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Jurnal Kesehatan Lingkungan
Journal of Environmental Health
Vol. 15 No. 3
DOI: 10.20473/jkl.v15i3.2023.217-225
ISSN: 1829 - 7285 | E-ISSN: 2040 - 881X

ORIGINAL RESEARCH **Open Access**

SPATIAL ANALYSIS OF ENVIRONMENTAL FACTORS RELATED TO DENGUE HEMORRHAGIC FEVER CASES IN BANYUWANGI REGENCY, 2020-2022

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Article Info
Submitted : 28 April 2023
In reviewed : 10 May 2023
Accepted : 23 July 2023
Available Online : 31 July 2023

Keywords : *DHF, Healthy Houses, Moran's I, Sanitation, Spatial autocorrelation*

Published by *Faculty of Public Health Universitas Airlangga*

Abstract

Introduction: *Based on the Banyuwangi Regency Health Office, the DHF incidence rate in Banyuwangi Regency in 2022 has experienced a significant increase of 30.14 per 100,000 inhabitants, previously 5.70. DHF can be affected by environmental factors such as mosquito larvae, rainfall, and house conditions. DHF control efforts can be carried out by mapping dengue vulnerability to formulate an appropriate policy. Conversely, the spatial analysis of DHF cases in Banyuwangi is rarely found. This study aims to analyze spatial factors at DHF IR and the relationship between an environmental factor and DHF IR in Banyuwangi Regency.* ***Methods:*** *This study used an ecological study approach. The data used was secondary data from 2020–2022. Data were obtained from Banyuwangi Regency Health Office and Banyuwangi Regency Central Statistic Agency. Moran's I and LISA determined the spatial autocorrelation. Spatial regression was also used in this study.* ***Results and Discussion:*** *DHF IR Banyuwangi Regency had spatial autocorrelation (p-value=0.0010) with clustered patterns (I=0.4789). The pattern of clustering dengue cases in an area could occur because of a relationship with previous dengue cases. Spatial autocorrelation was not found between DHF IR with LFI (p-value=0.4560), rainfall (p-value=0.0610), CBTS villages (p-value=0.1870), and healthy houses (p=value=0.3680). The independent variable in this study did not have a significant relationship with DHF IR.* ***Conclusion:*** *The average DHF IR in Banyuwangi Regency in 2020–2022 had a grouping pattern related to district proximity. LFI, rainfall, CBTS villages, and healthy houses had no significant relationship with DHF IR.*

INTRODUCTION

One of the health issues that persists in practically every region of the world is infectious diseases. Infectious diseases include those that are transmitted through vectors. One is Dengue Hemorrhagic Fever (DHF), spread by vectors. The World Health Organization (WHO) calls DHF one of the most prominent global health issues, evidenced by the spread of continuous cases (1). Indonesia is one of the countries that has dengue cases every year. Indonesia's climatic conditions, including the tropical climate, become an endemic area of *Aedes aegypti*, and dengue cases can be found yearly (2–3).

East Java, one of the provinces, has achieved an indicator of 75% of regencies/cities with DHF IR <49 per 100,000 inhabitants. In 2021, 34 (89.47%) regencies/cities in East Java Province have reached the DHF IR indicator, which is <49 per 100,000 inhabitants (4). Nevertheless, dengue cases continue to be found every year in regencies/cities in East Java. One of the regencies/cities in East Java where there are dengue cases every year is Banyuwangi Regency. Based on data from the Health Profiles of East Java Province, dengue cases in Banyuwangi Regency have increased from 2.11 to 13.77 per 100,000 inhabitants in 2018–2020 and decreased to 5.70 per 100,000 inhabitants in 2021 (4–7). A significant increase in cases occurred again in 2022, with 522 cases with an incidence rate of 30.14 per 100,000 inhabitants.

DHF is caused by dengue virus infection (8). The virus-indexed *Aedes aegypti* mosquito bite is how the dengue virus is spread. The incubation period of

Cite this as :
Saputra YD, Yudhastuti R. Spatial Analysis of Environmental Factors Related to Dengue Hemorrhagic Fever Cases in Banyuwangi Regency, 2020-2022. *Jurnal Kesehatan Lingkungan*. 2023;15(3):217–225. https://doi.org/10.20473/jkl.v15i3.2023.217-225

the dengue virus is 4–10 days until symptoms appear. DHF is characterized by sudden high fever and lasts 2–7 days. DHF is the leading cause of fever cases that require hospital treatment (9). Bleeding can also occur, such as easy bruising and red spots on the skin, or in severe cases, patients can experience gastrointestinal bleeding (9). Dengue sufferers are also at risk of death if not treated appropriately immediately. Death due to DHF is mainly found in elderly patients and people with comorbidities (10).

Old age and people with comorbidities such as obesity are also risk factors for someone easily affected by DHF (11). These factors are classified as individual factors along with sex, primary or secondary infection, immune response, and clinical features. Other factors related to DHF are viral factors (types of serotypes and genotypes) and abiotic factors such as climatic and environmental factors (11). Climate factors such as rainfall, humidity, and temperature in an area affect dengue cases (12). Environmental factors such as mosquito larvae affect dengue cases (13). Mosquito larvae can measure by Larvae Free Index (LFI). High LFI indicates an area is a low-risk DHF (14). Other environmental factors related to house sanitation, such as ventilation and lighting, affect dengue cases (15). A healthy house parameter measures house conditions in Indonesia (16). The availability of clean water in the houses and the behavior of the resident of the house can support the breeding of *Aedes aegypti* (17).

On the other hand, community-wide sanitation and hygiene practices are also related to dengue cases, such as waste management (18). To increase community-wide sanitation and hygiene practices, the Health Ministry does some intervention programs through community empowerment called Community Based Total Sanitation (CBTS) (19). One of the indicators from that program is CBTS villages, which is the percentage of villages that applied the pilar of the program. The government hopes that this program can decrease infectious diseases in the community.

Multifactor in DHF, the complexity of etiology (11), and the discovery of continuous cases yearly encourage attention to DHF prevention and control programs. DHF vectors in the form of mosquitoes that can move from one region to another, and their breeding which is influenced by environmental conditions, makes the level of dengue vulnerability different for each area. Spatial analysis can map the vulnerability level of a disease incidence in an area (20). The spatial analysis results can be used as a reference in focusing on control and prevention programs in areas with high levels of vulnerability. With an approach to geographical phenomena, spatial analysis can also be used to identify the variables that affect the incidence of a disease (13).

Spatial analysis of DHF cases has been conducted in several areas in Indonesia. In Depok City, a spatial study of DHF cases in 2020 showed DHF incidence had clustered patterns, and spatial autocorrelation between DHF and hygiene and clean latrines has been identified (21). Research in Bali Province, with dengue infection cases reported during 2012–2017 data, has similar results: dengue incidence in Bali Province was spatially clustered (22). Spatial analysis of DHF cases in Banyuwangi Regency is still rare. The previous research that can be found is a spatial analysis of data from 2014–2016, which produces a clustering pattern of DHF cases in the southeast of Banyuwangi Regency (23). But that research doesn't analyze factors related to DHF IR and spatial influence.

As a vector-borne disease, dengue cases may be related to location. Therefore, this study wants to answer how the spatial factors affect DHF IR and how the spatial relationship between environmental factors and DHF IR. This study aims to analyze the spatial factor at DHF IR and the relationship between LFI, rainfall, CBTS villages, and healthy houses to DHF IR in Banyuwangi Regency. It is expected that the findings of this study will be used as a guide by stakeholders to develop a successful DHF prevention program in Banyuwangi Regency.

METHODS

Research Design

This research was an ecological study. The analysis was conducted on Dengue Hemorrhagic Fever cases in Banyuwangi Regency in 2020–2022. The analysis unit of this research included 25 districts in Banyuwangi Regency, as shown in Figure 1.

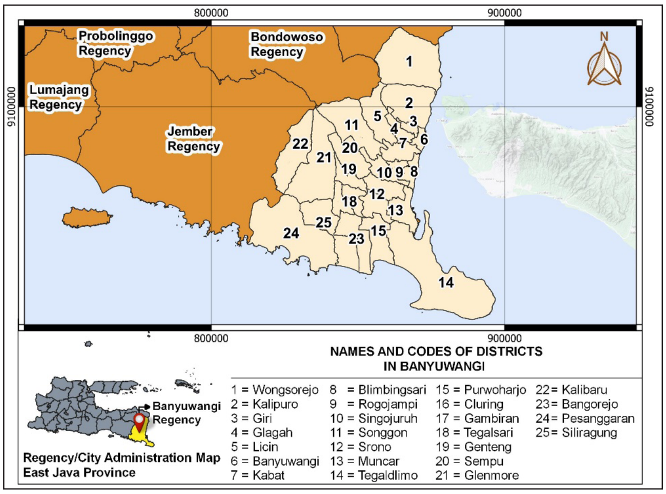


Figure 1. The Geographical Location of the Research Area, Banyuwangi Regency

This study aimed to analyze the spatial factor at DHF IR and the relationship between environmental actors to DHF IR in Banyuwangi Regency.

Data Sources

The research data used was in the form of secondary data. The research data was obtained from the Banyuwangi Regency Health Profile 2020–2021 and Banyuwangi Regency in Figures 2021–2023. Both data sources can be accessed publicly on the official websites of the Banyuwangi Regency Health Office and the Banyuwangi Regency Central Statistic Agency. Some data for 2022, except rainfall data, were obtained from the Infectious Disease Prevention and Control Section and the Environmental Health, Occupational Health, and Sports Section of the Banyuwangi Regency Health Office.

Variable

The variables in this study consisted of two types of variables in the form of dependent variables and independent variables. The dependent variable used was the DHF IR. The independent variables were LFI, rainfall, CBTS villages, and healthy houses. The operational definition of each variable can be seen in Table 1.

Table 1. Operational Definition of Variables

Variable	Description
Dependent Variable	
DHF IR	The average number of Dengue Hemorrhagic Fever cases is divided by the total population of each district multiplied by 100,000 inhabitants in 2020–2022.
Independent Variables	
LFI	The average percentage of houses or buildings free of larvae divided by the number of houses or buildings inspected by each district in 2020–2022.
Rainfall	The average of the high levels of rainwater collected in the rain gauge in a flat place does not absorb water, seep in, or flow in the rain station in each district in 2020–2022.
CBTS villages	The percentage of villages implementing the five Community-Based Total Sanitation (CBTS) pillars is divided by the total number of villages per district multiplied by 100 in 2022.
Healthy houses	The average percentage of houses that match the parameters of healthy houses is divided by the number of houses inspected by each district multiplied by 100 in 2020–2022.

Data Analysis

Data were analyzed using a Geographic Information System (GIS) approach. Geoda 1.20 64-bit (Version October 16, 2022) is used for analysis. Data were analyzed in three types. First, data were analyzed by descriptive with mapping each variable. Second, data were analyzed with Univariate Moran's I to determine each variable's spatial data distribution pattern by examining the proximity between regions. Third, data were analyzed with Bivariate Local Moran's I to determine the influencing factors from the proximity area. The weighting used in the analysis with Moran's I and LISA used queen contiguity. The weighting was based on the side-angle relationship between regions close to each other (24).

Univariate Moran's I shows the p-value and Moran Index (I). Results spatial autocorrelation occurs when the value is p-value<0.05. The spatial pattern formed is seen by comparing the Moran Index (I) and its expectation value (E(I)). I>E(I) indicates a clustered pattern, I<E(I) means a dispersed pattern, and I=E(I) indicates the absence of spatial autocorrelation and random patterns (25).

Bivariate Local Moran's I shows the p-value and Moran Index (I). P-value<0.05 interprets independent variable at the proximity location surrounding the observed area does not influence the dependent variable at the observed area. Moran Index (I) in Bivariate Local Moran's I have the same interpretation as Univariate Moran's I. Local Indicators of Spatial Association (LISA) also showed in Bivariate Local Moran's I. LISA shows four quadrants: High-High, Low-Low, High-Low, and Low-High. Location in the High-High quadrant means the observed area has a high value of a dependent variable and is surrounded by proximity location with a high value of other variables. Area in the High-Low quadrant has interpreted otherwise, observed location surrounded by proximity location with a low value of other variables.

The analysis continued using the Spatial Regression Test. Spatial regression was done by referring to the schematic of Luc Anselin in choosing the suitable model for spatial regression. This schematic is relevant to the GeoDa used in this study. This study used Spatial Error Model (SEM) to partially analyze the relationship between independent and dependent variables and consider spatial factors. The p-value in each independent variable means no relationship with the dependent variable when low than 0.05 (p-value<0.05).

Ethics

This research has been declared ethical by the Ethics Commission of the Faculty of Public Health, Universitas Airlangga, with certificate number 65/EA/KEPK/2023.

RESULTS

Distribution of DHF IR, LFI, Rainfall, CBTS Villages, and Healthy Houses

Table 2 shows the average DHF IR, LFI, rainfall, CBTS villages, and healthy houses from 2020–2022 in each district in Banyuwangi Regency. DHF IR low of 1.02 occurred in Kalibaru, and the highest was 47.67, which occurred in Banyuwangi. The distribution of DHF

IR can be seen in Figure 2(a), which was grouped into three quantiles automatically by the software used for data analysis. Eight districts that fell into the DHF IR high category were Banyuwangi, Glagah, Giri, Kabat, Kalipuro, Rogojampi, Blimbingsari, and Genteng.

Table 2. DHF IR, LFI, Rainfall, CBTS Villages, and Healthy Houses in Districts of Banyuwangi Regency 2020-2022

District Name	IR	LFI (%)	RNF	CBTSV (%)	HH (%)
Wongsorejo	14.13	92.20	79.56	9.09	84.14
Kalipuro	20.49	95.63	167.76	11.11	68.77
Giri	44.83	90.19	164.17	0.00	73.32
Glagah	26.23	91.70	140.45	0.00	85.37
Licin	11.24	91.50	234.67	0.00	75.52
Banyuwangi	47.67	92.17	144.80	0.00	86.08
Kabat	23.09	93.97	149.62	0.00	66.50
Blimbingsari	20.65	97.46	145.85	0.00	92.56
Rogojampi	31.05	93.00	227.47	0.00	83.63
Singojuruh	7.83	99.10	252.64	0.00	58.21
Songgon	5.76	97.83	390.77	0.00	16.83
Srono	15.32	95.04	174.83	10.00	57.70
Muncar	10.68	95.33	125.89	0.00	78.14
Tegaldlimo	10.42	88.96	142.87	0.00	51.89
Purwoharjo	15.21	88.96	126.70	0.00	79.65
Cluring	11.51	88.64	242.25	0.00	76.62
Gambiran	9.97	94.68	*NA	0.00	90.06
Tegalsari	9.49	96.66	181.62	0.00	91.77
Genteng	18.90	96.83	206.43	0.00	78.02
Sempu	12.29	96.16	290.69	0.00	74.29
Glenmore	8.38	91.53	244.80	0.00	75.75
Kalibaru	1.02	91.90	261.90	0.00	77.50
Bangorejo	7.06	83.54	163.18	0.00	78.63
Pesanggaran	2.47	90.58	186.10	0.00	80.32
Siliragung	18.40	93.00	163.58	0.00	84.75

*NA: Not Available

The highest LFI was 99.10 in Singojuruh. While the lowest was 83.54 in Bangorejo, other districts with a low LFI based on Figure 2(b) were Giri, Licin, Cluring, Glenmore, Pesanggaran, Bangorejo, Tegaldlimo, and Purwoharjo. Based on Figures 2(a) and 2(b), Giri districts classified DHF IR as high and LFI as low.

The highest rainfall was 390.77 mm in Songgon and as low as 79.56 in Wongsorejo. No rainfall data was found on Gambiran. Figure 2(c) shows other districts with high rainfall: Licin, Cluring, Songgon, Singojuruh, Sempu, Rogojampi, Glenmore, and Kalibaru. Rogojampi was a district with high DHF IR and high rainfall, based on Figures 2(a) and 2(c).

Districts that had villages achieved CBTS, based on 2022, there were three districts. Kalipuro had the highest percentage of villages that had completed CBTS at 11.11%. Banyuwangi, Glagah, Giri, Kabat, Rogojampi, Blimbingsari, and Genteng districts had a high DHF IR with a percentage of 0% CBTS villages based on Figures 2(a) and 2(d).

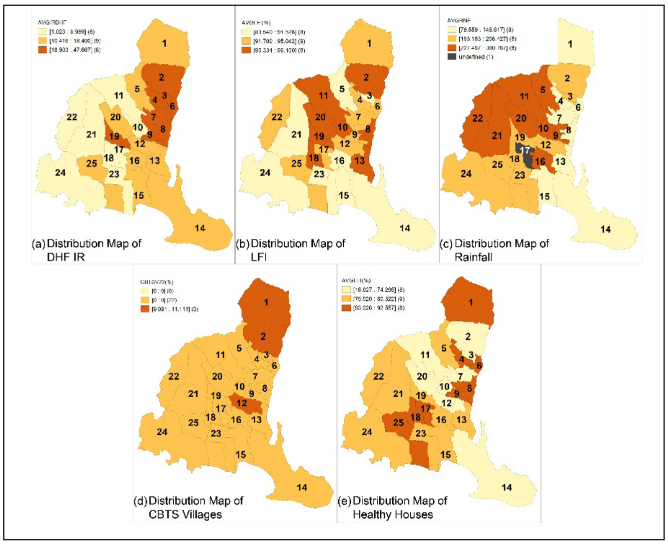

(a) Distribution Map of DHF IR
(b) Distribution Map of LFI
(c) Distribution Map of Rainfall
(d) Distribution Map of CBTS Villages
(e) Distribution Map of Healthy Houses

Figure 2. Distribution Map of DHF IR (a), LFI (b), Rainfall (c), CBTS Villages (d), and Healthy Houses (e)

Blimbingsari had the highest number of healthy houses at 92.56 and the lowest at 16.83 in Songgon. Based on Figure 2(e), the districts classified as having low healthy houses were Kalipuro, Giri, Kabat, Songgon, Singojuruh, Sempu, Srono, and Tegaldlimo. Based on Figures 2(a) and 2(e), districts classified as having a high DHF IR and low healthy houses were Giri, Kabat, and Kalipuro.

Spatial Influence on DHF IR, LFI, Rainfall, CBTS Villages, and Healthy Houses

The results of Univariate Moran's I listed in Table 3 used randomization with 999 permutations. The variables DHF IR, rainfall, and village CBTS had spatial autocorrelation (p-value<0.05). These results indicated that data from each variable had a relationship between locations, especially the areas adjacent to and surrounding them. Based on the value of (I) against the value of E(I) of the three variables showed a clustering pattern. LFI and healthy houses showed no spatial correlation between regions due to insignificant values (p-value>0.05).

Table 3. Result of Univariate Moran's I using Geoda

Variables	I	E(I)	p-value
DHF IR	0.4789	-0.0417	0.0010
LFI	0.1286		0.1330
Rainfall	0.2052		0.0370
CBTS villages	0.2481		0.0380
Healthy houses	0.1648		0.0430

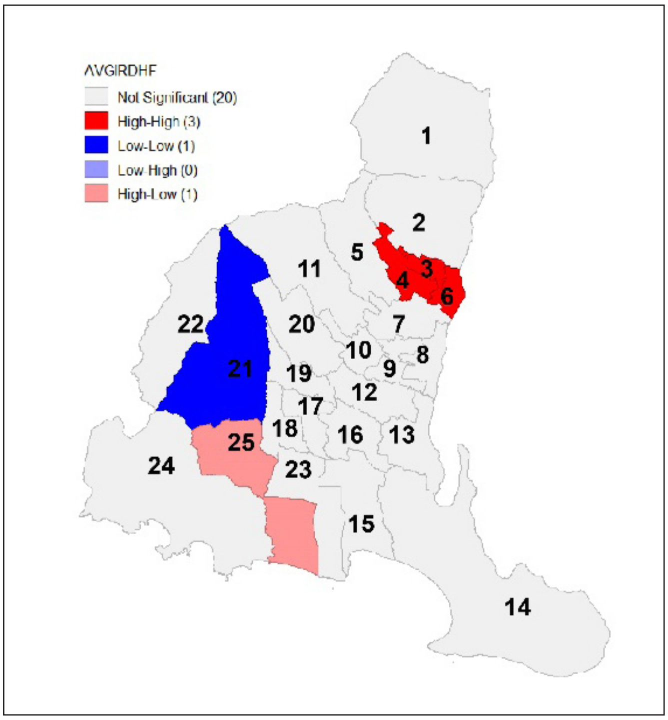


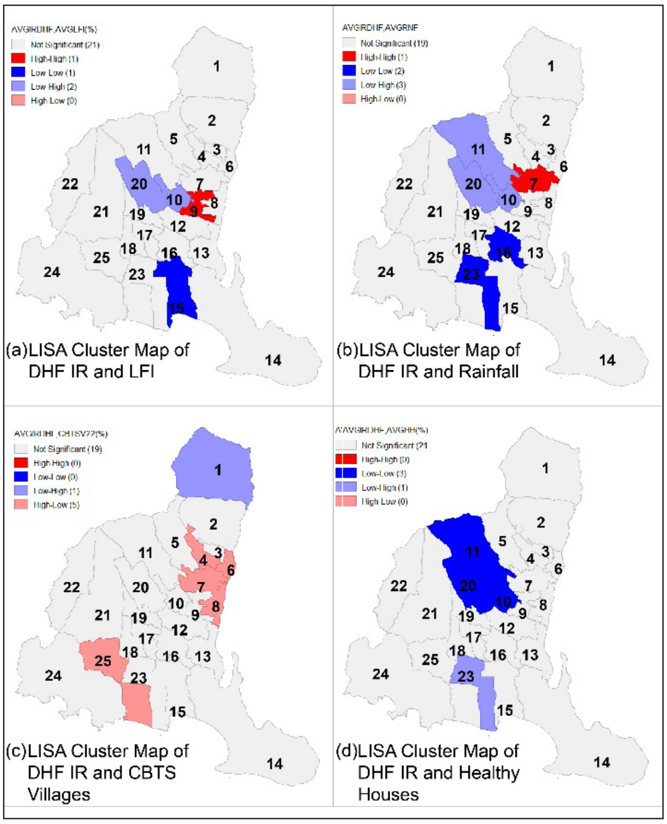
Figure 3. Lisa Cluster Map of DHF IR

Figure 3 shows the LISA cluster map describing DHF IR data distribution between regions. Of the 25 districts, there were 20 insignificant and five significant districts. It means significant areas had DHF IR related to DHF IR in other districts. Giri, Glagah, and Banyuwangi belong to the High-High quadrant. The district had a high DHF IR and was surrounded by areas with high DHF IR. Glenmore had the opposite condition. Siliragung was identified as having high DHF IR and was surrounded by areas with low DHF IR.

Spatial Relationship between LFI, Rainfall, CBTS Villages, and Healthy Houses on DHF IR

Bivariate Local Moran's I showed insignificant spatial autocorrelation (p-value>0.05) between DHF IR with LFI (p-value=0.4560), rainfall (p-value=0.0610), CBTS Villages (p-value=0.1870), and healthy houses (p-value=0.3680). These results showed the absence of bivariate global spatial autocorrelation between dependent and independent variables. These results also could be interpreted that DHF IR in one district was not influenced by LFI, rainfall, CBTS Villages, or healthy houses in proximity surrounding districts. Meanwhile, on a district basis, several districts showed significant spatial autocorrelation of DHF IR with four independent variables. The colored LISA Cluster Map illustrates this in Figure 4.

Figure 4(a) shows Rogojampi was located in the High-High quadrant, which means Rogojampi had a high DHF IR and was surrounded by areas with a high LFI. The opposite happened to Purwoharjo. DHF IR and Rainfall in Figure 4(b) showed Kabat in the High-High quadrant. Kabat had a high DHF IR and was surrounded by districts with high rainfall. The opposite was Bangorejo and Cluring. DHF IR and CBTS Village only found six outlier districts: Wongsorejo, Siliragung, Banyuwangi, Glagah, Kabat, and Blimbingsari. This condition can be seen in Figure 4(c). Wongsorejo had low DHF IR and was surrounded by an area with high CBTS villages. DHF IR and healthy houses were found in three districts, Songgon, Singojuruh, and Sempu, in the Low-Low quadrant, and Bangorejo, in the Low-High quadrant. This condition can be seen in Figure 4(d).



(a)LISA Cluster Map of DHF IR and LFI

(b)LISA Cluster Map of DHF IR and Rainfall

(c)LISA Cluster Map of DHF IR and CBTS Villages

(d)LISA Cluster Map of DHF IR and Healthy Houses

Figure 4. Lisa Cluster Map of DHF IR and LFI (a), Lisa Cluster Map of DHF IR and Rainfall (b), Lisa Cluster Map of DHF IR and CBTS Villages (c), Lisa Cluster Map of DHF IR and Healthy Houses (d)

By considering spatial characteristics, spatial regression analysis was used to ascertain the relationship between the independent and dependent variables. In this study, finding out the relationship of the independent variable to the dependent variable partially referred to the SEM results. The SEM results showed that the LFI (p=0.5837), rainfall (p=0.9725), CBTS villages (p=0.7224), and healthy houses (p=0.3480) had no effect (p>0.05) on DHF IR in Banyuwangi Regency in 2020–2022.

DISCUSSION

Mapping dengue cases can be a form of anticipation of dengue outbreaks. Mapping based on Moran's analysis of the average incidence rate in

Banyuwangi Regency in 2020-2022 showed a spatial autocorrelation with clustering patterns. This result was similar to the incidence rate of dengue fever in Depok City in 2020 (21). Spatial autocorrelation with clustered patterns in dengue cases was also found in Madurai, India, in 2009 and 2015 (26). Crowding dengue cases in an area occurred because of a relationship with previous dengue cases (25). The dengue virus transmission mechanism by *Aedes aegypti* mosquitoes that can be transmitted from one person to another in the immediate environment can cause this condition.

Mapping can also be done on factors that make an area prone to Dengue. LFI is one indicator to assess the dengue vulnerability area. LFI is the percentage of houses or other buildings with no larvae against the total number of places inspected (27). The LFI indicator nationally was set at ≥95% (28). The average LFI in Banyuwangi Regency in 2020–2022 was the highest at 99.10% in Singojuruh. Meanwhile, 16 (64%) of the 25 districts had an average LFI that had not reached the national indicator.

The result of Bivariate Local Moran's I DHF IR in one area globally was not influenced by LFI in the surrounding area. However, Rogojampi had a high DHF IR with a high LFI of surrounding districts in each district. Low LFI indicated the discovery of many larvae from the site examined. This condition can increase susceptibility to dengue disease transmission (14). Thus, the conditions found in several districts in Banyuwangi Regency, such as Rogojampi and Purwoharjo, showed incompatibility with the theory of the existence of LFI against DHF IR. This result was similar to cross-tabulating the dengue incidence rate with LFI in Banjarbaru City in 2018–2019 (29). The study in Banjarbaru City shows that areas with LFI at risk (<95%) have low dengue cases. Another factor that may cause this discrepancy is the mosquito's ability to move quickly from place to place and population density (14). As human transportation has dramatically increased, the *Aedes aegypti* mosquito can move over long distances (30). The spatial discrepancy conditions found in this study also align with the results of LFI's spatial regression of DHF. These results show no statistical spatial effect of LFI on the increase in DHF IR. The absence of a relationship between LFI and DHF IR was also found in research on dengue data in Blitar Regency in 2013–2017 (31).

Rainfall is one of the risk factors for Dengue. The result of Univariate Moran's I on the rainfall in Banyuwangi Regency shows the results of the influence of regional proximity. Rainfall data for 2013–2014 in Tegal Regency also show spatial patterns of rainfall clustering (32). The results of Bivariate Local Moran's I show one area globally was not influenced by rainfall in the surrounding area. Judging from each district in Banyuwangi Regency, Kabat district has a high DHF IR and is surrounded by neighborhoods with high rainfall. Similar conditions in dengue cases in 2018 in Banyumas Regency showed dengue cases generally occurred in districts with moderate rainfall (33). The effect of rainfall on Dengue IR in this study showed no impact statistically. The results align with spatial research conducted on aggregate data of Jombang Regency in 2014–2018 (13). The same thing was also obtained from the research results in Tegal Regency in 2012–2018 (32). This condition is likely to be affected because some regions do not have rainfall data in a particular year, such as Gambiran, which does not have rainfall data from 2020–2022.

Rainfall contributes to the breeding habitat of *Aedes aegypti* as a vector of dengue disease. However, this condition does not directly affect DHF IR. The effect of rainfall can depend on the amount of rainfall, the frequency of rainy days, geography, the physical properties of the children, and the habitat type of the *Aedes aegypti* mosquito (34). The time it takes for mosquitoes to develop to transmit the virus to humans causes fluctuations in overall rainfall to not affect dengue incidence in the same month (1). Rainfall intensity also needs to be considered in assessing the effect of rainfall on dengue cases because if the power of rainfall is very high, it can wash away mosquito breeding sites (35).

Another dengue factor assessed in this study was the achievement of Community-Based Total Sanitation (CBTS) villages. CBTS is an approach through community empowerment to change hygienic and sanitary behavior by triggering (19). CBTS consists of five pillars: stopping open defecation, washing hands with soap, managing drinking water and household food, securing household waste, and securing household liquid waste. A village is said to be a CBTS village when it has reached the five pillars of CBTS. Research that directly discusses the relationship between CBTS and dengue cases has not been found.

The result of Bivariate Local Moran's I showed CBTS villages did not influence DHF IR in one area globally in the surrounding area. As for per district, Wongsorejo identified districts with low DHF IR surrounding neighborhoods with high CBTS villages. The results of spatial regression in this study showed no significant influence between the achievement of CBTS villages in the region and DHF IR in the same area. Align with CBTS spatial regression tests on DHF in Java and Bali in 2015-2019 showing insignificant results (36). That is, CBTS does not have a spatial effect on dengue cases.

Nevertheless, CBTS pillars, such as securing household and liquid waste, are relevant to preventing *Aedes aegypti* breeding. Connecting household waste in the CBTS pillar aims to avoid storing waste in the houses by immediately handling or managing waste. The principles in handling this waste include *Reduce*, *Reuse*, and *Recycle*. Garbage at houses is considered a risk factor for dengue cases (37). Some types of waste, such as used bottles, cans, and old tires, can be a breeding ground for *Aedes aegypti* mosquitoes (38). The chi-square test results research conducted in Sendangmulyo Village, Tembalang District, in 2021 showed the results of a relationship between household waste management and dengue cases in 1 family (18). Poor environmental health conditions will increase the risk of environment-based diseases.

The cleanliness of the environment of the house is relevant to the variables of a healthy house in this study. A healthy house is a residence that meets the health requirements set by the Ministry of Health (16). A healthy house must at least meet the physical and biological conditions, sanitation facilities, and hygiene behavior of the house's occupants. Spatial analysis in this study shows no correlation between the percentage of healthy houses and DHF IR. However, spatial research between DHF IR and healthy houses shows several areas with low DHF IR surrounded by low healthy houses percentage area. This condition is not following the existing theory where unhealthy housing conditions will be at risk of being a factor causing disease. Houses conditions that do not pay attention to health aspects will support the development of *Aedes aegypti* larvae (17).

Research on dengue risk factors conducted in Bandung City in 2016 showed that unhealthy family status influences the increase in dengue cases (39). That is not in line with the results of spatial regression in this study, which shows no influence between the percentage of healthy houses and DHF IR in an area by considering spatial factors. Spatial regression analysis of healthy houses with DHF IR conducted on Jombang Regency data for 2014–2018 had similar results, namely having no relationship (13). This condition can occur due to the lack of maximum data from measuring healthy house indicators such as lighting and humidity. The house's physical condition, such as poor lighting and humidity, clean water availability, garbage disposal facilities, and the behavior of house residents, can support the breeding of *Aedes aegypti* (17).

DHF risk factors, as described earlier, must be understood by the community to encourage preventive behavior. Prevention programs that the government has prepared cannot run well without the community's involvement. Community triggering methods can be done to optimize existing programs. The triggering procedure is carried out by providing stimulus from the surrounding community in carrying out dengue prevention programs such as Mosquito Nest Eradication. This triggering method was previously studied in Rahandounda Village, Kendarai City, in 2019, with results showing the influence of triggering on LFI practices (40).

ACKNOWLEDGMENTS

Thank you to the Banyuwangi Regency Health Office, Banyuwangi Regency Central Statistic Agency, and the Regional Development Planning Agency of Banyuwangi Regency for granting permission to use data in this study.

CONCLUSION

The incidence rate of Dengue Hemorrhagic Fever in Banyuwangi Regency had a clustered pattern and was related to district proximity. The results of Bivariate Local Moran's I showed that DHF IR in one district was not influenced by LFI, rainfall, CBTS villages, or healthy houses in a proximity surrounded area. The spatial regression test also showed that LFI, rainfall, CBTS villages, and healthy houses did not affect DHF IR.

To control and prevent this, the government must continue to improve the surveillance system in dengue cases and related factors such as LFI, rainfall, CBTS villages, and healthy houses. Community triggering methods can be applied to prevent dengue cases, such as reducing mosquito breeding sites, improving clean and healthy lifestyles, and supporting the implementation of CBTS. Researchers can then make a regression equation model by comparing several models to see how influential a DHF risk factor is on DHF cases.

REFERENCES

1. Amelinda YS, Wulandari RA, Asyary A. The Effects of Climate Factors, Population Density, and Vector Density on the Incidence of Dengue Hemorrhagic Fever in South Jakarta Administrative City 2016–2020: An Ecological Study. *Acta Biomedica*. 2022;93(6):e2022323. https://doi.org/10.23750/abm.v93i6.13503
2. Harapan H, Michie A, Mudatsir M, Sasmono RT, Imrie A. Epidemiology of Dengue Hemorrhagic Fever in Indonesia: Analysis of Five Decades Data from the National Disease Surveillance. *BMC Research Notes.* 2019;12(350):1–6. https://doi.org/10.1186/S13104-019-4379-9
3. Hajrah U, Akmal D, Abdillah AD, Nugraha F. Spatial Pattern Analysis on Incidence of Dengue

Hemorrhagic Fever (DHF) in the Leuwigajah, West Java, Indonesia. *Spatial Information Research*. 2023;31(1):359–367. https://doi.org/10.1007/s41324-022-00501-1

4. Province Health Office of East Java. Health Profile of East Java Province 2021. Surabaya: Province Health Office of East Java; 2022. https://dinkes.jatimprov.go.id/userfile/dokumen/PROFIL%20KESEHATAN%202021%20JATIM.pdf
5. Province Health Office of East Java. Health Profile of East Java Province 2018. Surabaya: Province Health Office of East Java; 2019. https://dinkes.jatimprov.go.id/userfile/dokumen/BUKU%20PROFIL%20KESEHATAN%20JATIM%202018.pdf
6. Province Health Office of East Java. Health Profile of East Java Province 2019. Surabaya: Province Health Office of East Java; 2020. https://dinkes.jatimprov.go.id/userfile/dokumen/Profil Kesehatan Jatim 2019.pdf
7. Province Health Office of East Java. Health Profile of East Java Province 2020. Surabaya: Province Health Office of East Java; 2021. https://dinkes.jatimprov.go.id/userfile/dokumen/PROFIL%20KESEHATAN%202020.pdf
8. Pang X, Zhang R, Cheng G. Progress towards Understanding the Pathogenesis of Dengue Hemorrhagic Fever. *Virologica Sinica*. 2017;32(1):16–22. https://doi.org/10.1007/S12250-016-3855-9/METRICS
9. Ministry of Health of Republic Indonesia. Decree of the Minister of Health of the Republic of Indonesia Number HK.01.07/MENKES/9845/2020 concerning National Guidelines for Medical Services for Managing Dengue Infection in Adults. Jakarta: Directorate General of Health Services, Ministry of Health of Republc Indonesia; 2020. https://yankes.kemkes.go.id/unduhan/fileunduhan_1610413358_685089.pdf
10. Chang K, Huang CH, Lee IK, Lu PL, Lin CY, Chen TC, et al. Differences in Mortality and Clinical Manifestations of Dengue Hemorrhagic Fever in Taiwan in Different Years: A Comparison for Cases in 2014 and 2015 Epidemics. *The American Journal of Tropical Medicine and Hygiene*. 2017;97(2):361–368. https://doi.org/10.4269/AJTMH.16-1018
11. Wang WH, Urbina AN, Chang MR, Assavalapsakul W, Lu PL, Chen YH, et al. Dengue Hemorrhagic Fever – A Systemic Literature Review of Current Perspectives on Pathogenesis, Prevention and Control. *Journal of Microbiology, Immunology and Infection*. 2020;1;53(6):963–978. https://doi.org/10.1016/J.JMII.2020.03.007
12. Tosepu R, Tantrakarnapa K, Worakhunpiset S, Nakhapakorn K. Climatic Factors Influencing Dengue Hemorrhagic Fever in Kolaka District, Indonesia. *Environment and Natural Resources Journal*. 2018;16(2):1–10. https://doi.org/10.14456/ennrj.2018.10
13. Trihastuti R, Hendrati LY. Spatial Analysis of Dengue Hemorrhagic Fever based on Influencing Factors in Jombang, 2014–2018. *Jurnal Berkala Epidemiologi*. 2021;9(1):79–87. https://doi.org/10.20473/jbe.v9i12021.79-87
14. Chandra E, Hamid E, Jalius. Pengaruh Faktor Iklim, Kepadatan Penduduk dan Angka Bebas Jentik (ABJ) terhadap Kejadian Demam Berdarah Dengue (DBD) di Kota Jambi. *Jurnal Pembangunan Berkelanjutan*. 2019;2(1):1–15. https://doi.org/10.22437/JPB.V2I1.6434
15. Wijirahayu S, Sukesi TW. Hubungan Kondisi Lingkungan Fisik dengan Kejadian Demam Berdarah Dengue di Wilayah Kerja Puskesmas Kalasan Kabupaten Sleman. *Jurnal Kesehatan Lingkungan Indonesia*. 2019;18(1):19–24. https://doi.org/10.14710/JKLI.18.1.19-24
16. District Health Office of Banyuwangi. Health Profile of Banyuwangi Regency 2018. Banyuwangi: District Health Office of Banyuwangi; 2020. http://dinkes.banyuwangikab.go.id/portal/wp-content/uploads/2020/02/profil2018.rar
17. Sukesi TW, Satoto TBT, Murhandarwati EH, Padmawati RS. Effects of Health Education-Based Intervention on Community's Perception, Healthy House, and Social Capital of Dengue in Endemic Area of Sleman Regency Indonesia. *Open Access Macedonian Journal of Medical Sciences (OAMJMS)*. 2021;9(E):428–436. https://doi.org/10.3889/OAMJMS.2021.6087
18. Hidayah NN, PN Prabamurti P, Handayani N. Determinan Penyebab Perilaku Pengelolaan Sampah Rumah Tangga dalam Pencegahan DBD oleh Ibu Rumah Tangga di Kelurahan Sendangmulyo. *Media Kesehatan Masyarakat Indonesia*. 2021;20(4):229–239. https://doi.org/10.14710/MKMI.20.4.229-239
19. Ministry of Health of the Republic Indonesia. Regulation of the Minister of Health of the Republic of Indonesia No. 3/2014 on Community-Based Total Sanitation. Jakarta: Legal Bureau of the Ministry of Health of the Republic of Indonesia; 2014. http://hukor.kemkes.go.id/uploads/produk_hukum/PMK%20No.%203%20ttg%20Sanitasi%20Total%20Berbasis%20Masyarakat.pdf
20. Nilima, Kamath A, Shetty K, Unnikrishnan B, Kaushik S, Rai SN. Prevalence, Patterns, and Predictors of Diarrhea: A Spatial-Oral Comprehensive Evaluation in India 11 Medical and Health Sciences 1117 Public Health and Health Services. *BMC Public Health*. 2018;18(1):1–10. https://doi.org/10.1186/S12889-018-6213-Z/FIGURES/5
21. Naim S, Hastono SP, Rahayu S, Wangi MP. A Spatial Analysis of Dengue Hemorrhagic Fever (DHF), Hygiene, and Latrines in Depok City in 2020. *Jurnal Kesehatan Lingkungan*. 2022;14(2):122–129. https://doi.org/10.20473/jkl.v14i2.2022.122-129
22. Dhewantara PW, Marina R, Puspita T, Ariati Y, Purwanto E, Hananto M, et al. Spatial and Temporal Variation of Dengue Incidence in the Island of Bali, Indonesia: An Ecological Study. *Travel Medicine and Infectious Disease*. 2019;32(101437):1–10. https://doi.org/10.1016/j.tmaid.2019.06.008
23. Multazam AZ. Pemetaan Distribusi Kasus Demam Berdarah Dengue di Kabupaten Banyuwangi Tahun 2014–2016. *JIMKesmas: Jurnal Ilmiah Mahasiswa Kesehatan Masyarakat*. 2018;3(4):1–10. https://ojs.uho.ac.id/index.php/JIMKESMAS/article/view/4986

24. Suryowati K, Bekti RD, Faradila A. A Comparison of Weights Matrices on Computation of Dengue Spatial Autocorrelation. *IOP Conference Series: Material Science and Engineering*. 2018;335(012052):1–10. https://doi.org/10.1088/1757-899X/335/1/012052
25. Syamsir, Pangestuty DM. Autocorrelation of Spatial-Based Dengue Hemorrhagic Fever Cases in Air Putih Area, Samarinda City. *Jurnal Kesehatan Lingkungan*. 2020;12(2):78–86. https://doi.org/10.20473/JKL.V12I2.2020.78-86
26. Balaji D, Saravanabavan V. Geo Patial Variation of Dengue Risk Zone in Madurai City using Autocorrelation Techniques. *GeoJournal*. 2021;86(3):1481–1501. https://doi.org/10.1007/S10708-020-10143-1/FIGURES/9
27. Kuwa MKR, Sulastien H. Gambaran Presentasi Angka Bebas Jentik terhadap kejadian Demam Berdarah di Kabupaten Sikka. *Jurnal Ilmiah Permas: Jurnal Ilmiah STIKES Kendal*. 2021;11(4):635–640. https://doi.org/10.32583/PSKM.V11I4.1631
28. Ministry of Health of the Republic Indonesia. National Dengue Management Strategy 2021-2025. In: Farikha M, editor. Jakarta: Ministry of Health of the Republic Indonesia; 2021. https://p2pm.kemkes.go.id/storage/publikasi/media/file_1631494745.pdf
29. Afifah A, Fakhriadi R, Setyaningrum R, Musafaah M, Rosadi D. The Overview of Dengue Hemorrhagic Fever Based on Larva Free Index, Education Level, and Population Density. *Jurnal Berkala Kesehatan*. 2021;7(2):78–84. https://doi.org/10.20527/JBK.V7I2.9666
30. Tian C, Ruan S. A Free Boundary Problem for *Aedes aegypti* Mosquito Invasion. *Applied Mathematical Modelling*. 2017;46(1):203–217. https://doi.org/10.1016/j.apm.2017.01.050
31. Nuranisa R, Maryanto YB, Isfandiari MA. Correlation of Free Larvae Index and Population Density with Dengue Fever Incidence Rate. *The Indonesian Journal of Public Health*. 2022;17(3):477–487. https://doi.org/10.20473/IJPH.V17I3.2022.477-487
32. Arieskha FTA, Joko T, Rahardjo M. The Association between Weather Variability and Dengue Hemorrhagic Fever in Tegal Regency. *Jurnal Kesehatan Lingkungan*. 2019;11(4):339–347. https://doi.org/10.20473/JKL.V11I4.2019.339-347
33. Sarwani D, Rejeki S, Nurhayati N, Aji B. A Spatiotemporal Analysis of Dengue Hemorrhagic Fever in Banyumas, Indonesia. *International Journal of Public Health Science (IJPHS)*. 2021;10(2):231–240. https://doi.org/10.11591/ijphs.v10i2.20713
34. Ishak NI, Kasman K. The Effect of Climate Factors for Dengue Hemorrhagic Fever in Banjarmasin City, South Kalimantan Province, Indonesia, 2012–2016. *Public Health of Indonesia*. 2018;4(3):121–128. https://doi.org/10.36685/PHI.V4I3.181
35. Phanitchat T, Zhao B, Haque U, Pientong C, Ekalaksananan T, Aromseree S, et al. Spatial and Temporal Patterns of Dengue Incidence in Northeastern Thailand 2006–2016. *BMC Infectious Disease*. 2019;19(1):1–12. https://doi.org/10.1186/s12879-019-4379-3
36. Nabila A, Yotenka R. Spasial Data Panel dalam Menentukan Faktor-Faktor yang Berpengaruh terhadap Jumlah Kasus Demam Berdarah Dengue (DBD). *UJMC (Unisda Journal of Mathematics and Computer Science)*. 2021;7(2):49–60. https://doi.org/10.52166/UJMC.V7I2.2845
37. Ardianti W, Lapau B, Dewi O. Determinan Kejadian Demam Berdarah Dengue (DBD) di Wilayah Kerja Puskesmas Harapan Raya. *Photon: Jurnal Sain dan Kesehatan*. 2018;9(1):47–56. https://doi.org/10.37859/JP.V9I1.1057
38. Yusron M, Nurmala I, Soedirham O. Relationship of Waste Management towards the Event of DHF in the Work Area of Puri Health Center, Mojokerto Regency in 2021. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*. 2022;5(1):1653–1659. https://doi.org/10.33258/birci.v5i1.3766
39. Fuadzy H, Widawati M, Astuti EP, Prasetyowati H, Hendri J, Nurindra RW, et al. Risk Factors Associated with Dengue incidence in Bandung, Indonesia: A Household-Based Case-Control Study. *Health Science Journal of Indonesia*. 2020;11(1):45–51. https://doi.org/10.22435/HSJI.V11I1.3150
40. Mangidi MAGT, Sunarsih S, Jayadipraja EA. Pengaruh Pemicuan terhadap Angka Bebas Jentik (ABJ) di Kelurahan Rahandouna Kota Kendari. *Al-Sihah: The Public Health Science Journal*. 2019;11(2):133–142. https://doi.org/10.24252/AS.V11I2.9677