JPH RECODE October 2023; 7(1): 21-29
http://e-journal.unair.ac.id/JPHRECODE
http://dx.doi.org/10.20473/jphrecode.v7i1.34248

SPATIAL ANALYSIS OF DENGUE HEMORRHAGIC FEVER IN EAST MANGGARAI, INDONESIA: A CASE STUDY

Wilibaldus Julian Siga[1], Erni Astutik[1], Yohanes Ximenes[2]
[1] Department of Epidemiology, Biostatistics, Population and Health Promotion, Faculty of Public Health, Universitas Airlangga, Indonesia
[2] Lembaga Swadaya Masyarakat Yayasan Tanpa Batas, Indonesia
wilibaldussiga97@gmail.com

ARTICLE INFO

Article History:
Received: 11th, March 2022

Revised:
From 11th, March 2022

Accepted: 30th, May 2022

Published: 01st, October 2023

ABSTRACT

Background: East Manggarai is one of the District in East Nusa Tenggara Province with a high transmission area and a high number of Dengue Hemorrhagic Fever cases. Spatial analysis can provide spatial information related to the distribution pattern of DHF. **Purpose:** To spatially analyze the cases of DHF in East Manggarai District in 2021. **Methods:** This study used a descriptive survey method with a case study design sampling technique, Purposive sampling approach used a sample size of 103 cases. Data processing and spatial data analysis use Quantum Geographic Information Systems software with Nearest Neighbor Analysis and buffer analysis to describe the distribution of cases based on population density, House Index, Container Index, and Buffer Zone. **Results:** Spatial analysis using QGIS showed that the Nearest Neighbor Index was 0.323 < 1, and the CI value was 34.7, the HI value was 54 while the buffer zone showed the tendency for dengue transmission to occur in most cases within a radius of 100 meters. **Conclusion:** The pattern of DHF transmission is clustered, the sub-districts of Borong, Rana Mese, and Komba became the sources of DHF transmission where Container Index and House Index were classified as high categories, and population density was classified as high and low categories. Preventive action such as eliminating mosquito breeding areas were essential.

Keywords: spatial analysis, DHF, east manggarai

Cite this as: Siga, W, J., Astutik, E., & Ximenes, Y. (2023). Spatial Analysis of Dengue Hemorrhagic Fever in East Manggarai, Indonesia: A Case Study. *Journal of Public Health Research and Community Health Development,* 7(1), 21-29. http://dx.doi.org/10.20473/jphrecode.v7i1.34248

INTRODUCTION

Dengue Hemorrhagic Fever (DHF) is a disease that can spread from one place to another through an intermediary vector, namely the Aedes Sp. Dengue Hemorrhagic Fever (DHF) is a disease that has the potential for outbreaks/epidemic caused by the dengue virus and is transmitted by the mosquito vectors of Aedes aegypti and Aedes albopictus (Info Datin Kemenkes RI, 2017). This disease is mostly experienced by children < 15 years, but can also be found in adults. DHF can potentially become an epidemic, cause extraordinary events (KLB), and reduce productivity which has an impact on economic growth in some tropical countries in the world.

Indonesia occupies the second position with the most dengue cases in Southeast Asia with the number of dengue cases fluctuating in the last three years. DHF cases in 2018 amounted to 65.602 cases with a case fatality rate (CFR) of 0.71%. There was an increase from the previous year and reported cases of DHF as many as 138.127 cases with a CFR of 0.67% in 2019. However, the number of deaths showed an increase from 467 to 919 deaths (Kemenkes RI, 2021). In contrast, the number of dengue cases in January to July 2020 reached 71.633 cases, lower than in 2019 in the same period which amounted to 112.954, with 751 deaths or a case fatality rate (CFR) of 0.70% (Kemenkes RI, 2021).

This shows that the spread of DHF has not been fully resolved through various health programs that have been implemented. Nationally, there are 10 provinces that reported the highest number of cases, including the province of NTT which occupies the fifth position with 5.539 cases in 2020 (Kemenkes RI, 2021).

East Manggarai District has dengue cases with an incidence rate of 4.73 per 100.000 populations and occupies the second position after Kupang city in the period January-April 2021 in NTT Province (Dinkes Provinsi NTT, 2021). This incidence rate increased by 5.13 per 100.000 populations from 2020. An increase in dengue cases could potentially cause outbreaks, especially in non-endemic areas of DHF.

For this reason, in order to break the chain of transmission of DHF, the local government of East Manggarai District prioritizes the DHF eradication program by carrying out Mosquito Nest Eradication (MNE) and health education/promotion including epidemiological surveillance activities to produce information for decision making in planning, implementing and evaluating activities.

Epidemiological surveillance activities must describe the distribution based on epidemiological variables of people, place and time and produce information for the warning of DHF Extraordinary Events in accordance with established performance indicators (Kemenkes RI, 2017). The high number of dengue cases is caused by many factors including host immunity, mosquito population density, transmission of dengue virus, virus virulence and regional demographics, namely population density and mobilization and geographical conditions (Ximenes, Manurung and Riwu, 2019).

DHF tends to increase and spread widely due to the ease of transmission between individuals. Therefore, non-spatial and spatial analysis is needed (Hasirun, 2016). Geographic information systems can be used in public health, namely for spatial and temporal trend analysis (Setiawan, 2016). One of the area-based disease management analysis techniques used in dengue control is spatial analysis (Kusuma and Sukendra, 2016). The pattern of distribution of dengue cases can be known based on the area using spatial analysis. Spatial analysis using regional risk factor modeling will facilitate the control and management of dengue cases, especially in the distribution of dengue cases in high-risk areas. Spatial analysis based on Geographic Information Systems (GIS) can be used to be aware of potential outbreaks per region (Mandagi, Kalesaran and Kolibu, 2021). A study in Nepal by Acharya et al using the SATsan application showed that the spread of DHF was not random but clustered in space and time in the Chitwan and Jhapa areas (Acharya *et al.*, 2016).

The pattern of the spread of DHF can be determined by using spatial analysis. It was mapping the distance between cases, the radius of mosquito flight, the characteristics and geographical distribution of an area so that control can be easily performed. Information on the geographic distribution of the population enables governments to reduce the risks associated with overcrowding and affect health promotion efforts. Higher population density correlates with shorter flight distance of dengue vectors, thereby increasing the risk of dengue spreading (Siregar and Djadja, 2021). Research using spatial analysis by Marizal in Tanah Datar District in 2008-2014 shows that densely populated sub-districts are the places with the most distribution of cases (Masrizal and Sari, 2016).

Based on a preliminary study conducted by researchers, the incidence of dengue fever was spread in several sub-districts, such as Borong sub-district, Komba sub-district, Rana Mese sub-district, Sambi Rampas sub-district, and Lamba Leda sub-district. Regional factors can be used as a reference for planning in prevention and control measures across sectors. Characteristics of different areas can be studied through spatial studies. Spatial analysis can provide useful information for predicting ongoing situation models and as an early warning system for dengue fever to guide vector control operations (Phanitchat *et al.*, 2019). The spatial pattern of DHF cases in the East Manggarai district is not yet known and spatial analysis has never been carried out, so this study aims to spatially analyze the pattern of distribution of DHF cases in the East Manggarai district. In this study, the distribution of cases is described based on population density, House Index (HI), Container Index (CI) and Buffer Zone. Thus, the government through the East Manggarai District health office can predict the situation model of the spread of DHF cases for decision making in efforts to prevent and control DHF.

METHOD

This research was a descriptive survey with a case study design. Based on the research design, the study was conducted to describe the spatial pattern of dengue fever occurrence in the East Manggarai District in 2021.

The study population, all DHF patients recorded at the East Manggarai Health Service in 2021 (as of January-June), totaled 143 cases. The research sample was collected using a purposive sampling technique with inclusion criteria: DHF cases with known spatial points of 103 samples.

Data on the coordinates of DHF patients was measured based on the address in the DHF patient report from the East Manggarai District Health Office which was obtained directly by the researcher using the Avenza Maps application. Secondary data are as follow: data from the East Manggarai Health Office and the case source Health Center and related population data from the Central Statistics Agency (BPS).

This study employed data collection techniques of observation and interviews. Interviews were conducted with Kshatan officers at the East Manggarai District Health Office. Data was collected using the Avenza Maps application and closed and open questions. Spatial data analysis using Nearest Neighbor Analysis (NNA) in Quantum Geographic Information Systems (QGIS) software to determine the pattern of spread of dengue cases. Nearest Neighbor Analysis can show whether or not there is a spatial pattern and the average distance between DHF cases in East Manggarai district. Determination of the distribution pattern using Nearest Neighbor Analysis can be expressed by the value of the Nearest Neighbor Index (NNI), if NNI = 1 indicates a random distribution pattern, NNI <1, indicates a clustered distribution pattern, NNI> 1 indicates a distribution pattern that spread (dispersed) (Wahyuningsih, 2014).

Spatial data processing using QGIS software to describe the distribution of cases based on the House Index (HI), Container Index (CI) and population density using spatial analysis with classification methods and data overlaying research variables namely HI, CI, population density with the distribution of DHF cases so that it is formed classification map and point of distribution of dengue cases. Buffer analysis to describe the pattern of spread of dengue cases according to the distance of the mosquito within a radius of 100 meters from the source of transmission.

This research has no ethical clearance, because the data taken is secondary data from the East Manggarai District Health Office for collecting coordinate points based on permission from the East Manggarai District Health Office and the Head of District of Borong sub-district, the Head of District of Kota Komba sub-district and the Head of sub-District Ranamese.

RESULT

Distribution Pattern of Dengue Fever

The pattern of distribution of dengue fever in the work area of the East Manggarai District Health Office for the period January-June 2021 with a total of 103 cases was analyzed using Nearest Neigbhour Analysis and the results are listed in table 1:

Table 1. The Calculation Results of the Nearest Neighbor Analysis of DHF Cases in East Manggarai Regency in 2021

Nearest Neigbhour Analysis Parameter	
Average distance between observed cases	340.58
Nearest Neighbour Index	0.3246
Observed point	103
Z-Score	-13.112
Scatter Pattern	*Cluster*

Based on Table 1, it is discovered that the calculation results using Nearest Neighbor Analysis with NNI of 0.32 <1, thus it can be concluded that the distribution pattern of DHF incidence in the working area of the Health Office of East Manggarai Regency is in groups or clusters. The following is a map of the distribution of dengue cases in East Manggarai Regency in 2021.

Source: DHF case register at the East Manggarai District Health Office, 2021

Figure 1. The Distribution Map of Dengue Cases in the Health Office of East Manggarai Regency Working Area in 202

Figure 1 showed that the largest distribution of dengue cases in 2021 was in the Borong sub-district with 57 cases, followed by Kota Komba sub-district with 31 cases and Ranamese sub-district with 15 cases. Furthermore, the other 6 sub-districts namely Elar, South Elar, Sambi Rampas, Poco Ranaka, East Poco Ranaka and Lamba Leda had zero dengue cases.

Container Index and House Index

Container Index (CI) and House Index (HI) figures used in this study were numbers collected at the point of location of the case. The CI and HI figures in the 3 sub-districts were shown in Table 2:

Table 2. Figures for Container Index (CI) and House Index (HI) in Three Districts Affected by DHF Cases in East Manggarai Regency in 2021

District	Cointainer Index			Density Index (ID)	House Index			Density Index (ID)
	Number of Containers inspected	Number of Positive Containers	CI Number (%)		Number of houses inspected	Number of Positive Houses	HI Number (%)	
Borong	181	63	34.80	8	57	29	50.87	7
Komba City	90	34	37.77	8	31	16	51.61	7
Ranamese	86	27	31.39	7	15	8	53.33	7

Notes: Density Index= 1 = Low Density, Density Index = 2-5 = Medium Density, Density Index = 6-9 = High Density

Table 2 showed that based on the calculation of the Cointainer Index (CI) and House Index (HI) numbers, the three sub-districts (Borong District, Komba City and Ranamese) have density index numbers in the 6-9 interval. Therefore, they are categorized as areas with a high density of Aedes aegypti mosquito larvae.

Population Density

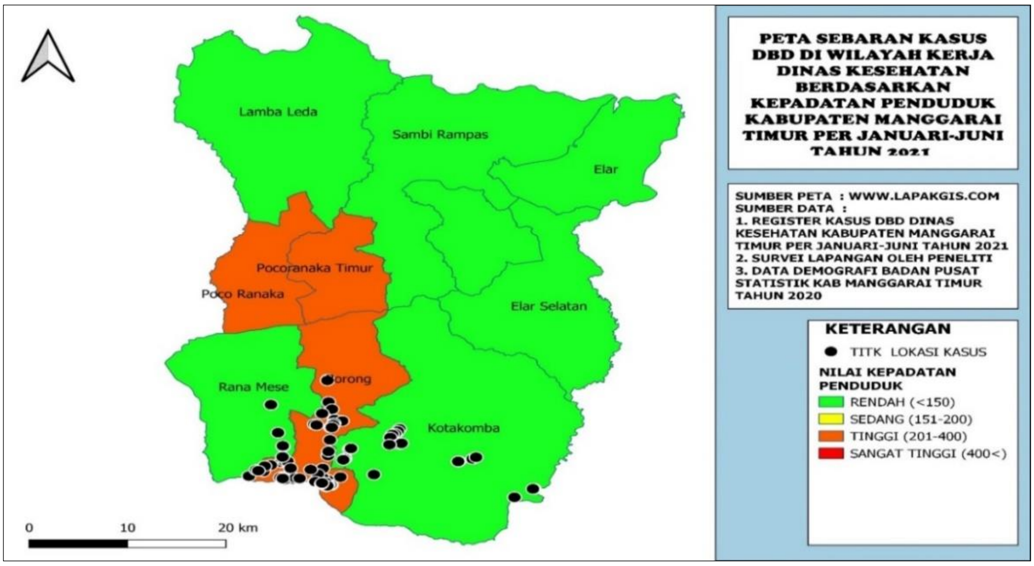
Population density per sub-district tends to vary according to the area. Information on population density per sub-district is presented in Table 3 (Bps Manggarai Timur, 2020):

Table 3. Population Density per District in East Manggarai Regency in 2020

District	Total population (Soul)	Area (km^2)	Population density (Soul/ km^2)
Borong	42600	17709	240.50
Elar	15100	276.71	54.56
South Elar	17600	239.24	76.56
Komba City	51300	511.00	100.34
Lamba Leda	32600	395.08	82.51
Sambi Rampas	27300	368.87	74.01
Poco Ranaka	33400	121.99	273.79
East Poco Ranaka	26600	104.24	255.18
Ranamese	28900	207.10	139.54

Source: Manggarai Timur Central District Bureau of Statistics, 2020

Table 3 showed that Poco Ranaka sub-district with a total of 273.79 people/km2 is the highest density area. Moreover, Elar sub-district with 76.56 inhabitants/km2 is the area with the lowest density. Population density based on the distribution of dengue cases was presented in Figure 2:



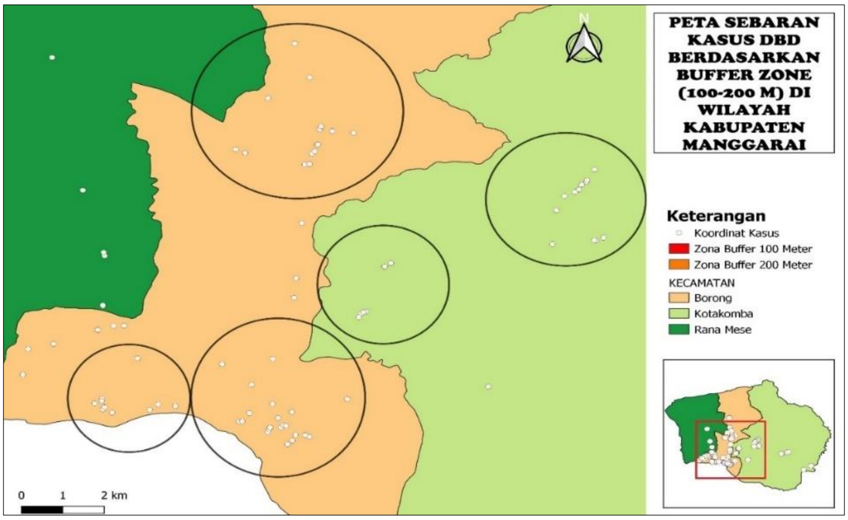
Source: DBD case register at the East Manggarai District Health Office, 2021

Figure 2. Distribution of DHF cases based on population density in the working area of the Health Office of East Manggarai Regency in 2021

Figure 2 showed the distribution of dengue cases mostly in areas with a high population density, namely in the Borong sub-district with a total of 240.50 people/km2. Other cases are spread in the sub-districts of Kota Komba and Ranamese with a low population density of 100.34 people/km2 and 139.54 people/km2, respectively.

Buffer Zone

Buffer Zone analysis using the Quantum GIS application with a buffer area 100 m from the case coordinates. The distance of 100 m is determined based on the distance the mosquito can fly horizontally. The following analysis results are described in Figure 3.



Source: DHF case register at the East Manggarai District Health Office, 2021

Figure 3. Distribution of Cases by Buffer zone of 100 meters & 200 meters in the working area of the Health Office of East Manggarai Regency in 2021

Figure 3. Shows that there are several cases of DHF occurring within a radius of 100 m from the coordinates of the cases. This is indicated by a circle of buffer zones that overlap one another. The large number of cases in the buffer area shows that local/local transmission of DHF is quite high in that area.

DISCUSSION

Nearest Neighbor Analysis with QGIS software obtained Nearest Neighbor Index 0.323 <1 which showed the distribution pattern in groups or clusters. The clustered pattern showed that the locus of transmission tends to be centered on geographically adjacent areas. The group distribution pattern indicates that there is a concentration of vector habitat that has the potential to increase the occurrence of transmission (Ruliansyah *et al.*, 2017). This group distribution pattern is also supported by the high Aedes aegypti mosquito vector habitat in the case house. The low behavior of the people in East Manggarai in eradicating mosquito nests, namely not using abate, rarely cleaning and closing water reservoirs and littering are factors that play a role in the high dengue vector habitat. This is in accordance with research conducted by Ashlihah in Palopo City which showed that the distribution pattern of DHF incidence is cluster or in groups. The distribution pattern of clustered cases as an indicator of virus transmission is not only mediated by mosquito activity but is also strongly influenced by human activities in urban areas (Ashlihah, Indriani and Lazuardi, 2016).

The existence of live mosquito larvae is very possible for the occurrence of dengue fever. This is also supported by the high percentage of Container index and House index as an indicator of the high density of Aedes aegypti mosquito larvae. The density of the Aedes aegypti mosquito increases the risk of dengue transmission in the community. The results of research by Yuanita, Setiani and Wahyuningsih in the Pringsewu area of Semarang showed a relationship between CI (p=0.000) and HI (p=0.000) with the incidence of dengue fever (Yuanita, Setiani and Wahyuningsih, 2019).

The existence of a container (water reservoir) is a risk factor for high mosquito density and affects the survival of mosquitoes. The results of interviews and observations showed that most areas of East Manggarai Regency are areas that have low clean availability so that people have many containers including water reservoirs, drums in an open condition which are used as containers to collect rainwater and river water for daily needs. This is in line with research by Narmala & Azizah (2019) in Tegalrejo Hamlet and Krajan Kidul Hamlet, Nanggungan Pacitan, which showed that the presence of containers greatly influences the presence of mosquito larvae, thus affecting the virtual status index and larva density (Narmala and Azizah, 2019). In addition, the results of research by Fatati, Wijayanto and Soleh in Central Java Province in 2017 illustrated that the number of dengue cases tends to decrease in areas with increased access to proper drinking water. (Fatati, Wijayanto and Sholeh, 2017). Population density is defined as the number of inhabitants per square kilometer (area) of an area (Retno Trihastuti, 2021).

One of the factors that influence the process of disease transmission from one person to another is population density. Population density has a directly proportional relationship with dengue cases. In line with this, WHO stated that the frequency of contact with Aedes aegypti mosquitoes increases in urban areas with high population density (Ashlihah, Indriani and Lazuardi, 2016)

The distribution of dengue cases in East Manggarai Regency was mostly found in areas with a high population density, namely in Borong sub-district with a total of 240.50 people/km2. Meanwhile, other cases are spread in the sub-districts of Komba City and Ranamese with a low population density of 100.34 people/km2 and 139.54 people/km2, respectively. The population density factor affects the process of DHF transmission between individuals. This is in line with the results of Kusuma and Sukendra's research in the working area of the Kedungmundu Health Center which showed a spatial relationship between the distribution of DHF and population density (Kusuma and Sukendra, 2016). The results of another study from Zulfa, Rafika Fauziah, Munaya in South Tangerang in 2016-2019 showed that the distribution pattern of Dengue Hemorrhagic Fever moved in line wihe sth the increase in population. (Zulfa and Fauziah, 2020).

The buffer zone analysis shows that most cases tend to occur within a radius of 100 meters from the case point. The case distribution zone within a radius of 100 m can occur in areas that have a high population density, namely Borong District. This is in line with research conducted by Ximenes in the Oesapa Health Center Working Area which showed that most of the cases were transmitted within a radius of 100 meters (Ximenes, Manurung and Riwu, 2019). Research by Hazrin et al in Putra Jaya Malaysia in 2016 showed that dengue cases in the district were very clustered and occurred at an average distance of 264.91 meters.

The buffer analysis does not look at the administrative boundaries of the region but considers the flying distance of mosquitoes from the source of transmission, namely dengue cases. This analysis is carried out by looking at the flying range of mosquitoes to determine the direction of transmission of dengue disease, the potential for spread and the place of occurrence of dengue so that prevention efforts can be carried out..

The use of GIS applications in this study can be useful in developing strategies for implementing dengue infection prevention and control activities (Hazrin *et al.*, 2016). Furthermore, the results of spatial information on DHF are used as a tool in formulating policies, making decisions, and implementing activities related to DHF (Sarwani *et al.*, 2021).

Spatial analysis techniques can be used in determining the steps to prevent dengue fever (Nuckols, Ward and Jarup, 2004). Utilization of spatial analysis can describe the location of the spread of DHF events and the actual transmission pattern through existing maps. The strength of this research is the ease of collecting case spatial points in areas that have limited internet networks using the Avenza Maps application. The drawback of this research is that the Cointainer Index (CI) and House Index (HI) data are data collected at the location of the case. The data analysis used is limited to determining the distribution pattern of DHF cases without analyzing the relationship between clusters, so that it can be considered for further research.

CONCLUSION

The pattern of distribution of dengue fever is a clustered pattern, with transmission tending to occur within a radius of 100 meters from the case point. Borong, Rana mese and Kota Komba sub-districts are included in the high category of Container Index, House Index and most cases occur in areas with high population density category.

SUGGESTIONS

Mosquito nest eradication activities, namely using abate, cleaning and closing water reservoirs and disposing of garbage in its place, are a solution for the community. In addition, it is necessary to manage periodic larvae monitoring activities from Health Officers to monitor Aedes mosquito larvae so that prevention and early warning efforts can be carried out.

ACKNOWLEDGMENTS

We thanks to Mrs. Erni for her assistance in study design, data collection, data supervision, data analysis, and revision the important content of manuscript. We also thanks to Mr. Yohanes Ximenes for helping in data analysis, manuscript revision.

CONFLICT OF INTEREST

Author have no conflict of interest.

FUNDING SOURCE

The funding source for this research is a personal fund.

AUTHOR CONTRIBUTION

Author Wilibaldus Julian Siga Data collection, data analysis, manuscript writing, literature review, reference. Author Erni Astutik study design, supervision, data analysis, manuscript revision. Author Yohanes Ximenes data analysis, manuscript revision.

REFFERENCES

Acharya, B. K. *et al.* 2016. Spatiotemporal Analysis Of Dengue Fever In Nepal From 2010 to 2014. *BMC Public Health*, *16*(1), pp. 849. doi: 10.1186/s12889-016-3432-z.

Ashlihah, S., Indriani, C., and Lazuardi, L. 2016. Pola spasial-temporal kejadian demam berdarah dengue di kota Palopo, *Berita Kedokteran Masyarakat*, *32*(2), pp. 45. doi: 10.22146/bkm.6861.

BPS Kabupaten Manggarai Timur. 2020. Kabupaten Dalam Angka Manggarai Timur.

Dinkes Provinsi NTT. 2021. Data Kasus DBD Bulan Januari- April 2021 Provinsi Nusa Tenggara Timur. (APRIL), p. 19750712.

Fatati, I. F., Wijayanto, H., and Sholeh, A. M. 2017. Analisis Regresi Spasial Dan Pola Penyebaran Pada Kasus Demam Berdarah Dengue (DBD) Di Provinsi Jawa Tengah', *Media Statistika*, 10(2), pp. 95. doi: 10.14710/medstat.10.2.95-105.

Hasirun. 2016. *Model Spasial Faktor Risiko Kejadian Demam Berdarah Dengue Di Provinsi Jawa Timur Tahun 2014*. Surabaya: Perpustakaan Universitas Airlangga.

Hazrin, M. *et al.* 2016. Spatial Distribution of Dengue Incidence : A Case Study in Putrajaya, (February), pp. 89–97.

Kemenkes RI. 2017. Buku Pedoman Penyelidikan Dan Penanggulangan Kejadian Luar Biasa Penyakit Menular Dan Keracunan Pangan (Pedoman Epidemiologi Penyakit). Jakarta: Kemenkes RI.

Kemenkes RI. 2018. Situasi Penyakit Demam Berdarah di Indonesia. Jakarta: Kemenkes RI.

Kemenkes RI. 2019. Profil Kesehatan Indonesia Tahun 2019. *Short Textbook of Preventive and Social Medicine*. doi: 10.5005/jp/books/11257_5.

Kemenkes RI. 2021. Data Dbd Indonesia'. Available at https://sehatnegeriku.kemkes.go.id/baca/umum/20201203/2335899/data-kasus-terbaru-dbd-indonesia/.

Kusuma, A. P. and Sukendra, D. M. 2016. Analisis Spasial Kejadian Demam Berdarah Dengue Berdasarkan Kepadatan Penduduk', *Unnes Journal of Public Health*, *5*(1), pp. 48. doi: 10.15294/ujph.v5i1.9703.

Mandagi, C. K. F., Kalesaran, A. F. C., and Kolibu, F. K. 2021. Spatial analysis of dengue hemorrhagic fever in Talaud Islands regency. *International Journal Of Community Medicine And Public Health*, *8*(1), pp. 104–110. doi: 10.18203/2394-6040.ijcmph20205683

Masrizal and Sari, N. P. 2016. Analisis kasus DBD berdasarkan unsur iklim dan kepadatan penduduk melalui pendekatan GIS di tanah datar. *Jurnal Kesehatan Masyarakat Andalas*, *10*(2), pp. 166–171. doi: 10.24893/jkma.v10i2.202

Narmala, Y. A. and Azizah, R. 2019. Maya Index Dan Kepadatan Larva Aedes Aegypti Antara Dusun Tegalrejo Dan Dusun Krajan Kidul Nanggungan Pacitan. *The Indonesian Journal of Public Health*, *10*(2), pp. 199. doi: 10.20473/ijph.v14i2.2019.200-210.

Nuckols, J. R., Ward, M. H., and Jarup, L. 2004. Using geographic information systems for exposure assessment in environmental epidemiology studies', *Environmental Health Perspectives*, *112*(9), pp. 1007–1015. doi: 10.1289/ehp.6738.

Phanitchat, T. *et al.* 2019. Spatial and temporal patterns of dengue incidence in northeastern Thailand 2006 – 2016. *BMC Infectious Diseases 19*(1), pp. 743. doi: 10.1186/s12879-019-4379-3

Retno Trihastuti, L. Y. H. 2021. Spatial Analysis Of Dengue Hemorrhagic Fever Based On Influencing Factors In Jombang, 2014–2018. *Jurnal Berkala Epidemiologi*, *9*(1), pp. 79–87. doi: 10.20473/jbe.v9i12021.79.

Ruliansyah, A. *et al.* 2017. Analisis Spasial Sebaran Demam Berdarah Dengue di Kota Tasikmalaya Tahun 2011 – 2015. *ASPIRATOR - Journal of Vector-borne Disease Studies*, *9*(2), pp. 85–90. doi: 10.22435/aspirator.v9i2.6474.85-90.

Sarwani, D. *et al.* 2021. A spatiotemporal analysis of dengue hemorrhagic fever in Banyumas , Indonesia. *International Journal of Public Health Science (IJPHS). 10*(2), pp. 231–240. doi: 10.11591/ijphs.v10i2.20713.

Setiawan, I. 2016. Peran Sistem Informasi Geografis (Sig) Dalam Meningkatkan Kemampuan Berpikir Spasial (Spatial Thinking. *Jurnal Geografi Gea*, *15*(1), pp. 83–89. doi: 10.17509/gea.v15i1.4187.

Siregar, D., and Djadja, I. M. 2021. Spatial Analysis And Mapping Of Dengue Hemorrhagic Fever (DHF) Risk In Rural Populations In Panongan Subdistrict, Tangerang. *Annals of Tropical Medicine & Public Health*, *24*(03), pp. 3–8. doi: 10.36295/asro.2021.24367.

Wahyuningsih, F. 2014. *Dengue Di Wilayah Kerja Puskesmas Pengasinan Kota Bekasi Tahun 2011-2013.* (Skripsi, Fakultas Kedokteran dan Ilmu Kesehatan UIN Syarif Hidayatullah)

Ximenes, Y. A. W., Manurung, I. F. E., and Riwu, Y. R. 2019. Analisis Spasial Kejadian DBD di Wilayah Kerja Puskesmas Oesapa Tahun 2019. *Timorese Journal of Public Health*, *1*(4), pp. 150–156. doi: 10.35508/tjph.v1i4.2142.

Yuanita, Y. N., Setiani, O. and Wahyuningsih, N. E. 2019. Spatial Analysis of Breeding Place and Larva Density Existence with DHF (Dengue Hemorrhagic Fever) Incidence Rate in Pringsewu District, Indonesia. *International Journal of English Literature and Social Sciences*, *4*(5), pp. 1357–1364. doi: 10.22161/ijels.45.17.

Zulfa, R. and Fauziah, M. 2020. Analisi Spasial Kejadian Demam Berdarah Dengue di Kota Tangerang Selatan Tahun 2016-2019. *Jurnal kajian dan Pengembangan Kesehatan Masyarakat. 1*(1), pp. 74–98.

