Russian Journal of Infection and Immunity = Infektsiya i immunitet
2024, vol. 14, no. 1, pp. 155–162

Инфекция и иммунитет
2024, Т. 14, № 1, с. 155–162

ANALYSIS OF TEMPERATURE, HUMIDITY, RAINFALL, AND WIND VELOCITY ON DENGUE HEMORRHAGIC FEVER IN BANDUNG MUNICIPALITY

A. Sutriyawan[a], N. Kurniati[b], Novianti[b], U. Farida[c], L. Yusanti[b], S.N. Destriani[b], M.K.F. Saputra[d]

[a] *Bhakti Kencana University, Bandung, Indonesia*
[b] *University of Bengkulu, Bengkulu, Indonesia*
[c] *Bhakti Wiyata Institute of Health Sciences, Kediri, Indonesia*
[d] *Baitul Hikmah Nursing Academy, Bandar Lampung, Indonesia*

Abstract. The trend of dengue hemorrhagic fever prevalence every year continues to show an increase and number of deaths. This is due to an increase in the population of aedes aegypti mosquitoes. Climate change has the potential to affect mosquito-borne diseases, including dengue fever, which is a vulnerability for residents in Bandung Municipality. This research aims to analyse the relationship between temperature, humidity, rainfall, and wind velocity with dengue hemorrhagic fever in Bandung Municipality. The methodology research used in this study is descriptive analysis with a cross-sectional approach. This research was conducted in Bandung Municipality. The study samples were taken from data on dengue hemorrhagic fever sufferers, as well as data on temperature, humidity, rainfall, and wind speed. This study used secondary data. The data collected is in the form of data on temperature, humidity, rainfall, and wind speed, and the number of cases. To assess the correlation between variables using the person correlation test. To test the effect of all four variables simultaneously on the incidence of dengue hemorrhagic fever using a linear regression test. Average value of air temperature is 25.8°C, air humidity is 69.9%, rainfall is 201.5 mm, and the wind velocity is 1.8 knots. The prevalence of dengue hemorrhagic fever is 232.5 cases. There is a significant relationship between humidity with dengue hemorrhagic fever prevalency ($p = 0.018$, $r = 0.873$). Wind velocity with dengue hemorrhagic fever prevalency ($p = 0.018$, $r = 0.629$). The result of the coefficient of determination test on temperature, humidity, rainfall, and wind velocity with DHF cases is $R^2 = 0.745$. The increase in dengue prevalence in Bandung City occurred from January to June, the decrease in prevalence occurred from July to December. Variations in temperature, humidity, rainfall and wind speed can simultaneously affect the incidence of dengue fever in Bandung. Therefore, in the future it is necessary to increase mosquito nest eradication activities to prevent dengue transmission considering that this disease has the potential to spread at any time.

Key words: *prevalence of dengue fever, climate, temperature, humidity, rainfall, wind velocity.*

Адрес для переписки:
Агунг Сутрияван
40614, Индонезия, Бандунг, ул. Сукарно Хатта, 754,
Университет Бхакти Кенчана.
Тел.: +6282377700705.
E-mail: agung.epid@gmail.com

Contacts:
Agung Sutriyawan
40614, Indonesia, Bandung, Soekarno Hatta str., 754,
Department of Public Health, Bhakti Kencana University.
Tel.: +6282377700705.
E-mail: agung.epid@gmail.com

Для цитирования:
Сутрияван А., Курниати Н., Новианти, Фарида У., Юсанти Л., Дестриани Ш.Н., Сапутра М.Х.Ф. Анализ взаимосвязи между температурой, влажностью, количеством осадков и скоростью ветра и распространенностью геморрагической лихорадки денге в муниципалитете Бандунга // Инфекция и иммунитет. 2024. Т. 14, № 1. С. 155–162. doi: 10.15789/2220-7619-AOT-2110

Citation:
Sutriyawan A., Kurniati N., Novianti, Farida U., Yusanti L., Destriani S.N., Saputra M.K.F. Analysis of temperature, humidity, rainfall, and wind velocity on dengue hemorrhagic fever in Bandung municipality // Russian Journal of Infection and Immunity = Infektsiya i immunitet, 2024, vol. 14, no. 1, pp. 155–162. doi: 10.15789/2220-7619-AOT-2110

DOI: http://dx.doi.org/10.15789/2220-7619-AOT-2110

АНАЛИЗ ВЗАИМОСВЯЗИ МЕЖДУ ТЕМПЕРАТУРОЙ, ВЛАЖНОСТЬЮ, КОЛИЧЕСТВОМ ОСАДКОВ И СКОРОСТЬЮ ВЕТРА И РАСПРОСТРАНЕННОСТЬЮ ГЕМОРРАГИЧЕСКОЙ ЛИХОРАДКИ ДЕНГЕ В МУНИЦИПАЛИТЕТЕ БАНДУНГА

А. Сутрияван[1], Н. Курниати[2], Новианти[2], У. Фарида[3], Л. Юсанти[2], Ш.Н. Дестриани[2], М.Х.Ф. Сапутра[4]

[1] Университет Бхакти Кенчана, Бандунг, Индонезия
[2] Университет Бенгкулу, Бенгкулу, Индонезия
[3] Институт наук о здоровье Бхакти Вията, Кедири, Индонезия
[4] Академия медсестер Байтул Хикмах, Бандар Лампунг, Индонезия

Резюме. Распространенность геморрагической лихорадки денге и смертность от нее с каждым годом продолжают демонстрировать тенденцию к росту, что обусловлено увеличением численности популяции комаров *Aedes aegypti*. Изменение климата может опосредованно влиять на распространенность заболеваний, переносимых комарами, включая лихорадку денге, которая представляет опасность для жителей муниципалитета Бандунг. Настоящее исследование было направлено на изучение взаимосвязи между температурой, влажностью, количеством осадков и скоростью ветра и распространенностью геморрагической лихорадки денге в муниципалитете Бандунг, для чего был использован метод поперечного описательного анализа. Собранные данные представляли собой информацию о температуре, влажности, количестве осадков и скорости ветра, а также о количестве случаев заболеваний геморрагической лихорадкой денге. Корреляция между переменными оценивалась с помощью теста корреляции Пирсона. Одновременное влияние всех четырех переменных на заболеваемость геморрагической лихорадкой денге анализировалось с помощью линейного регрессионного теста. Среднее значение температуры воздуха составило 25,8°C, влажности воздуха — 69,9%, количества осадков — 201,5 мм, скорости ветра — 1,8 узла. Распространенность геморрагической лихорадки денге составила 232,5 случая. Описана достоверная взаимосвязь между влажностью и распространенностью геморрагической лихорадки денге (p = 0,018, r = 0,873), а также между скоростью ветра и распространенностью геморрагической лихорадки денге (p = 0,018, r = 0,629). Оценка коэффициента определения температуры, влажности, количества осадков и скорости ветра на заболеваемость геморрагической лихорадкой денге составляет R^2 = 0,745, то есть перечисленные метеорологические показатели одновременно способны определять распространенность геморрагической лихорадки денге на 74,5%. Повышенный риск заболеваемости геморрагической лихорадкой денге зависит от влажности и скорости ветра. Изменения климата, проявляющиеся колебаниями метеорологических показателей, могут одновременно влиять на увеличение числа случаев геморрагической лихорадки денге. В дальнейшем необходимо прилагать больше усилий по эрадикации комаров для предупреждения передачи геморрагической лихорадки денге, учитывая всевозрастающий потенциал ее распространения.

***Ключевые слова:** распространенность лихорадки денге, климат, температура, влажность, количество осадков, скорость ветра.*

Introduction

Dengue hemorrhagic fever (DHF) is a disease with an excessive morbidity and mortality rate in international locations with tropical and subtropical DHF is transmitted from the bite of the aedes aegypti and aedes albopictus mosquito, defined as the dengue virus [7, 10]. Global warming and environmental change cause enormous dengue fever cases in every part of the world, where mosquito bites will increase and cause the rise of DHF cases [5]. There is one study that calculated 390 million DHF infections every year. Another study on the prevalence of DHF estimates that 3.9 billion people are at risk of infection. Although the risk of infection is in 129 countries, 70% come from Asia [19, 26]. From 2015 to 2019, DHF cases in Southeast Asia increased by 46%, whereas the death rate decreased by 2%. One of the main problems is the uprising of DHF cases in Southeast Asia [34].

Indonesia has the most prominent DHF burden cases in Southeast Asia. Indonesia had 248 127 cases in 2019. A significant increase emerged from the previous year, 65 602 cases. Other than that, there was also an increase in fatality cases from 0.65 to 0.94 [20, 21]. Indonesia still has many DHF-endemic cities. As per the previous study in Yogyakarta, the peak of DHF prevalence happened seasonally between November and May. This incident in Yogyakarta was proven by the high cases of DHF that being hospitalised and high seroprevalence from dengue fever disease, dengue virus neutralising antibody (68%) for children from 1–10 years old [13].

Specific antiviral treatments or vaccines to prevent dengue hemorrhagic fever are not yet available, so the only way to control the incidence of dengue fever is through vector control [31]. Many control efforts have been carried out by programs at the central and regional levels, including mosquito nest eradication activities by draining, closing, burying water reservoirs and affixing larvicides, maintaining larva-eating fish and using mosquito nets, periodic inspection and eradication of larvae no later than once every 3 months, and fumigation [1]. However, this action has not been able to reduce the number of dengue sufferers nationally, and this shows that anticipatory steps have not worked well because countermeasures are still reactive.

Fluctuations in DHF incidence and distribution of DHF cases like other vector-borne diseases are influenced by climate, but how and how much influence from climatic factors on the intensity of transmission of vector-borne pathogens is still not known with certainty [17]. Several studies have stated the influence of variations in climate factors on the distribution of DHF cases [8, 12, 21]. Impact on life cycle, biting behavior, infectivity and resistance of vectors and incubation period of dengue virus [9, 38]. Although the effect of climate change on vector-borne diseases is an indirect influence, it needs to be a concern because it can affect the ability of vectors to transmit diseases.

Based on previous findings, the spread dynamic of dengue fever is a little indirect, and the effect of temperature and humidity is also significant and complex. The higher rainfall anomaly, like +69,74 (240 mm rainfall), the DHF case tends to be lower than the amount of DHF cases in average rainfall. With the increase in rainfall intensity (200 mm above average annually), dengue fever cases tend to decrease [15]. The study on air humidity in Singapore stated that the weather factor is the best predictor among other weather factors being analysed. High humidity is associated or linked with the rise of dengue fever occurrences. Thus, humidity has the potential to be a weather element to predict scarlatina or scarlet fever and help to push the prevention attempt of dengue fever in the future [36]. Humidity also affects the mosquito's life because low humidity will shorten the mosquito's lifetime. 60% of humidity rate is the lowest limit for aedes aegypti mosquitos to live [24].

Better understanding and prediction of DHF outbreaks and their transmission risks based on temporal data is needed so that vector control resources can be optimally allocated. This research tested the relationship between climate and DHF occurrences in Bandung Municipality using a cross-sectional survey design and correlation test. Epidemiology studies have often used the correlation test to explore the relationship between climate and various infectious diseases (for instance, a disease infected through a vector) [11, 22]. This study is suitable to use as the basis for the periodic prevention of DHF. Furthermore, the researchers analysed how much the climate influenced the increase in DHF cases.

Materials and methods

Location and research design. The research was conducted in Bandung, West Java. The basis for viewing and sample selection as Bandung is an endemic region of DHF. The research methodology used in this study is a descriptive analysis with a cross-sectional survey design. This study has been approved by the Ethical Committee of STIK Immanuel Bandung, decisions number 054/KEPK/STIKI/VI/2021.

Population and research sample. The sample of this research was gathered and measured from the combined DHF data throughout 2020, inscribed in the Bandung Health Office, along with the data of temperature, humidity, rainfall, and wind velocity from the Central Bureau of Statistics for the City of Bandung in 2021.

Data collection. This research used secondary data from the Bandung Health Office and the Central Bureau of Statistics for the City of Bandung. The data is like the temperature, humidity, rainfall, wind velocity, and total DHF cases.

Data analysis. The data process used a descriptive analysis test, and then the researchers analysed the correlation between temperature, humidity, rainfall, and wind velocity variables with DHF case occurrence. Those five variables were described in one year, January-December. The temperature was dispersed in °C, humidity in percentage, rainfall in millimetres (mm), wind velocity in knots, and the occurrence of DHF cases on the amount total of the event. To evaluate the correlation between the variables, the researchers used Pearson Correlation Test. The researchers used a linear regression test to test four variables' effect on DHF cases simultaneously.

Results

The highest air temperature in Bandung occurred in September, around 26.9°C, whereas the lowest was in February, around 25.2°C. The highest air temperature also occurred in February, around 76.4%, while the lowest occurred in September, around 59.7%. The highest rainfall occurred in February, around 337 mm, and the lowest occurred in August, around 42 mm. The highest rainfall occurred in December, around 2.7 knot, as the lowest was in May at 1.3 knot. The highest number of DHF cases in Bandung city occurred in May for around 479 cases, whereas the lowest was in October for around 60 cases (Table 1 and Figure).

Based on Table 2, the average value of air temperature is 25.8°C with SD in the amount of 0.44°C. The average air humidity value is 69.9%, with SD as big as 5.0%. The average rainfall value is 201.5 mm, with SD as big as 115.0 mm. The average weight of wind velocity is 1.8 knots with SD in the amount of 0.3 knots. The average DHF prevalence during the whole of 2022 in Bandung Municipality is 232.5 cases, with SD as big as 148.7.

Based on Table 3, the results of the Pearson Correlation Test on temperature with DHF events (p) is 0.324 (> 0.05). The correlation coefficient (r) is –0,312; hence, it has no significant relationship between temperature and DHF prevalence. Humidity with DHF prevalence (p) is 0.018 (< 0.05). The correlation coefficient (r) is 0.668, significantly affecting

Table 1. Frequency distribution of temperature, humidity, rainfall, and wind velocity and prevalence of DHF during 2020 in Bandung Municipality

Month	Temperature	Humidity	Rainfall	Wind Velocity	Prevalence
January	25.7	73.9	207.6	2.1	248
February	25.2	76.4	337.0	1.9	330
March	25.8	73.9	291.0	1.5	479
April	25.9	74.4	271.0	1.4	409
May	25.9	74.3	292.0	1.3	365
June	26.0	68.4	30.0	1.8	335
July	25.4	65.1	64.0	1.9	209
August	26.2	64.1	42.0	1.9	107
September	26.9	59.7	88.0	2.1	77
October	25.8	69.8	327.0	1.9	60
November	26.2	68.4	207.0	1.7	74
December	25.4	70.5	262.0	2.7	97

Source: Taken from Bandung Municipality Health Office and Bandung City Central Statistics Agency report in 2021.

humidity and DHF prevalence. Rainfall with DHF prevalence (p) is 0.383 (> 0.05). The correlation coefficient (r) is 0.277; hence it be concluded that it has no significant relationship between rainfall and DHF prevalence. Wind velocity with DHF prevalence (p) is 0.028 (< 0.05). The correlation coefficient (r) is –0.629, which means it has a significant relationship between wind velocity and DHF prevalence.

This significant correlation between p and the correlation coefficient concluded that the closeness of the relationship between humidity and DHF prevalence has a tight positive correlation. It means the higher humidity is, the more prevalence of DHF cases increases. The closeness of the relationship between wind velocity and DHF prevalence has a tight negative correlation. It means the lower the wind velocity is, the higher prevalence of DHF cases.

Discussion

The highest prevalence of DHF in Bandung Municipality during 2020 was 479 cases in March with a temperature of 25.8°C, while the lowest prevalence of DHF was 60 cases in October with a temperature of 25.8°C.

This is because the temperature in Bandung City changes relatively every month. This same temperature is caused by the peak rainfall in the city of Bandung occurs in November to March while rainy days begin to increase since September. This means that in October the beginning of rainfall increases, so that people usually immediately anticipate dengue transmission, while in March, is the end of high rainfall, in this period people usually begin to neglect preventive measures. In line with

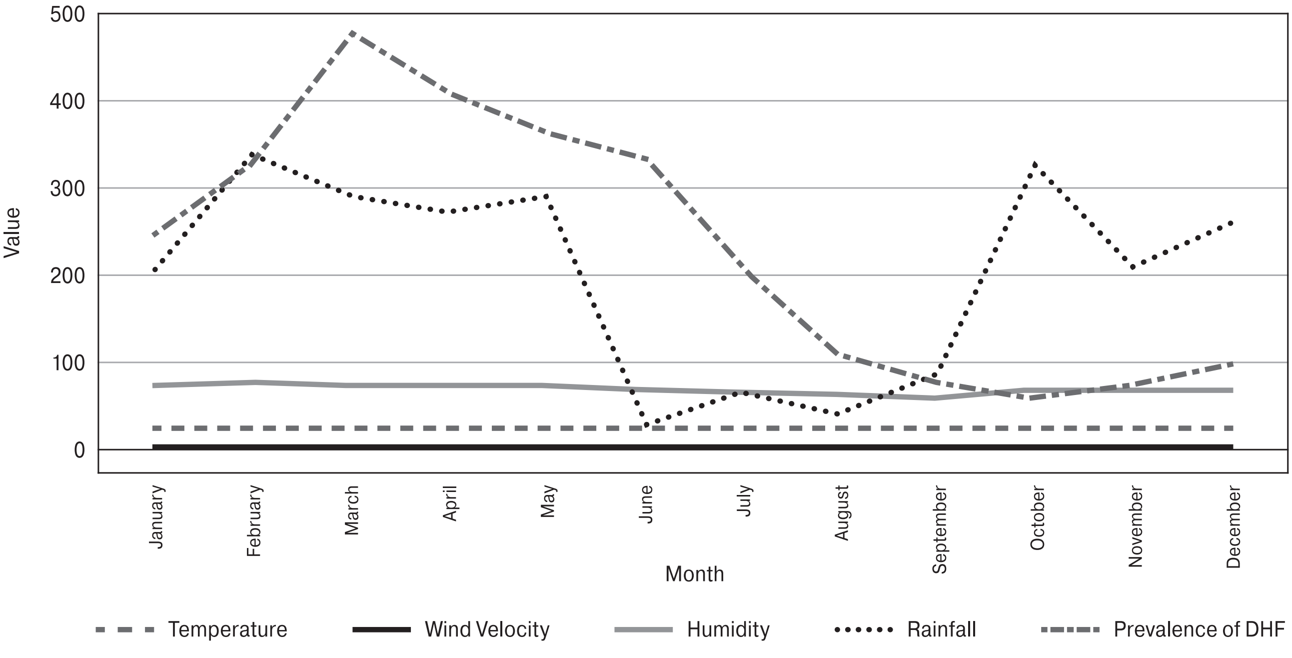

Figure. Month-wise dengue cases during 2020 in Bandung Municipality

Table 2. Mean, median, standard deviation, minimum maximum value of temperature, humidity, rainfall, wind velocity and prevalence of DHF in Bandung 2020

Variable	Mean	Median	SD	Min	Max
Temperature	25.867	25.850	0.4499	25.2	26.9
Humidity	69.908	70.150	5.0403	59.7	76.4
Rainfall	201.550	234.800	115.0138	30.0	337.0
Wind Velocity	1.850	1.900	0.3705	1.3	2.7
Prevalence	232.50	228.50	148.766	60	479

Table 3. Results of correlation analysis between temperature, humidity, rainfall, and wind velocity to prevalence of DHF during 2020 in Bandung

Variable	Incident of DHF		Signification
	p-value (p)	Correlation coefficient (r)	
Temperature	0.324	–0.312	The correlation is no significant
Humidity	0.018	0.668	The correlation is significant, the positive is strong
Rainfall	0.383	0.277	The correlation is no significant
Wind Velocity	0.028	–0.629	The correlation is significant, the negative is strong

this research, the problem of climate and weather variability in Indonesia is changing in several regions in Indonesia. Previous studies in Java and Bali using the Local Indicator of Spatial Association (LISA) portrayed DHF case distribution patterns. They resulted in information on the aggregation of dengue cases through observation every month in January, June, August, and November [25].

Dengue is an infectious disease transmitted by tropical mosquitoes and caused by an arbovirus [27]. In the city of Bandung, the types of mosquitoes that are often encountered are aedes aegypti and aedes albopictus. These mosquitoes can survive at low temperatures that is the range of 10°C. The metabolic will decrease and can even be triggered when the temperature drops below the critical temperature of 4.5°C. A temperature higher than 35°C also changes because physiological processes are slower. The optimum average temperature for mosquito growth is 25–30°C. Air temperature affects the development of the virus in the mosquito body, the speed of biting, the behaviour of rest and mating, and the spread and duration of the gonotrophic cycle [16, 28].

Previous studies have stated that changes in temperature and humidity are significantly associated with an increased incidence of dengue fever [4]. A study in Taiwan evaluating the impact of weather variability on dengue incidence using the Autoregressive Integrated Moving Average (ARIMA) model showed that weather variability is a significant indicator of an increase in dengue incidence in metropolitan cities. Assessing the adverse health impacts associated with climate change often requires analysis at different geographic scales and times. Large-scale prediction models are known to provide valuable information that projects global potential in dengue epidemics when there is an increase in temperature [35]. This research is in line with Wirayoga, which proves that changes in humidity provide a significant relationship with moderate levels. Positive relationships and relationships are increased humidity followed by an increase in the prevalence of DHF disease and vice versa. However, this is only partially the case in almost every occurrence because there are times when humidity increases and the incidence of DHF decreases [33].

Table 4. Result of prediction of DHF prevalence and simultaneous test of temperature, humidity, rainfall, and wind velocity to prevalence of DHF during 2020 in Bandung

Dependent Variable: Prevalence	
R	0.863
R Square	0.745
F	5.102
Anova (Simultan)	0.030

Mosquitoes use the respiratory system of air pipes (trachea) with holes in the walls of the mosquito body (spiracles). The spiral is wide open without any regulatory mechanism. If low humidity can cause water to evaporate from the body, this causes fluids in the body to mongering. It is known that one of the enemies of mosquitoes is evaporation. Clamps can affect mosquito lifespan, rest, biting habits, flight distance, and breeding speed [32]. Optimum temperatures and low humidity can increase vector production, while low humidity can decrease mosquitoes' survival effectiveness. Diverse variations in humidity, temperature, and rainfall play an essential role and influence mosquito populations [37]. Previous studies have stated a tendency to increase the incidence of dengue in tropical regions in Indonesia, such as Sumatra and Sulawesi, that have the potential to be affected by climate warming. The occurrence of dengue cases is sporadic in Kalimantan due to the burning of forests and land, which results in an increase in temperature and humidity, which has an impact on the dynamics of large mosquito populations in the surrounding environment. In Java Island, the population density continues to increase, resulting in ecological transformation so that humans and the people are deficient against dengue infection [2, 37].

Climatic variations can substantially modify vector-borne diseases. Aedes aegypti is the primary vector of several infectious diseases transmitted by vectors. Its ecology is currently an essential focus because, climatically, it is the primary determinant of mosquito habitat [6]. Different climatic factors affect the growth and survival of aedes aegypti; temperatures regulate reproduction rates, maturation and death, and precipitation results in breeding grounds for larvae and pupae. Unlike other species of mosquitoes, aedes aegypti eggs are laid above the water's surface and hatch only when the water level rises and wets them. The long survival time of its dried eggs gives aedes aegypti a competitive advantage over other mosquito species during long periods of drought. Still, winter rains can force the hatching and subsequent death of larvae. Determining how climate change affects these mosquitoes' geographical distribution cannot be underestimated [30]. Studies in Japan studied the continuity of hid larvae in Nagasaki. They argued that winter rainfall could cause mosquito eggs to hatch before spring so that larvae could die from low temperatures [29]. Similarly, field studies in Taiwan showed that larval mortality increases rapidly due to cold weather. Since rainfall can trigger the hatching process, winter rainfall can negatively impact aedes aegypti and can colonise new areas, especially in «cool margins» areas [3].

Wind velocity at sunrise and sunset at which mosquitoes fly in or out of the house determines human contact with mosquitoes. Wind velocity ranging from 11–14 m/s affects or impedes mosquito flight. Wind velocity will affect the flight distance of mosquitoes. A study in Banjarmasin City, Indonesia, states an average wind velocity of 4–6 knots. This speed cannot inhibit mosquitoes from flying and can be ideal for mosquito vectors [14]. Previous analysis also found that winds could affect spatial patterns of dengue transmission in Iquitos. It has been observed that mosquitoes can seek shelter during solid winds; thus, there is a positive relationship between wind speed and aedes aegypti. Breezy conditions can increase the likelihood of mosquitoes hiding indoors [23]. The high spread of cases and the impact of endemic tropical diseases in Indonesia were also carried out in the research of Kusnoputra et al. in the Depok and Bogor regions, where the number of dengue cases increased due to the environment and climate change. Based on the Intergovernmental Panel on Climate Change (IPCC) prediction in 1996, it is also stated that the incidence of dengue fever in Indonesia will increase three times from 2070 if it occurs in the environment and society with unchanged conditions [18].

Conclusion

The increase in dengue prevalence in Bandung City occurred from January to June, the decrease in prevalence occurred from July to December. There is a significant relationship between humidity and wind speed and DHF prevalence. Variations in temperature, humidity, rainfall and wind speed can simultaneously affect the incidence of DHF in Bandung. It is necessary to increase mosquito nest eradication activities to prevent DHF transmission considering that this disease has the potential to spread at any time. Further studies need to be carried out to determine the relationship between climate factors and dengue incidence by adding other variables, such as the presence of vectors, free numbers of larvae, community participation in eradicating mosquito nests, population density, urbanization flows and program management.

Acknowledgments

The author's gratitude goes to the Center for Research and Community Service at Bhakti Kencana University (LPPM-UBK) for providing support so that this research can be carried out as expected.

References

1. Anwar A., Ariati J. Dengue hemorrhagic fever (DHF) prediction model based on climate factors in Bogor city, West Java. *Indonesian Bulletin of Health Research, 2014, vol. 42, no. 4: 20092. doi: 10.22435/bpk.v42i4 Des.3663.249-256*
2. Carrington L.B., Armijos M.V., Lambrechts L., Barker C.M., Scott T.W. Effects of fluctuating daily temperatures at critical thermal extremes on Aedes aegypti life-history traits. *PLoS One, 2013, vol. 8, no. 3: e58824. doi: 10.1371/journal.pone.0058824*
3. Chang L.H., Hsu E.L., Teng H.J., Ho C.M. Differential survival of Aedes aegypti and Aedes albopictus (Diptera: Culicidae) larvae exposed to low temperatures in Taiwan. *J. Med. Entomol., 2007, vol. 44, no. 2, pp. 205–210. doi: 10.1603/0022-2585(2007)44[205:dsoaaa]2.0.co;2*
4. Chen Y., Yang Z., Jing Q., Huang J., Guo C., Yang K., Chen A., Lu J. Effects of natural and socioeconomic factors on dengue transmission in two cities of China from 2006 to 2017. *Sci. Total Environ., 2020, vol. 724: 138200. doi: 10.1016/j.scitotenv.2020.138200*
5. Cheng J., Bambrick H., Frentiu F.D., Devine G., Yakob L., Xu Z., Li Z., Yang W., Hu W. Extreme weather events and dengue outbreaks in Guangzhou, China: a time-series quasi-binomial distributed lag non-linear model. *Int. J. Biometeorol., 2021, vol. 65, no. 7, pp. 1033–1042. doi: 10.1007/s00484-021-02085-1*
6. Dhimal M., Gautam I., Joshi H.D., O'Hara R.B., Ahrens B., Kuch U. Risk factors for the presence of chikungunya and dengue vectors (Aedes aegypti and Aedes albopictus), their altitudinal distribution and climatic determinants of their abundance in central Nepal. *PLoS Negl. Trop. Dis., 2015, vol. 9, no. 3: e0003545. doi: 10.1371/journal.pntd.0003545*

7. Ferreira-de-Lima V.H., Lima-Camara T.N. Natural vertical transmission of dengue virus in Aedes aegypti and Aedes albopictus: a systematic review. *Parasit. Vectors, 2018, vol. 11, no. 1: 77. doi: 10.1186/s13071-018-2643-9*
8. Fuller D.O., Troyo A., Beier J.C. El Niño Southern Oscillation and vegetation dynamics as predictors of dengue fever cases in Costa Rica. *Environ. Res. Lett., 2009, vol. 4, pp. 140111–140118. doi: 10.1088/1748-9326/4/1/014011*
9. Fouque F., Carinci R., Gaborit P., Issaly J., Bicout D.J., Sabatier P. Aedes aegypti survival and dengue transmission patterns in French Guiana. *J. Vector Ecol., 2006, vol. 31, no. 2, pp. 390–399. doi: 10.3376/1081-1710(2006)31[390:aasadt]2.0.co;2*
10. Gan S.J., Leong Y.Q., Bin Barhanuddin M.F.H., Wong S.T., Wong S.F., Mak J.W., Ahmad R.B. Dengue fever and insecticide resistance in Aedes mosquitoes in Southeast Asia: a review. *Parasit. Vectors, 2021, vol. 14, no. 1: 315. doi: 10.1186/s13071-021-04785-4*
11. Hidayati L., Hadi U.K., Soviana S. Dengue hemorrhagic fever incidence in Sukabumi City according to climate condition. *Acta Vet. Indones., 2017, vol. 5, no. 1, pp. 22–28.*
12. Hii Y.L., Rocklöv J., Ng N., Tang C.S., Pang F.Y., Sauerborn R. Climate variability and increase in intensity and magnitude of dengue incidence in Singapore. *Glob. Health Action, 2009, no. 2. doi: 10.3402/gha.v2i0.2036*
13. Indriani C., Ahmad R.A., Wiratama B.S., Arguni E., Supriyati E., Sasmono R.T., Kisworini F.Y., Ryan P.A., O'Neill S.L., Simmons C.P., Utarini A., Anders K.L. Baseline characterization of dengue epidemiology in Yogyakarta City, Indonesia, before a randomized controlled trial of wolbachia for arboviral disease control. *Am. J. Trop. Med. Hyg., 2018, vol. 99, no. 5, pp. 1299–1307. doi: 10.4269/ajtmh.18-0315*
14. Ishak N.I., Kasman K. The effect of climate factors for dengue hemorrhagic fever in Banjarmasin City, South Kalimantan Province, Indonesia, 2012–2016. *Public Heal. Indones., 2018, vol. 4, no. 3, pp. 121–128.*
15. Islam S., Haque C.E., Hossain S., Hanesiak J. Climate variability, dengue vector abundance and dengue fever cases in Dhaka, Bangladesh: a time-series study. *Atmosphere (Basel)., 2021, vol. 12, no. 7: 905. doi: 10.3390/atmos12070905*
16. Jahan Y., Rahman A. Management of dengue hemorrhagic fever in a secondary level hospital in Bangladesh: a case report. *IDCases, 2020, vol. 21: e00880. doi: 10.1016/j.idcr.2020.e00880*
17. Johansson M.A., Dominici F., Glass G.E. Local and global effects of climate on dengue transmission in Puerto Rico. *PLoS Negl. Trop. Dis., 2009, vol. 3, no. 2: e382. doi: 10.1371/journal.pntd.0000382*
18. Kusnoputranto H., Sintorini M.M., Utomo S.W., Aliyyah E.R.K.S.N., Pratiwi O.A. Dynamic transmission of dengue hemorraghic fever and climate variability patterns in Depok and Bogor. *Indian J. Public Health Res. Dev., 2020, vol. 11, no. 6, pp. 1263–1266.*
19. Mekuriaw W., Kinde S., Kindu B., Mulualem Y., Hailu G., Gebresilassie A., Sisay C., Bekele F., Amare H., Wossen M., Woyessa A., Cross C.L., Messenger L.A. Epidemiological, entomological, and climatological investigation of the 2019 dengue fever outbreak in Gewane district, Afar region, North-East Ethiopia. *Insects, 2022, vol. 13, no. 11: 1066. doi: 10.3390/insects13111066*
20. Ministry of Health R.I. Indonesia's Health Profile in 2019. Ministry of Health R.I., 2020. *URL: https://www.kemkes.go.id/downloads/resources/download/pusdatin/profil-kesehatan-indonesia/Profil-Kesehatan-Indonesia-2019.pdf*
21. Monintja T.C.N., Arsin A.A., Amiruddin R., Syafar M. Analysis of temperature and humidity on dengue hemorrhagic fever in Manado Municipality. *Gac Sanit., 2021, vol. 35, suppl. 2, pp. S330–S333. doi: 10.1016/j.gaceta.2021.07.020*
22. Nugraha F., Haryanto B., Wulandari R.A., Pakasi T.T. Ecological study of the relationship between dengue hemorrhagic fever (DHF) and climate factors in the administrative city of Central Jakarta, Indonesia, 1999–2018. *Jurnal Ilmu Kesehatan Masyarakat, 2021, vol. 10, no. 3, pp. 142–148.*
23. Reiner R.C. Jr., Stoddard S.T., Vazquez-Prokopec G.M., Astete H., Perkins T.A., Sihuincha M., Stancil J.D., Smith D.L., Kochel T.J., Halsey E.S., Kitron U., Morrison A.C., Scott T.W. Estimating the impact of city-wide Aedes aegypti population control: an observational study in Iquitos, Peru. *PLoS Negl. Trop. Dis., 2019, vol. 13, no. 5: e0007255. doi: 10.1371/journal.pntd.0007255*
24. Ridha M.R., Indriyati L., Tomia A., Juhairiyah J. The effect of climate on the incidence of dengue hemorrhagic fever in the city of Ternate. *Spirakel, 2019, vol. 11, no. 2, pp. 53–62*
25. Saputro D.R.S., Widyaningsih Y., Widyaningsih P., Sutanto, Widiastuti. Spatio-temporal patterns of dengue hemorrhagic fever (DHF) cases with local indicator of spatial association (LISA) and cluster map at areas risk in Java-Bali Indonesia. *AIP Conference Proceedings, 2021, vol. 2326, no. 1: 020027. doi: 10.1063/5.0040334*
26. Sutriyawan A., Herdianti H., Cakranegara P.A., Lolan Y.P., Sinaga Y. Predictive index using receiver operating characteristic and trend analysis of dengue hemorrhagic fever incidence. *Open Access Maced J. Med. Sci., 2022, vol. 10, no. E, pp. 681–687. doi: 10.3889/oamjms.2022.8975*
27. Simo Tchetgna H., Sado Yousseu F., Kamgang B., Tedjou A., McCall P.J., Wondji C.S. Concurrent circulation of dengue serotype 1, 2 and 3 among acute febrile patients in Cameroon. *PLoS Negl. Trop. Dis., 2021, vol. 15, no. 10: e0009860. doi: 10.1371/journal.pntd.0009860*
28. Thamrin Y., Pisaniello D., Guerin C., Rothmore P. Correlates of work-study conflict among international students in Australia: a multivariate analysis. *Int. J. Environ. Res. Public Health, 2019, vol. 16, no. 15: 2695. doi: 10.3390/ijerph16152695*
29. Tsuda Y., Takagi M. Survival and development of Aedes aegypti and Aedes albopictus (Diptera: Culicidae) larvae under a seasonally changing environment in Nagasaki, Japan. *Environ Entomol., 2021, vol. 30, no. 5, pp. 855–860. doi: 10.1603/0046-225X-30.5.855*
30. Valdez L.D., Sibona G.J., Condat C.A. Impact of rainfall on Aedes aegypti populations. *Ecol. Modell., 2018, vol. 385, pp. 96–105. doi: 10.1016/j.ecolmodel.2018.07.003*
31. Widawati M., Fuadiyah M.E.A. Climate factors influence the incidence of dengue hemorrhagic fever in Cimahi City in 2004-2013. *Spirakel, 2018. vol. 10, no. 2, pp. 86–96*
32. Williams C.R., Mincham G., Ritchie S.A., Viennet E., Harley D. Bionomic response of Aedes aegypti to two future climate change scenarios in far north Queensland, Australia: implications for dengue outbreaks. *Parasit. Vectors, 2014, vol. 7: 447. doi: 10.1186/1756-3305-7-447*
33. Wirayoga M.A. Hubungan kejadian demam berdarah dengue dengan Iklim di Kota Semarang tahun 2006–2011. *Unnes Journal of Public Health., 2013, vol. 2, no. 4, pp. 1–9.*

34. Wiyono L., Rocha I.C.N., Cedeño T.D.D., Miranda A.V., Lucero-Prisno Iii D.E. Dengue and COVID-19 infections in the ASEAN region: a concurrent outbreak of viral diseases. *Epidemiol. Health, 2021, vol. 43: e2021070. doi: 10.4178/epih.e2021070*
35. Wu P.C., Guo H.R., Lung S.C., Lin C.Y., Su H.J. Weather as an effective predictor for occurrence of dengue fever in Taiwan. *Acta Trop., 2007, vol. 103, no. 1, pp. 50–57. doi: 10.1016/j.actatropica.2007.05.014*
36. Xu H.Y., Fu X., Lee L.K., Ma S., Goh K.T., Wong J., Habibullah M.S., Lee G.K., Lim T.K., Tambyah P.A., Lim C.L., Ng L.C. Statistical modeling reveals the effect of absolute humidity on dengue in Singapore. *PLoS Negl. Trop. Dis., 2014, vol. 8, no. 5: e2805. doi: 10.1371/journal.pntd.0002805*
37. Xu L., Stige L.C., Chan K.S., Zhou J., Yang J., Sang S., Wang M., Yang Z., Yan Z., Jiang T., Lu L., Yue Y., Liu X., Lin H., Xu J., Liu Q., Stenseth N.C. Climate variation drives dengue dynamics. *Proc. Natl Acad. Sci. USA, 2017, vol. 114, no. 1, pp. 113–118. doi: 10.1073/pnas.1618558114*
38. Yang H.M., Macoris M.L., Galvani K.C., Andrighetti M.T., Wanderley D.M. Assessing the effects of temperature on the population of Aedes aegypti, the vector of dengue. *Epidemiol. Infect., 2009, vol. 137, no. 8, pp. 1188–1202. doi: 10.1017/S0950268809002040*

Авторы:

Сутрияван А., магистр общественного здравоохранения, ассистент, Департамент общественного здравоохранения, Университет Бхакти Кенчана, Бандунг, Индонезия;
Курниати Н., магистр социологии, бакалавр общественного здравоохранения, магистр прикладного акушерства, ассистент, кафедра акушерства, Университет Бенгкулу, Бенгкулу, Индонезия;
Новианти, магистр социологии, магистр акушерства, ассистент, кафедра акушерства, Университет Бенгкулу, Бенгкулу, Индонезия;
Фарида У., к.м.н., магистр фармакологии, доцент, факультет фармации, Университет Аирлангга, Институт медицинских наук Бхакти Вията, Сурабая, Индонезия;
Юсанти Л., магистр социологии, магистр акушерства, ассистент, кафедра акушерства, Университет Бенгкулу, Бенгкулу, Индонезия;
Дестриани Ш.Н., магистр социологии, магистр акушерства, ассистент, кафедра акушерства, Университет Бенгкулу, Бенгкулу, Индонезия;
Сапутра М.Х.Ф., магистр сестринского дела, преподаватель, кафедра сестринского дела, Колледж медицинских наук Байтул Хикма, Бандар Лампунг, Индонезия.

Authors:

Sutriyawan A., SKM, MPH, Assistant Professor, Department of Public Health, Bhakti Kencana University, Bandung, Indonesia;
Kurniati N., S.ST., S.KM., M.Tr.Keb, Assistant Professor, Department of Midwifery, University of Bengkulu, Bengkulu, Indonesia;
Novianti, S.ST., M.Keb, Department of Midwifery, University of Bengkulu, Assistant Professor, Bengkulu, Indonesia;
Farida U., apt., M.Farm, Assistant Professor, Department of Pharmacy, Airlangga University, Bhakti Wiyata Institute of Health Sciences, Surabaya City, Indonesia;
Yusanti L., S.ST., M.Keb, Assistant Professor, Department of Midwifery, University of Bengkulu, Bengkulu, Indonesia;
Destriani S.N., S.ST., M.Keb, Assistant Professor, Department of Midwifery, University of Bengkulu, Bengkulu, Indonesia;
Saputra M.K.F., S.Kep., Ns., M.Kep, Lecturer, Department of Nursing, Baitul Hikmah College of Health Sciences, Bandar Lampung, Indonesia.

Поступила в редакцию 02.01.2023
Отправлена на доработку 10.03.2023
Принята к печати 05.03.2024

Received 02.01.2023
Revision received 10.03.2023
Accepted 05.03.2024