings can be used for developing an early warning system that is reinforced by utilizing the application of HDF–climate information.

Keywords: dengue fever, vector, climate, early warning system

1. Introduction

Dengue Haemorrhagic Fever (DHF) is caused by the Dengue virus which is transmitted to humans through the bites of *Aedes Aegypti* and *Aedes Albopictus* mosquitoes. Initial symptoms in DHF patients are fever 2-7 days accompanied by bleeding manifestations, decreased platelets (thrombocytopenia), haemoconcentration marked by plasma leakage (increased haematocrit, pleural effusion ascites, hypoalbuminemia). It also may be accompanied by atypical symptoms such as headache, muscle and bone pain, skin rash, or back pain in the eyeball [1].

In the last three decades, the incidence of DHF has increased in various parts of the world. According to WHO data, after a decline in incidence in 2017-2018, there was a sharp increase in 2019 across the countries, such as Australia, Cambodia, China, Laos, Malaysia, the Philippines, Singapore, and Vietnam [2]. It was estimated that 500,000 people with DHF require hospitalization, and 2.5% of them died [3]. Indonesia is one of the dengue-endemic countries where DHF outbreaks occurred every year in various cities, included DKI Jakarta Province. Throughout January to August 2019, the number of dengue fever sufferers in DKI Jakarta Province has been reported as many as 7,889 cases with two deaths (Incidence Rate was 78.94 per 100,000 population and Case Fatality Rate was 0.02%). East Jakarta is one of the six regions in the DKI Jakarta Province with the largest population. The number of DHF cases in East Jakarta until August 2019 was 2,194 cases of DHF (Incidence Rate was 99.19 per 100,000 population), and the number of deaths was two people (Case Fatality Rate was 0.07%) of the total DHF sufferers in East Jakarta [4].

Climate change affects the increase in DHF cases because climate change can prolong the period of transmission of vector-borne diseases and enlarge its geographic area [5, 6]. Dengue Haemorrhagic Fever is transmitted by the Aedes mosquito vector, which is very sensitive to environmental conditions. Apart from temperature, one of the physical environmental factors is rainfall and humidity. The activity and metabolism of Aedes mosquitoes are directly influenced by environmental factors, such as temperature, humidity, breeding places, and rainfall. The Aedes mosquito requires an average rainfall of more than 500 mm per year. Other factors that are associated with the increase in dengue cases, namely the larva density factor. In general, larva density is obtained through a larva survey that is calculated with Larva Free Index (LFI), Container Index (CI), House Index (HI), and Breteau Index (BI) [1]. Until now, mosquito control has not been handled optimally. In addition to its wide distribution from urban areas to remote rural areas, these mosquitoes are also very easy to breed, especially in the environment around where humans are active [5]. The mosquito breeding places vary widely, but generally prefer various kinds of clear water reservoirs that are widely available around residential areas, such as bathtubs, jars, and used items that accommodate the remnants of rain [7].

Several studies had assessed the correlation of climatic conditions (rainfall, humidity, temperature) with vector density and the incidence of dengue. Kurniawati et al. [8] reported a significant correlation between climate and LFI with the incidence of dengue. Diaz-Quijano et al [9] reported a significant association between average rainfall in five weeks. The association between rainfall and dengue cases was also reported in study conducted by Zubaedah et al. [10]. The rainfall variable had the highest effect (27%) compared to other climate variables in the study on the impact of climate change on the incidence of dengue haemorrhagic fever in Banjarbaru City, South Kalimantan [10].

Since 2018, the East Jakarta Sub Department of Health had started to conduct an Early Warning System Fact Sheet related to the description of the dengue situation that was disseminated through the website communication media and WhatsApp's communication media to policyholders from the city level to the village level. However, the current information sheet was still based on case surveillance. Therefore, a broader development that was included other risk factors such as vector surveillance and climate factors is developed. DKI Jakarta Province had collaborated with the Meteorological, Climatological, and Geophysical Agency to create a climate-based early warning system. It was a useful source of information for the development of dengue fever early warning systems in DKI Jakarta Province, including East Jakarta. Hence, this study aimed to develop a DHF Early Warning System by looking at the correlation between rainfall and humidity and the larva density rate after a time interval with an increase in DHF cases in East Jakarta. By knowing this correlation, it can help to develop the dengue fever early warning system for anticipating an increase of DHF cases in East Jakarta.

2. Material and Method

This descriptive quantitative study used an ecological study design to see the correlation of climates, such as rainfall and humidity, as well as vector density on the increase in DHF cases in East Jakarta based on the weekly time trend from week 1 to week 33 in 2019.

The DHF data were obtained from the hospital reports to the outbreak section and surveillance of the DKI Jakarta Provincial Health Office. Meanwhile, rainfall and humidity data were obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG). Vector density data were obtained based on a weekly period Larva Free Index (LFI) conducted by health workers. The weekly period rainfall curve was matched with the number of dengue fever cases in the weekly period to see the correlation between the increase in rainfall, the humidity after a certain period, and the vector density with

DHF cases. Statistical tests were performed by assessing the Spearman correlation coefficient between rainfall, humidity, and vector density figures with the number of DHF cases at weekly time intervals.

3. Results

Figure 1 showed the changes in rainfall, humidity, and vector density that were matched to the number of DHF cases in week 1 to 33 during the 2019 period. This figure showed a consistent effect between the trend of increasing and decreasing DHF cases with rainfall, and also the trend of humidity and larva free rate. DHF cases increased after eight weeks of peak rainfall, 11 weeks for humidity, and six weeks for larvae free numbers at every week of the observation period.

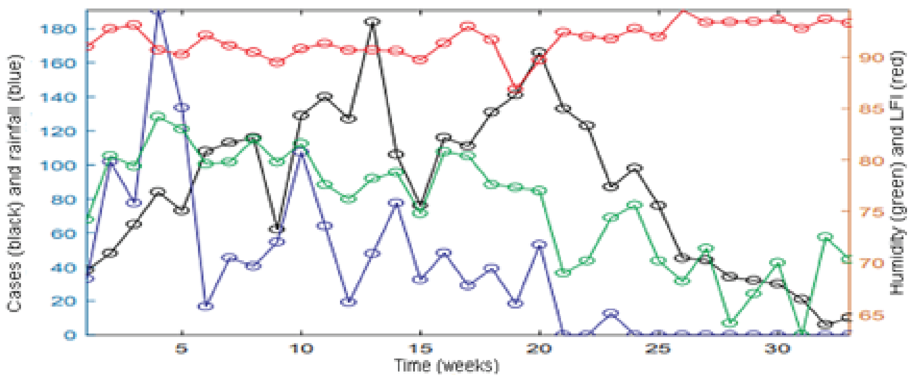

Figure 1: Rainfall, humidity, and vector density along with the number of DHF cases in East Jakarta in week 1 to 33 of 2019. (**Source:** Author's own work.)

The results of the cross-correlation analysis between weekly rainfall and DHF cases showed that there was a strong positive correlation between rainfall and DHF cases. Increased rainfall followed by an increase in DHF cases. The highest correlation (r=0.87) was found at the 8th time lag. It meant that the peak of DHF cases could be predicted eight weeks earlier from the peak of rainfall (Figure 2).

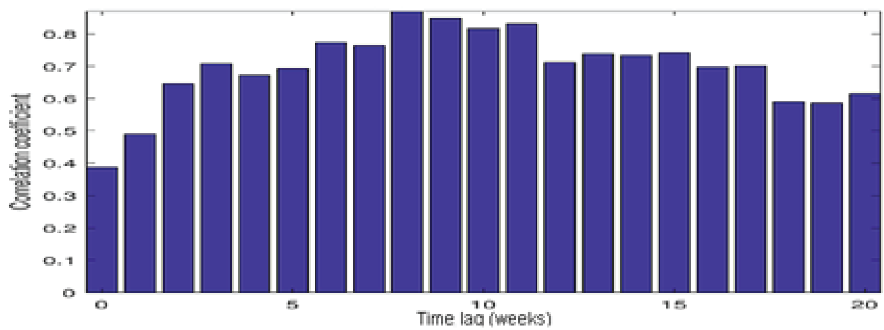

Figure 2: Correlation between weekly rainfall and DHF cases in East Jakarta. (**Source:** Author's own work.)

DOI 10.18502/kls.v0i0.8867

The results of the correlation assessment showed a strong correlation between humidity and DHF cases. Increased humidity followed by an increase in DHF cases. On a weekly analysis, the highest correlation (r=0.80) was found at the 11th time lag. It meant that humidity affected DHF cases up to 11 weeks earlier (Figure 3).

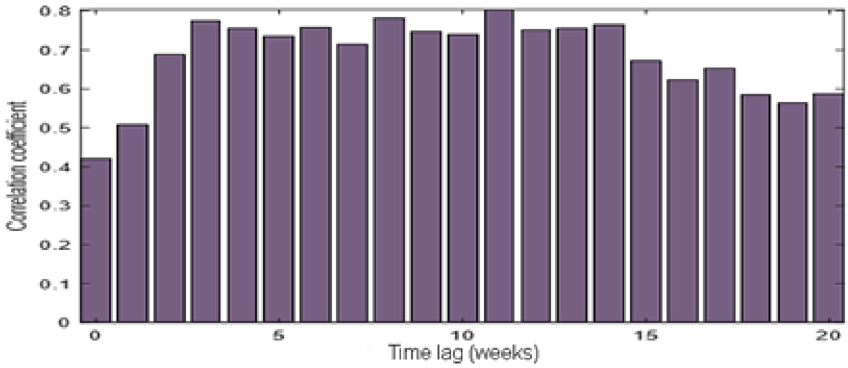

Figure 3: Correlation between humidity and DHF cases in East Jakarta. (**Source:** Author's own work.)

Correlation analysis showed that there was a strong negative correlation between Larva Free Index (LFI) and DHF cases in East Jakarta. Increased LFI followed by a decrease in DHF cases. The strongest negative correlation between LFI and DHF cases (r=-0.72) was found at the 6th time lag. It meant that LFI affected DHF cases up to 6 weeks earlier (Figure 4).

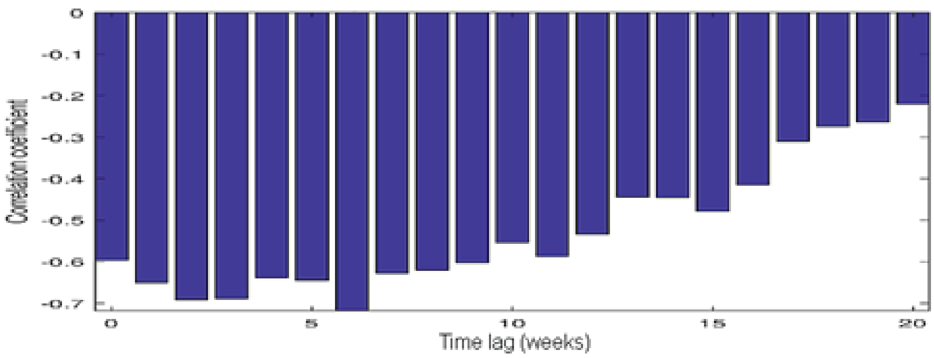

Figure 4: Correlation between Larva Free Index (LFI) and DHF cases in East Jakarta. (**Source:** Author's own work.)

The results of the cross-correlation analysis showed that there was a strong negative correlation between rainfall and LFI. The strongest negative correlation was found at the 5th time (r=-0.86). It meant that the rainfall affected the LFI up to 5 weeks (Figure 5).

The strongest negative correlation between humidity and Larva Free Index (LFI) was found at time lag 5 (r=-0.76). It meant that humidity affected LFI up to the next five weeks (Figure 6).

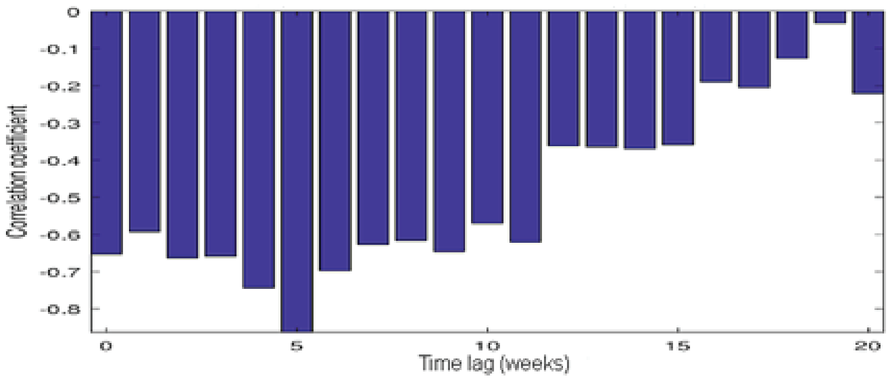

Figure 5: Correlation between rainfall and Larva Free Index (LFI) in East Jakarta. (**Source:** Author's own work.)

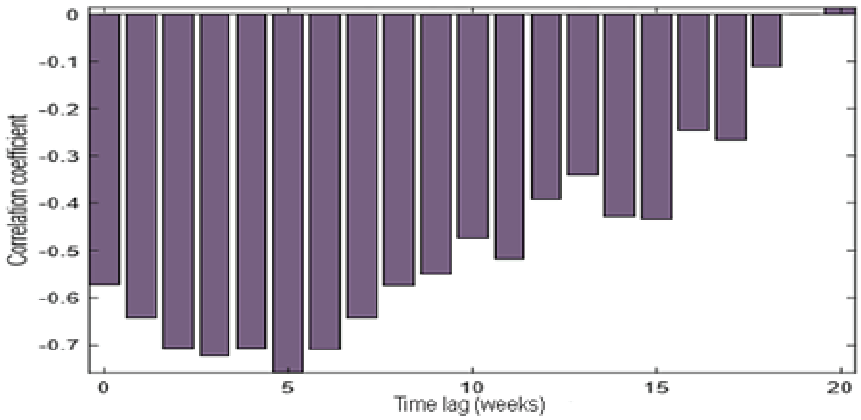

Figure 6: Correlation between humidity and Larva Free Index (LFI) in East Jakarta. (**Source:** Author's own work.)

4. Discussion

This study found that there was a correlation between rainfall, humidity, and vector density with DHF cases in East Jakarta. It showed a fairly good correlation between rainfall (r= 0.87) at a time lag of 8 weeks, humidity (r=0.80) at a time lag of 11 weeks, and larvae free numbers (r=-0.72) at time lag 6 with DHF cases. The correlation was seen well between rainfall with (r = -0.86) at a time lag of 6 weeks, likewise between humidity and larva free rate (r=-0.76) at a time lag of 5 weeks. These findings could illustrate well the correlation between DHF cases with climate variables and vector density.

DHF involves three organisms, namely, the dengue virus, vectors, and hosts/humans. These three factors, both individually and in population, were influenced by several biological environments, the physical environment, and the host's immunity factors. The different interaction patterns between agent, vector, and the host could affect the degree of endemicity from one location to another from year to year [11]. Climate and mosquito breeding places were part of the environment that physically sensitive to optimal conditions of vector development [5].

Rainfall can increase the transmission of vector-borne diseases by stimulating the proliferation of vector development sites. Rainwater stagnating in a container, such as a hollow in a tree midrib, used can, used tires, or house gutters can be a breeding place for mosquitoes. The availability of those breeding places caused the mosquito eggs to hatch and will turn into mosquitoes within the next 10-12 days. If a mosquito with the dengue virus bites a human, the symptoms of dengue fever will appear within 4-7 days [1]. Generally, mosquitoes can transmit the disease for more than ten days. They need a high humidity environment to survive. If the humidity is low, mosquitoes will die [11]. Based on this fact, the results of this study could explain the correlation between climate, namely rainfall, and humidity, as well as the larva free rate of the increase in dengue cases.

The results of this study were in line with the study that was conducted by Zubaedah et al. [10]. It found that rainfall had a significant effect on the increase in dengue cases in Banjarbaru City, South Kalimantan between 2005-2010. In that study, the rainfall variable had the highest influence (27%) compared to other climate variables. In a retrospective study that was conducted by Iriani [12], rainfall was related to dengue cases in Palembang. Similar research that was conducted by Ehelepola et al. [13] in Kandy City, Sri Lanka showed a significant correlation between climate variables, included rainfall, temperature, and humidity at a time lag of 5 to 11 weeks 12, with DHF cases. Sanchez L. et al. [14] also reported a significant correlation between vector density and the predicted increase in DHF cases in Playa Municipality Havana.

5. Conclusion

This study found that rainfall, humidity, and vector density had a strong correlation with DHF cases. Rainfall and humidity had a strong positive correlation with DHF cases, while vector density that was measured by Larva Free Index (LFI) parameter had a strong negative correlation with DHF cases. Increase in rainfall and humidity followed by an increase in DHF cases. The relationship between LFI and DHF cases showed the opposite pattern. These findings could be used as a reference in developing the dengue fever early warning systems that aimed to prevent and eradicate the DHF disease in East Jakarta.

Acknowledgement

The authors would like to thank the East Jakarta Sub Department of Health and Meteorological, Climatological, and Geophysical Agency (BMKG). The gratitude also expressed to all hospitals and Public Health Centres that had reported DHF cases and the epidemiological investigations.

Conflict of Interest

The authors declare that there is no conflict of interest in this study.

References

[1] Kementerian Kesehatan Republik Indonesia. (2017). *Pedoman pencegahan dan penanggulangan Demam Berdarah Dengue di Indonesia*. Jakarta: Kementerian Kesehatan Republik Indonesia.

[2] World Health Organization. (2020). *Dengue Situation Updates* 2020. Retrieved from https://iris.wpro.who.int/handle/10665.1/14461.

[3] Kementerian Kesehatan Republik Indonesia. (2016, May). *Situasi DBD di Indonesia*. Retrieved May 1, 2020 from https://www.kemkes.go.id/resources/download/pusdatin/infodatin/infodatin dbd 2016.pdf.

[4] Dinas Kesehatan Provinsi DKI Jakarta. (2020). *Laporan tahunan data DBD Provinsi DKI Jakarta 2009 sampai 2019.* Jakarta: Dinas Kesehatan Provinsi DKI Jakarta.

[5] Naish, S., *et al*. (2014). Climate Change and Dengue: A Critical and Systematic Review of Quantitative Modelling Approaches. *BMC Infectious Disease*, vol. 14, issue 167, pp. 1-14.

[6] Lee, H., *et al*. (2018). Potential Effects of Climate Change on Dengue Transmission Dynamics in Korea. *PLoS One*, vol. 13, issue 6, p. e0199205.

[7] Ferede, G., *et al*. (2018). Distribution and Larval Breeding Habitats of Aedes Mosquito Species in Residential Areas of Northwest Ethiopia. *Epidemiology and Health*, vol. 40, issue e2018015, pp. 507-15.

[8] Kurniawati, R. (2015). *Analisis spasial sebaran kasus demam berdarah dengue di Kabupaten Jember Tahun 2014*. Jember: Universitas Jember.

[9] Díaz-Quijano, F. A., *et al*. (2008). Rainfall and Acute Febrile Syndrome in a Dengue-Endemic Area. *Revista De Salud Publica*, vol. 10, issue 2, pp. 250–9.

[10] Zubaidah, T., Ratodi, M. and Marlinae, L. (2016). Pemanfaatan informasi iklim sebagai sinyal peringatan dini kasus DBD di Banjarbaru, Kalimantan Selatan. *Vektora*, vol. 8, issue 2, pp. 99–106.

[11] Kementerian Kesehatan Republik Indonesia. (2013). *Pedoman survei entomologi DBD dan kunci identifikasi nyamuk Aedes*. Jakarta: Kementerian Kesehatan Republik Indonesia.

[12] Iriani, Y. (2012). Hubungan Antara Curah Hujan Dan Peningkatan Kasus Demam Berdarah Dengue Anak Di Kota Palembang. *Sari Pediatri*, vol. 13, issue 6, pp. 378–83.

[13] Ehelepola, N. D. B., *et al*. (2015). A Study of the Correlation Between Dengue and Weather in Kandy City, Sri Lanka (2003 -2012) and Lessons Learned. *Infectious Diseases of Poverty*, vol. 4, issue 42, pp. 1-14.

[14] Sanchez, L., *et al*. (2006). Aedes Aegypti Larval Indices and Risk for Dengue Epidemics. *Emerging Infectious Disease*, vol. 12, issue 5, pp. 800-6.