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ORIGINAL RESEARCH

SPATIAL ANALYSIS OF DENGUE HEMORRHAGIC FEVER BASED ON INFLUENCING FACTORS IN JOMBANG, 2014–2018

Analisis Spasial Demam Berdarah Berdasarkan Faktor yang Mempengaruhi di Kabupaten Jombang Tahun 2014 - 2018

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ABSTRACT

Background: Jombang District is an endemic area of dengue hemorrhagic fever (DHF). **Purpose**: The aim of this study was to spatially analyze various factors simultaneously (multivariate analysis) in relation to the incidence of DHF in Jombang District during the period 2014–2018. The factors studied were population density, larvae free index, rainfall, coverage of healthy homes, and healthy lifestyle coverage. **Methods**: The research was conducted as an observational study with an ecology research design. The data were secondary data from the Health Office and Statistic Central Bureau of Jombang District. The population consisted of 21 sub-districts in Jombang District in 2014–2018. The sample used the total population. The data analysis tool used in this study was GeoDa regression Moran's I software. **Results**: The bivariate analysis showed that there was a correlation between larvae free index (p = 0.04), healthy lifestyle coverage (p = 0.02), rainfall intensity (p = 0.20), population density (p = 0.07), and coverage of healthy houses (p = 0.22) with DHF incidence. According to Moran's I for spatial dependence (multivariate analysis), showed that there was a correlation between all the variables and DHF (p = 0.03). **Conclusions**: The variables of larvae free index and healthy lifestyle coverage related to the Incidence Rate (IR) of DHF cases. There was no correlation between IR and variable population density, rainfall, or coverage of healthy homes. Various spatial factors are simultaneously related to IR, even though only two variables are shown to be related to IR in the bivariate analysis.

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ABSTRAK

Latar Belakang : *Kabupaten Jombang merupakan daerah endemis demam berdarah dengue (DBD).* ***Tujuan:*** *Penelitian ini bertujuan untuk menganalisis secara spasial berbagai faktor secara simultan (analisis multivariat) terhadap kejadian demam berdarah dengue di Kabupaten Jombang tahun 2014 – 2018. Faktor yang diteliti adalah kepadatan penduduk, Angka Bebas Jentik (ABJ), curah hujan, cakupan rumah sehat, dan cakupan Perilaku Hidup Bersih dan Sehat (PHBS).* ***Metode:*** *Penelitian ini merupakan penelitian observasional dengan desain studi ekologi. Data yang digunakan adalah data sekunder dari Dinas Kesehatan Kabupaten Jombang dan Badan Pusat Statistik Kabupaten Jombang. Populasi adalah 21 kecamatan di Kabupaten Jombang Tahun 2014–2018. Penelitian ini menggunakan total populasi. Data dianalisis dengan menggunakan software GeoDa Local Moran's I.* ***Hasil :*** *Hasil analisis bivariate menunjukkan bahwa variabel Angka Bebas Jentik (ABJ) (p=0,04), cakupan PHBS (p=0,02) curah hujan (p=0,20), kepadatan penduduk (p=0,07) dan cakupan rumah sehat (p=0,22). Berdasarkan Moran's I spasial dependence secara multivariate mendapatkan hasil p=0.03* ***Kesimpulan:*** *Angka bebas jentik dan cakupan PHBS berhubungan dengan angka insiden (IR) kasus DBD. Tidak ada korelasi antara IR dengan variabel kepadatan penduduk, curah hujan, atau cakupan rumah sehat. Berbagai faktor spasial secara simultan berhubungan dengan IR walaupun pada bivariate hanya terdapat dua variabel saja yang berhubungan dengan IR DBD.*

INTRODUCTION

Dengue Hemorrhagic Fever (DHF) is a disease that threatens human health. It is caused by the dengue virus, which is classified as an arthropod-borne virus of the genus Flavivirus and the family Flaviviridae. It is transmitted by mosquito bite (genus Aedes, especially Aedes aegepty). The genus has four serotypes: Den-1, Den-2, Den-3, and Den-4. In addition to DHF, Aedes mosquitoes can carry other diseases such as chikungunya, yellow fever, and the Zika infection (Ministry of Health RI, 2017).

DHF is widespread throughout the tropics and sub-tropics, with risk factors affected by rainfall, temperature, relative humidity, urbanization rate, and quality of vector control services. Before 1970, only nine countries were experiencing a DHF epidemic. Today, the disease is endemic to more than 100 countries in the African, American, Eastern Mediterranean, Southeast Asian, and Western Pacific regions. Symptoms arise 3–14 days after an infective bite, and DHF affects people of all ages, including infants, children, and adults. The symptoms are a mild to high fever accompanied by severe headaches, pain in the back of the eyes, muscle and joint aches, and rashes. No specific anti-virus medication for DHF is available (World Health Organization, 2017).

Based on the Jombang Distritcal Health Office (2018), there were 204,171 cases of DHF in 2016 at Jombang District, with the number of deaths totaling 1,598. In 2017, the number of cases decreased dramatically to 68,407 with a total of 493 deaths, and in 2018, there were 65,602 cases with 467 deaths. The decrease in the incidence rate (IR) of DHF in 2017 compared with 2016 was quite high, from 78.85 to 26.10 per 100,000 population, with a further decrease in 2018 to 24.75 per 100,000 population.

Jombang District is an endemic area for DHF, and the disease often appears as an outbreak with relatively high morbidity rates. The East Java province's IR target is 49 per 100,000 population in line with the national target. In 2016, Jombang District's IR reached 91.6 per 100.00 population. In 2017, it decreased to 28.10 per 100,000 population, but in 2018, it increased again to 41.95

per 100,000 population. Efforts to prevent DHF cases have been carried out, including mosquito eradication, support of three pillars for the implementation of PSN in various regions, traveling broadcasts to carry out mosquito eradication, counseling about handling DHF, and distributing circulars about early precaution systems to related institutions. These control efforts were carried out in 2017, but the DHF IR continued to increase in 2018 (Jombang Distritcal Health Office, 2018).

Increased cases occur due to climate change, which adds to the dengue vector habitat, thereby increasing the risk of transmission. In addition to endemic DHF, Jombang District is estimated to have other risk factors that support the occurrence of the disease, including population density, larvae free index, rainfall, coverage of healthy homes, and healthy lifestyle coverage (PHBS) (Jombang Distritcal Health Office, 2018).

The aim of this study was to spatially analyze various factors simultaneously (multivariate analysis) in relation to the IR of DHF in Jombang District during the period 2014–2018. One of the approaches to prevention of DHF utilizes spatial statistics with the aim of unveiling any factors that underlie the occurrence of geographical phenomena related to DHF cases. The difference between this study and previous research is that there additional variables were applied in the spatial test using GeoDa: the coverage of healthy home, and the PHBS coverage.

METHODS

This study was conducted as observational research, and the design of this research was an ecological study. The research used profile data from the provincial health Department of Jombang District. Sources of data regarding DHF IRs, larvae free index, coverage of healthy homes, and coverage of PHBS Behaviors for 2014–2018 were obtained from Profile Jombang District Health Office, while rainfall and population density data for the same period were retrieved from the Indonesia Statistics Agency.

The population sample consisted of 21 sub-districts in Jombang District during the period 2014–2018. The sample was taken by using the total population. The independent variables were the average larvae free index, the average rainfall, the average population density, and the coverage of PHBS for 2014–2018, as well as the coverage of healthy houses (average 2014–2015).

The dependent variable was the average IR in 2014–2018. The average IR was defined by identifying all patients who had been diagnosed with DHF by a doctor as recorded at the District Health Office Jombang in each year, dividing by the population of each sub-district (per 100,000 residents), and dividing over five years for 2014–2018. The average larvae free index was defined as the number of houses that were free of larvae per the number of houses or buildings inspected in each year, multiplied by 100%, and divided over five years. Average rainfall was defined as the average annual rainfall in the study site environment in Jombang district each year (2014–2018) and divided over five years. The average population density was defined by taking the number of residents living in the urban area per square kilometer in 2014–2018 and dividing over five years. Coverage of healthy houses was defined by residences that met health requirements, including building and structuring homes based on physical and biological requirements. The method of calculation was the number of healthy homes in an area within each year against the number of existing homes in the area, multiplied by 100% and divided for five years. In this variable, there was no categorization because the data used in accordance with the GeoDa application were ratio data.

Data were analyzed by a multivariate approach with classic regression. The variables analyzed were various factors related to the IR of DHF cases based on spatial analysis in Jombang District. The study was conducted in August–September 2019. The research location was the working area of Jombang District Health Office. The research was carried out using spatial analysis through GeoDa. This research received a permission that granted by the ethics committee of the Faculty of Dental Health (No. 509/HRECCFODM/VII/2019).

RESULTS

According to Table 1, DHF cases in Jombang District in 2014–2018 tended to fluctuate. The highest number of cases occurred in 2016 (1,142 cases), while 2017 saw a decline of 69%, with the number of cases dipping to 351. However, in 2018, cases of DHF increased again by 50% from the previous year.

Table 2 shows that, for average IRs across the five years, the highest value was in Diwek sub-district, at 92 per 100,000 inhabitants, and the lowest was in Ngusikan sub-district, at 14 per

100,000 inhabitants. The highest average value for larvae free index across the five years was in the Perak sub-district, at 89%, while the lowest was in the Diwek sub-district, at 50%.

The highest average population density across the five years was in the Jombang sub-district, with 3,983 people/km², and the lowest density was in the Wonosalam sub district, with 261 people/km². The highest average rainfall value across the five years was in Wonosalam sub-district, at 207 mm/year, and the lowest rainfall level was found in Jogoroto District, at 113 mm/year (Table 2).

Table 3 shows the results of GeoDa analysis per variable. A p-value of 0.05 was calculated for the larvae-free and PHBS variables, which shows the relationship of these variables to DHF. For the variables of population density, rainfall, and healthy home coverage, there was a p-value of 0.05, which indicates that there was no correlation between these variables and DHF. The results of the multivariate analysis returned a value of $p < 0.05$, indicating a connection between all the variables and DHF.

For the variable of average healthy home coverage across the five years, the highest value was in the Sumobito sub-district, at 90%, and the lowest was in the Plandaan sub-district, at 27%. For the average PHBS coverage across the five years, the highest value was in the Jogoroto sub-district, at 82%, and the lowest was in the Wonosalam sub-district, at 15%.

DISCUSSION

Incident Rate

Jombang District is a region with a relatively number of DHF cases. This district's IR target of 49 per 100,000 population is in line with the East Java Province incident rate. There were eight sub-districts with an average case rate of DHF higher than 49 per 100,000 population during 2014–2018: Diwek, Jogoroto, Ngoro, Peterongan, Sumobito, Jombang, Bareng, and Mojowarno. The lowest incidence rates were recorded in Ploso, Wonosalam, and Ngusikan.

Larvae Free Index

The larvae free index measure is one tool used to determine the density of the dengue vector as it can give an idea of the extent of development of the disease vector in a given area (Ashlihah, Indriani, & Lazuardi, 2016). The higher the number of Aedes aegypti-breed mosquito vectors, the more larvae are found, indicating a higher risk for dengue disease (Narmala & Azizah, 2019).

Table 1
DHF Case and IR Distribution in Jombang District, 2014–2018

Sub District	2014		2015		2016		2017		2018	
	Cases	IR	Cases	IR	Cases	IR	Cases	IR	Cases	IR
Bandar K.M	1	2	14	32	19	43	7	16	12	21
Perak	6	12	25	48	47	90	13	25	28	48
Gudo	6	12	29	57	25	49	21	41	37	46
Diwek	21	20	73	70	211	200	45	42	75	128
Ngoro	16	23	21	30	47	67	30	43	66	193
Mojowarno	42	48	50	57	65	73	24	27	40	49
Bareng	20	40	32	63	52	103	20	39	17	17
Wonosalam	4	13	4	13	14	44	3	9	0	0
Mojoagung	11	15	58	76	77	100	18	23	28	20
Sumobito	18	23	78	97	79	98	23	28	28	40
Jogoroto	9	14	51	76	138	204	30	44	31	35
Peterongan	15	23	42	63	95	141	19	28	24	35
Jombang	19	13	72	50	119	82	45	31	55	97
Megaluh	6	16	24	64	37	99	3	8	13	30
Tembelang	10	20	13	26	25	49	6	12	16	41
Kesamben	4	7	18	29	39	63	8	13	16	37
Kudu	2	7	6	21	9	32	7	25	15	46
Ploso	3	8	7	18	15	38	7	18	5	7
Kabuh	5	13	19	48	18	45	5	13	10	24
Plandaan	5	14	7	20	5	14	14	39	8	34
Total	224	16	646	46	1,142	79	351	26	528	45

Table 2
Average Distribution of Case Incident Rate, Larvae Free Index, Population Density, Rainfall, Healthy Home Coverage, PHBS Coverage in Jombang District, 2014–2018

Sub District	IR	Larvae Free Index (%)	Population Density	Rainfall	Healthy Home	PHBS
Diwek	92	50	2,211	123	74	62
Jogoroto	75	67	2,390	113	60	82
Ngoro	71	66	1,409	157	75	57
Peterongan	58	51	2,279	123	78	56
Sumobito	57	70	1,700	138	90	46
Jombang	55	68	3,983	157	87	47
Bareng	52	66	537	170	57	29
Mojowarno	51	88	1,129	141	71	62
Mojoagung	47	49	1,274	150	88	37
Perak	44	89	1,807	179	67	61
Megaluh	43	52	1,317	118	82	45
Gudo	41	87	1,496	167	78	48
Kesamben	30	71	1,190	136	76	38
Tembelang	30	72	1,541	148	83	38
Kabuh	29	89	407	140	55	56
Bandar K.M	23	64	1,358	0	81	36
Kudu	26	70	367	159	75	68
Plandaan	24	81	296	0	27	22
Ploso	18	70	1,525	155	62	37
Wonosalam	16	76	261	207	36	15
Ngusikan	14	69	611	0	75	50
Average	43	70	1,398	128	70	47

Table 3
Spatial Analysis Results Using GeoDa

Variable	Analysis Result (*p*)
Larvae Free Index (ABJ)	0.04
Population density	0.07
Rainfall	0.20
Coverage of Healthy Homes	0.22
PHBS Coverage	0.02
All Factors Combined	0.03

The findings of this study show a relationship between the IR of DHF and the variable of larvae free index. This is in line with a study in the city of Yogyakarta, which also reported that there was a relationship between larvae free index and DHF cases (Wahyu & Widayani, 2018). The incidence of DHF is inseparable from the breeding of Aedes aegypti mosquitoes; therefore, the higher the larvae free index level, the fewer DHF cases occur, and vice versa (Kusuma & Sukendra, 2017).

Population Density

Population density was defined as the number of residents per square kilometer of area. Population density is the ratio between the number of inhabitants and the area (units = km²) (Subekti & Islamiyah, 2017). Based on the analysis of this study, there was no relationship between the IR and the population density. This is in line with another study that was conducted in Yogyakarta, which found that population density was not related to the incidence of DHF (Setiawan, Supardi, & Bani, 2017). Other studies indicating no correlation between population density and DHF cases include research in Malayang sub-district, Manado City (Paomey, Nelwan, & Kaunang, 2019) and in Banjarmasin (Kasman & Ishak, 2018).

Population density in downtown areas tends to be higher than in suburban areas (Handayani, Fannya, Roza, & Angelia, 2015). The denser the population, the easier it is for DHF to be transmitted. This is because the mosquito's flight distance is 50 meters; therefore, transmission can spread more quickly (Fatati, Wijayanto, & Sholeh, 2017). Another factor that explains why population density has no impact on the incidence of DHF is population mobility, which was not measured in this study. Both Murwanto, Trigunarso, & Purwono (2019) and Taryono, Ispriyanti, & Prahutama (2018) report that

population mobility is a factor that influences the incidence of DHF.

Rainfall

Rainfall refers to the amount of rainwater that falls in an area in a certain time period. High rainfall will indirectly lead to high levels of mosquito breeding as it leads to more mosquito breeding locations being formed (Azhari, Darundiati, & Dewanti, 2017). Current results show no relationship between rainfall level and the DHF IRs, as supported by a study in Tanah Datar, which also found that rainfall did not show a significant relationship with DHF cases (Masrizal & Sari, 2016). Other research showing that rainfall does not affect DHF cases has been conducted in Kenali Besar of Jambi City (Hardianti, 2017) and Ternate (Tomia, Hadi, Soviani, & Retnani, 2016).

In the rainy season, the population of Aedes aegypti increases because eggs that have not yet hatched begin to do so when the breeding habitat starts to fill with rainwater. This condition will also increase the mosquito population and thus cause an increase in the transmission of DHF (Ministry of Health RI, 2017). Research in Bandung confirms that high rainfall provides ideal locations for breeding larvae (Fitriana & Yudhastuti, 2018), however in Nisaa, Hartono, & Sugiharto (2016) study stated that rainfall can sweep mosquito breeding places; thus, rainwater and flooding can cause the disappearance of mosquito breeding sites (Ayumi, Iravati, & Umniyati, 2016). This process possibly indicates why there is no relationship between rainfall and the IR of DHF.

Coverage of Healthy Houses

A healthy house is defined as a house that meets health requirements (Jombang Distritcal Health Office, 2018). The sanitation condition of the home environment is related to an increase in regional dengue cases. This is because of the low awareness of environmental sanitation, which leads to an increase in the presence of Aedes aegypti mosquito breeding places in the home environment (Sitepu, Nasution, Supriyadi, & Depari, 2018). Indicators of a healthy home include assessments of ventilation, lighting, and air quality. Ventilation is closely related to air humidity—good ventilation helps to maintain air temperature and humidity. The movement of mosquito populations in some parts of their habitat is regulated by many factors, including temperature, humidity, the appeal of the house, and places to settle (Sari, Wahyuningsih, & Murwani, 2017).

This study's findings indicate that there is no relationship between the coverage of healthy homes and the IR. This is not in line with another study, in Purwokerto Subdistrict, which found a relationship between the types of houses and dengue cases (Mardiah, Satoto, & Pramono, 2015). In the inspection of healthy homes in Jombang, there are three components investigated based on the form of the Ministry of Health: building and structuring homes based on physical and biological requirements, sanitation facilities, and occupant behavior. The investigations are carried out regularly and accumulated across a year. The test is less than optimal because it does not use lighting and humidity measurement tools. This process indicates a possible reason why no relationship is indicated between healthy home coverage and the incidence of DHF.

Healthy Lifestyle Coverage

Clean living behavior is defined as a set of actions that is practiced based on awareness to be able to play an active role in public health programs (Jombang Distritcal Health Office, 2018). This study's findings show that there is a relationship between PHBS coverage and IR. Previous research in Lowokwaru Sub District, Malang City has reported that there is a relationship between PHBS and the prevalence of DHF (Madeira, Yudiernawati, & Maemunah, 2019). Research in Yogyakarta has also indicated a similar relationship between (Wahyu & Widayani, 2018).

Various Factors Associated with DHF IR

The results of our analysis indicate a relationship of various factors with DHF based on spatial analysis in Jombang. Multiple factors which were rainfall, population density, and PHBS in the spatial analysis affect the incidence of DHF in Jombang. The spatial report per variable also indicates that rainfall and population density did influence the spatial analysis. Different results were obtained from the bivariate and multivariate analyses. This was because the multivariate analysis involved analyzing all factors simultaneously in relation to the incidence of dengue, and in the bivariate analysis, a partial review of DHF occurrence was conducted. Other factors that are assumed to have an influence include mobility, which was not measured in this study. The findings are in line with research conducted in Blitar Sub-district, with Moran's I

test results indicating a p-value of 0.53 ($p > 0.05$), which means that there was not a relationship between the various factors and the incidence of DHF (Maryanto, 2019).

The strength of this study is that the data used were valid data from the health department in Jombang for 2014–2018. We applied six variables that were suspected to be factors in the spread of DHF. The results suggest that the variables of larvae free index and PHBS coverage do affect DHF rates. This research is intended be used as input for relevant agencies to help reduce and break the chain of transmission of dengue disease. Contributions to this research could be used by the Office of Health or related agencies concerned with handling of the problem of dengue cases intensively by plotting the chain of transmission of disease incidence. The recommended activities to be carried out are eradicating mosquito nests by draining and scrubbing water reservoirs, closing water reservoirs, utilizing or recycling used items that can collect rainwater (3M) thoroughly, effectively, simultaneously, routinely, and continuously, and larvae control via administering larvicide routinely in areas that are difficult to water or to drain.

Research Limitations

In this study, the main limitation was the rainfall data recorded in Jombang District. Three sub-districts (Bandar Kedung Mulyo, Ngusikan, and Plandaan) did not have rainfall registers, so their data values were entered as 0.

CONCLUSION

Most of the average IRs of DHF cases in Jombang during the period 2014–2018 exceeded the East Java Province IR target. Based on the results of the bivariate analysis, there are connections between IR and the variables of larvae free index and PHBS. The variables of population density, rainfall, and coverage of healthy homes show no correlation with IR. Various spatial factors are simultaneously related to IR, even though there are only two in variables related to IR according to the bivariate analysis.

CONFLICT OF INTEREST

In this study, there were no conflicts of interest declared by any parties involved.

AUTHOR CONTRIBUTIONS

RT and LYH conceived the study. RT led on statistical analysis and drafting the manuscript. LYH led on interpretation of the findings. All authors read and approved the final version of the manuscript. All authors have agreed to authorship and order of authorship for this manuscript.

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REFERENCES

Ashlihah, S., Indriani, C., & Lazuardi, L. (2016). Pola spasial-temporal kejadian demam berdarah dengue di Kota Palopo. *Berita Kedokteran Masyarakat, 32*(2), 45–52. https://doi.org/10.22146/bkm.6861

Ayumi, F., Iravati, S., & Umniyati, S. R. (2016). Hubungan iklim dan kondisi lingkungan fisik rumah terhadap insidensi demam berdarah dengue di beberapa zona season di Daerah Istimewa Yogyakarta. *Berita Kedokteran Masyarakat, 32*(12), 455–460. https://doi.org/10.22146/bkm.8790

Azhari, A. R., Darundiati, Y. H., & Dewanti, N. A. (2017). Studi korelasi antar faktor iklim dan kejadian demam berdarah dengue tahun 2011-2016. *Higeia Journal of Public Health Research and Development, 1*(4), 163–175.

Fatati, I. F., Wijayanto, H., & Sholeh, A. M. (2017). Analisis regresi spasial dan pola penyebaran pada kasus demam berdarah dengue (DBD) di Provinsi Jawa Tengah. *Media Statistika, 10*(2), 95–105. https://doi.org/10.14710/medstat.10.2.95-105

Fitriana, B. R., & Yudhastuti, R. (2018). Hubungan faktor suhu dengan kasus demam berdarah dengue (DBD) di Kecamatan Sawahan Surabaya. *The Indonesian Journal of Public Health, 13*(1), 83–94. https://doi.org/10.20473/ijph.vl13il.2018.83-94

Handayani, S., Fannya, P., Roza, S. H., & Angelia, I. (2015). Analisis spasial temporal hubungan kepadatan penduduk dan ketinggian tempat dengan kejadian DBD Kota Padang. *Jurnal Kesehatan Medika Saintika, 8*(1), 25–33.

Hardianti, H. (2017). Hubungan suhu, kelembaban dan curah hujan terhadap keberadaan jentik nyamuk aedes aegypti di RT 45 Kelurahan Kenali Besar. Riset Informasi Kesehatan, 6(1), 95–101. https://doi.org/10.1017/CBO9781107415324.004

Jombang Distritcal Health Office. (2018). *Health profile of Jombang District 2018*. Jombang: Dinas Kesehatan Kabupaten Jombang.

Kasman, & Ishak, N. I. (2018). Analisis penyebaran penyakit demam berdarah dengue di Kota Banjarmasin tahun 2012-2016. *Media Publikasi Promosi Kesehatan Indonesia, 1*(2), 32–39. https://doi.org/10.31934/mppki.v1i2.176

Kusuma, A. P., & Sukendra, D. M. (2017). Analisis spasial kejadian demam berdarah dengue berdasarkan angka bebas jentik. *Jurnal Ilmiah Permas: Jurnal Ilmiah Stikes Kendal*, 7(2), 66–73.

Madeira, E., Yudiernawati, A., & Maemunah, N. (2019). Hubungan perilaku hidup bersih dan sehat (PHBS) ibu dengan cara pencegahan demam berdarah dengue. *Nursing News, 4*(1), 288–299.

Mardiah, A., Satoto, T. B. T., & Pramono, D. (2015). Pola sebaran dan faktor risiko kejadian demam berdarah dengue (DBD) di Kecamatan Purwokerto Selatan Kabupaten Banyumas. *Thesis.* Daerah Istimewa Yogyakarta: Universitas Gajah Mada.

Maryanto, Y. B. (2019). Berbagai faktor yang berkaitan dengan incidence rate penyakit demam berdarah dengue berdasarkan analisis spasial di Kabupaten Blitar. *Undergraduated Thesis.* Surabaya: Faculty of Public Health. Universitas Airlangga.

Masrizal, & 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), 166–171.

Ministry of Health RI. (2017). *Guidelines for the prevention and control of dengue hemorrhagic fever in Indonesia*. Jakarta: Ministry of Health RI.

Murwanto, B., Trigunarso, S. I., & Purwono. (2019). Faktor lingkungan sosial, lingkungan fisik, dan pengendalian program DBD terhadap kejadian demam berdarah dengue (DBD). *Jurnal Kesehatan, 10*(3), 453–458. https://doi.org/10.26630/jk.v10i3.1424

Narmala, Y. A., & 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, 14*(2), 199–209. https://doi.org/10.20473/ijph.vl14i1.2019.199-209

Nisaa, A., Hartono, & Sugiharto, E. (2016). Analisis spasial dinamika lingkungan pada kejadian DBD berbasis GIS di Kecamatan Colomadu Kabupaten Karanganyar. *Journal of Information Systems for Public Health, 1*(2), 23–28.

Paomey, V. C., Nelwan, J. E., & Kaunang, W. P. J. (2019). Sebaran penyakit demam berdarah dengue berdasarkan ketinggian dan kepadatan penduduk di Kecamatan Malalayang Kota Manado tahun 2019. *Jurnal Kesmas, 8*(6), 521–527.

Sari, E., Wahyuningsih, N. E., & Murwani, R. (2017). Hubungan lingkungan fisik rumah dengan kejadian demam berdarah dengue di Semarang. *Jurnal Kesehatan Masyarakat (e-Journal), 5*(5), 609–617.

Setiawan, B., Supardi, F., & Bani, V. K. B. (2017). Analisis spasial kerentanan wilayah terhadap kejadian demam berdarah dengue di wilayah kerja Puskesmas Umbulharjo Kota Yogyakarta Tahun 2013. *Jurnal Vektor Penyakit, 11*(2), 77–87. https://doi.org/10.22435/vektorp.v11i2.6464.77-87

Sitepu, F. Y., Nasution, H., Supriyadi, T., & Depari, E. (2018). Penyelidikan epidemiologi dan entomologi kejadian luar biasa demam dengue di Kabupaten Nias Selatan, Sumatera Utara, Indonesia, 2016. *Outbreak, Surveillance, Investigation & Response (OSIR) Journal, 11*(3), 8–12.

Subekti, P., & Islamiyah, M. (2017). Penentuan model hubungan kepadatan. *Jurnal Matematika dan Pendidikan Matematika, 2*(1), 48–57.

Taryono, A. P. N., Ispriyanti, D., & Prahutama, A. (2018). Analisis faktor-faktor yang mempengaruhi penyebaran penyakit demam berdarah dengue (DBD) di Provinsi Jawa Tengah dengan metode spasial autoagressive model dan spatial durbin model. *Indonesian Journal of Applied Statistics, I*(1), 1–13.

Tomia, A., Hadi, U., Soviani, S., & Retnani, E. (2016). Kejadian demam berdarah dengue

(DBD) berdasarkan faktor iklim di Kota Ternate. *Media Kesehatan Masyarakat Indonesia Universitas Hasanuddin, 12*(4), 241–249.

Wahyu, G. N., & Widayani, P. (2018). Analisis spasial wabah demam berdarah dengue (DBD) terhadap kondisi kesehatan lingkungan permukiman dan perilaku masyarakat (kasus Kecamatan Pakualaman Kota Yogyakarta dan sekitarnya). *Jurnal Bumi Indonesia*, *7*(4), 1–10.

World Health Organization. (2017). *Dengue control*. Geneva: World Health Organization. Retrieved April, 2, 2020 from https://www.who.int/denguecontrol/epidemiology/en/