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(RESEARCH ARTICLE)

Spatial autocorrelation analysis of Dengue Hemorrhagic Fever (DHF) incidence in Jombang Regency in 2021

Rivaldi Akhyar Nasrullah * and Muhammad Rafi Mufti

Department of Environmental Health, Faculty of Public Health, Airlangga University, Surabaya, Indonesia.

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Abstract

Dengue hemorrhagic fever (DHF) is a disease caused by the Dengue virus transmitted from person to person through mosquito bites. This study aims to see whether there is a spatial autocorrelation of DHF incidence in Jombang district and if spatial patterns are formed. The population in this study consists of 21 sub-districts, which were determined using the total sampling method. Data analysis was conducted using the Global Moran's I Test and the Local Indicator of Spatial Autocorrelation (LISA) Test. The results show that there is no spatial autocorrelation of DHF incidence in Jombang Regency in 2021 (Z = 0.078). LISA analysis shows that Kudu sub-district is an outlier, which means it can affect the surrounding sub-district. The results also show that there is a spatial autocorrelation between the population density and DHF incidence (Z = 1.9815), with the clustered spatial pattern clustered. This means that sub-districts with a high population density are surrounded by sub-districts that have a high DHF incidence. Related parties, in this case Jombang Regency Health Office need to pay more attention to sub-districts that have high DHF incidence and are surrounded by sub-districts with low DHF incidence and need to pay attention to areas with high population density because dengue transmission is more likely to happen in areas with high population density.

Keywords: Dengue; DHF; Population; Spatial Autocorrelation

1. Introduction

Dengue hemorrhagic fever (DHF) is a disease caused by the Dengue virus transmitted from person to person through mosquito bites. The main vector of transmission is *Aedes aegypti*, although other species can also serve as vectors. DHF is commonly found in tropical areas and often leads to outbreaks. Several factors influence the occurrence of DHF, including low community immunity status and high mosquito population density due to the abundance of mosquito breeding sites, which typically occur during the rainy season [1]. The increase and transmission of DHF are greatly influenced by environmental factors [2]. One of the factors that affects the occurrence and transmission of DHF is population density. High population density and close proximity of houses can intensify the spread of DHF due to the estimated flight range of mosquitoes, which is around 50–100 meters [3].

Jombang Regency is a regency with a dense population, with a total population of 1,389,374 people in 2020 [4]. The population density in Jombang Regency reaches 1,143 people per square kilometer, which falls under the category of high population density according to the regulation of the Head of the National Disaster Management Agency Number 2 of 2012 [5]. Additionally, 95% of the area in Jombang Regency consists of low-lying areas that provide suitable habitats for Aedes aegypti mosquitoes. *Aedes aegypti* are kosmotropic animals that can survive in tropical and subtropical climates. The endophilic nature of *Aedes aegypti* enables them to live at altitudes of up to 1700 meters above sea level as long as they are in enclosed environments [6].

* Corresponding author: Rivaldi Akhyar Nasrullah.

The incidence rate of DHF in Jombang Regency has decreased over the past five years, but the Case Fatality Rate (CFR) has increased. This situation has the potential for DHF to become an outbreak in Jombang Regency. However, it should be noted that the increase in CFR is due to a significant decrease in the number of DHF cases caused by the COVID-19 pandemic that occurred from early 2020 to late 2022. The COVID-19 pandemic has caused health care facilities to focus on handling the spread of COVID-19 so that the recording and handling of other health cases are slightly disrupted, one of which is DHF. In addition, there are similarities between the symptoms of COVID-19 and the symptoms of DHF, resulting in potential bias. Non-severe dengue may be more symptomatic than COVID-19 in a co-epidemic setting with higher dengue attack rates [7].

2. Material and methods

2.1. Research design and locations

This research is a quantitative study. The study design used is an ecological study. The location of this study was in Jombang district, East Java, Indonesia. This study was conducted in January–April 2023. This study aims to see whether there is a spatial autocorrelation of DHF incidence in Jombang district and if spatial patterns are formed. The population in this study was from 21 sub-districts in Jombang Regency. The samples used in this study were from 21 sub-districts, which were determined using the total sampling method.

2.2. Data sources

This research was conducted using secondary data analysis obtained from the Jombang Regency Central Bureau of Statistics and the Jombang Regency Health Office. Data on population and population density were obtained from the Central Bureau of Statistics of Jombang Regency, while data on the incidence of DHF were obtained from the Jombang Regency Health Office.

2.3. Data analysis

Data analysis was conducted with the Global Moran's I Test and the Local Indicator of Spatial Autocorrelation (LISA) Test. Both tests were used in univariate and bivariate analysis. Univariate analysis was used to examine the spatial autocorrelation of dengue incidence, while bivariate analysis was used to examine the spatial autocorrelation between population density and diarrhea incidence. The univariate analysis also included a Choropleth map of DHF incidence and population density, which was conducted using QGIS Desktop 3.28.0. The method used to make choropleth maps is "Natural Breaks (Jenks)". The Global Moran's I and LISA tests were conducted using GeoDa 10.20.0.8.

3. Results and discussion

3.1. Overview of DHF incidence in Jombang Regency in 2021

Table 1 DHF Incidence in Jombang Regency in 2021

No	Sub-district	Population	DHF Cases	DHF Incidence Rate (per 100,000 population)
1	Jombang	139,831	10	7.15
2	Diwek	110,495	11	9.96
3	Ngoro	77,814	6	7.71
4	Tembelang	54,891	1	1.82
5	Megaluh	39,725	1	2.52
6	Plandaan	37,383	0	0.00
7	Ploso	41,777	0	0.00
8	Kabuh	41,311	1	2.42
9	Ngusikan	22,793	0	0.00
10	Kudu	31,513	6	19.04

11	Perak	55,975	4	7.15
12	Bandarkedungmulyo	49,959	3	6.00
13	Gudo	55,997	6	10.71
14	Mojowarno	95,660	0	0.00
15	Bareng	56,539	4	7.07
16	Wonosalam	33,520	0	0.00
17	Mojoagung	81,051	5	6.17
18	Peterongan	67,822	4	5.90
19	Jogoroto	70,760	10	14.13
20	Sumobito	86,385	1	1.16
21	Kesamben	66,861	3	4.49

Source: Jombang Regency Health Office

Based on the table above, the sub-district with the highest DHF Incidence Rate is Kudu sub-district, with an IR of 19.04 per 100,000 population. Meanwhile, the sub-districts with the lowest DHF IR are Plandaan, Ploso, Ngusikan, Mojowarno, and Wonosalam, with a DHF IR of 0 because no DHF cases were found throughout 2021 in these sub-districts.

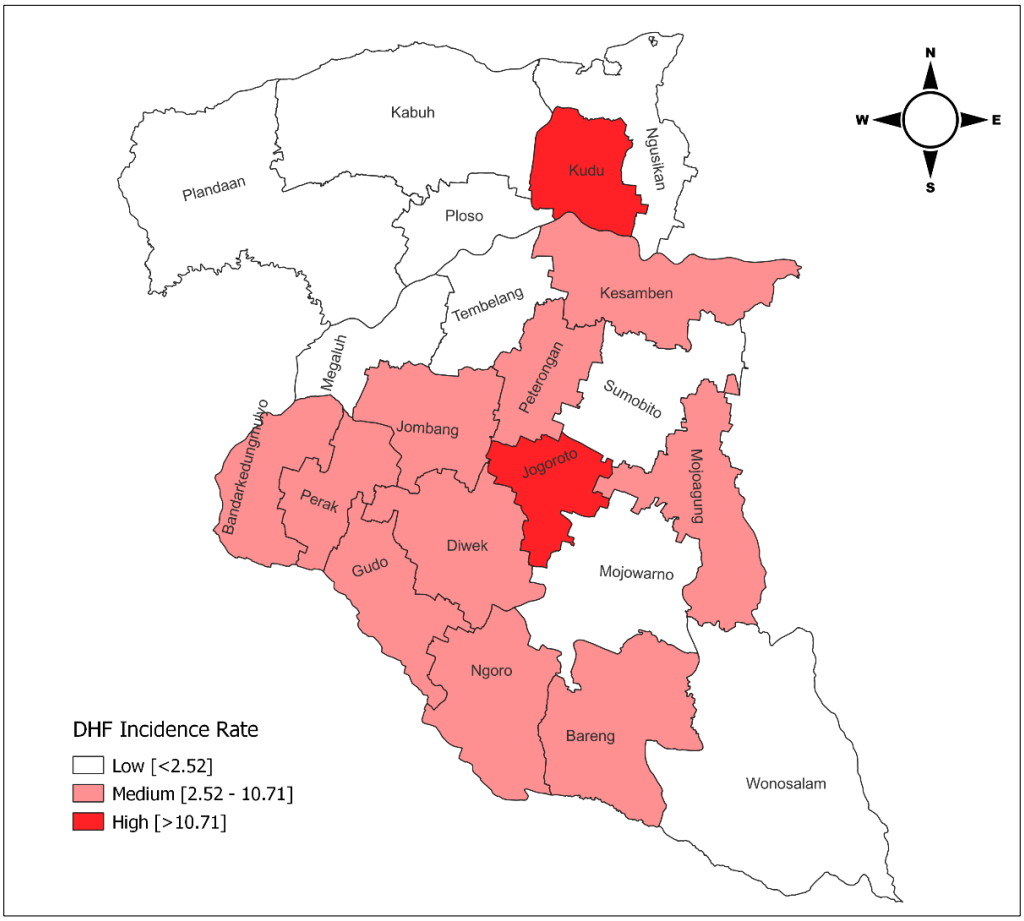

Figure 1 DHF Incidence Rate Choropleth Map

Based on the figure of the choropleth map of DHF incidence rate above, the sub-districts with high dengue incident rates are Kudu and Jogoroto. An incident rate >10.71 is categorized as a high incidence rate of DHF. The medium incident rate is between 2.52 and 10.71, while the low incident rate is below 2.52 (per 100.000 population). There are 9 sub-districts in the Low category, and 10 sub-districts in the medium category.

3.2. Overview of population density in Jombang Regency in 2021

Table 2 Population Density in Jombang Regency in 2021

No	Sub-district	Population	Percentage of Total Population	Population Density (per sq. km)
1	Jombang	139,831	10.61	3,842
2	Diwek	110,495	8.38	2,316
3	Ngoro	77,814	5.90	1,561
4	Tembelang	54,891	4.16	1,666
5	Megaluh	39,725	3.01	1,398
6	Plandaan	37,383	2.84	310
7	Ploso	41,777	3.17	1,609
8	Kabuh	41,311	3.13	424
9	Ngusikan	22,793	1.73	652
10	Kudu	31,513	2.39	405
11	Perak	55,975	4.25	1,927
12	Bandarkedungmulyo	49,959	3.79	1,537
13	Gudo	55,997	4.25	1,628
14	Mojowarno	95,660	7.26	1,217
15	Bareng	56,539	4.29	600
16	Wonosalam	33,520	2.54	276
17	Mojoagung	81,051	6.15	1,813
18	Peterongan	67,822	5.15	2,301
19	Jogoroto	70,760	5.37	2,502
20	Sumobito	86,385	6.55	1,813
21	Kesamben	66,861	5.07	1,293

Source: Jombang Regency Central Bureau of Statistics

Based on the table above, the sub-district with the densest population in Jombang Regency is Jombang sub-district, with a population density of 3,842 people per km^2 and contributing 10.61% of the population in Jombang Regency. Meanwhile, the area with the smallest population density is Wonosalam sub-district, with a population density of only 276 people per km^2. The lowest population percentage in Jombang Regency is in Ngusikan sub-district, with a population percentage of around 1.73% of the total population in Jombang Regency.

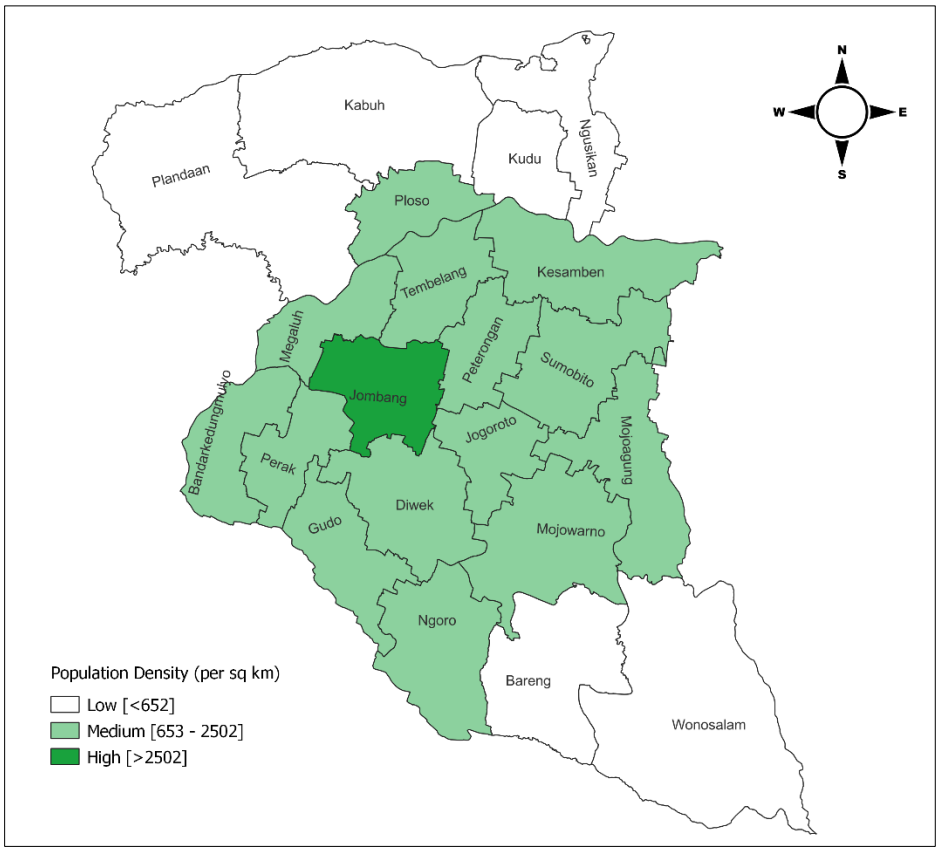

Figure 2 Population Density Choropleth Map

Based on the figure of choropleth map of population density above, Jombang subdistrict is the only subdistrict with a high population density. There are 6 subdistricts with low population density, and 14 other subdistricts with medium population density. This shows that most of the population density in Jombang district is medium.

3.3. Spatial autocorrelation of DHF incidence in Jombang Regency in 2021

Table 3 Spatial autocorrelation of DHF incidence using Global Moran's

I	E(I)	Mean	SD	Z-Value	p-value
-0.0423	-0.0500	-0.0514	0.1282	0.078	0.4320

Source: Geoda Spatial Autocorrelation Analysis

Spatial autocorrelation of DHF incidence using Global Moran's shows that the Z-value < Z-score table for 5% significance level (1,96). These results show that the null hypothesis fails to be rejected, which means there is no spatial autocorrelation of DHF Incidence in Jombang Regency in 2021. No spatial autocorrelation means that the spatial pattern of DHF incidence tends to be random [8]. The results of this study are in line with research conducted by Aulya and Idris (2020), which explains that there is no autocorrelation in the incidence of DHF in Kendari City [9].

To be more specific, a LISA analysis was conducted to determine the spatial autocorrelation locally in each sub-district area in Jombang Regency in 2021. The LISA analysis produces a significance map, which contains information about spatial autocorrelation in each sub-district studied. The significance map of DHF incidence is shown in Figure 3 below.

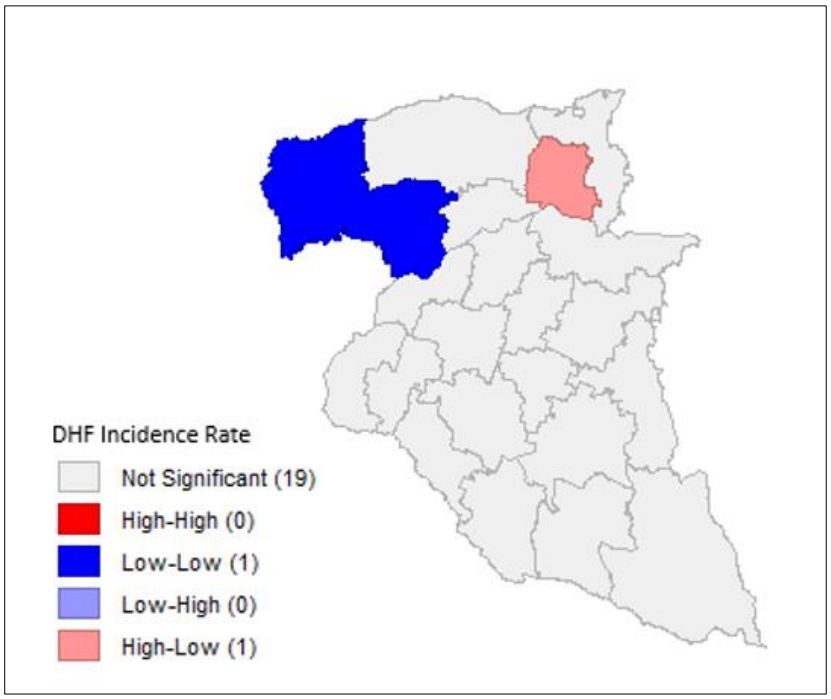

Figure 3 LISA Cluster Map of DHF Incidence

The figure shows that there are two sub-districts with significant spatial autocorrelation, namely Plandaan and Kudu. Plandaan sub-district is significant in the low-low quadrant, which means that the sub-district has a low DHF incidence and is surrounded by other sub-districts that also have a low DHF incidence. This means that Plandaan sub-district is a cold spot. On the other hand, Kudu sub-district is significant in the high-low quadrant. This means that Kudu sub-district has a high DHF incidence and is surrounded by other sub-districts that have a low DHF incidence. Kudu sub-district is an outlier.

Human mobility allows exposure to the virus to occur when moving from home to other places [10]. Related parties need to pay attention to sub-districts that are identified as outliers. Outliers' region needs more attention because Kudu sub-district can influence the surrounding sub-districts that have low dengue incidence.

3.4. Spatial autocorrelation between population density and DHF incidence in Jombang Regency in 2021

Table 4 Spatial autocorrelation between population density and DHF incidence using Global Moran's

I	E(I)	Mean	SD	Z-Value	p-value
0.186	-0.0500	-0.0097	0.0988	1.9815	0.0033

Source: Geoda Spatial Autocorrelation Analysis

Moran's global bivariate results show that Z-score > Z-table with a significance level of 5% (1.96), which means that the null hypothesis is rejected so that there is a spatial autocorrelation between population density and DHF incidence. The Moran's Index value (I) is also greater than the Expected Moran's Index (E(I)), which means that the spatial pattern between population density and DHF incidence is clustered. Clustered spatial patterns indicate that regions with low population density are surrounded by regions with low DHF incidence; on the other hand, regions with high population density may be surrounded by regions with high DHF incidence. High population density results in shorter flight distances for mosquitoes, making their potential spread to others easier and faster [11].

To see the spatial autocorrelation between population density and DHF incidence specifically in each sub-district, a LISA analysis was conducted. LISA analysis can identify sub-districts that have locally significant spatial autocorrelation between population density and DHF incidence.

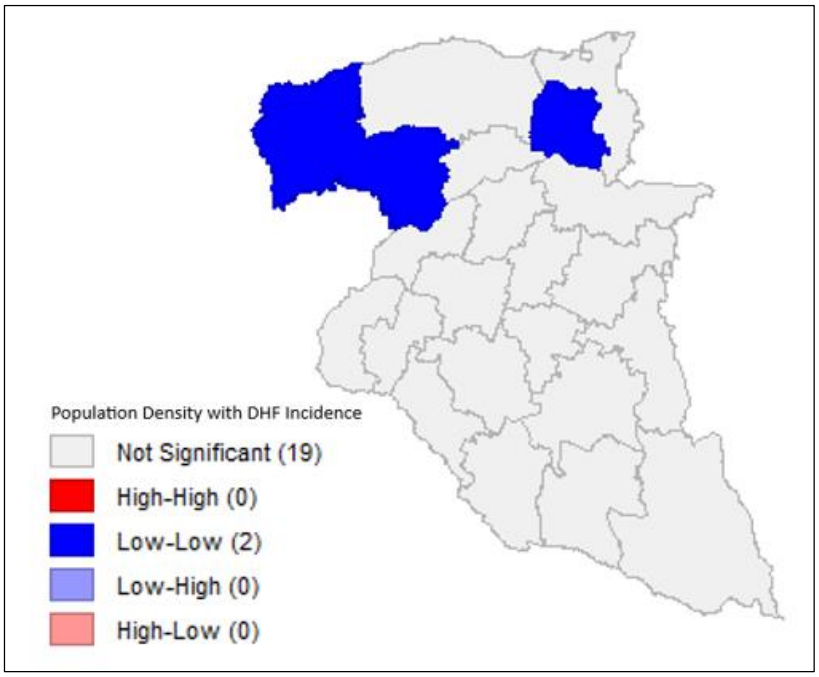

Figure 4 LISA Cluster Map of Population Density and DHF Incidence

Figure 4 above shows there are only 2 sub-districts that have spatial autocorrelation between population density and DHF incidents. Plandaan and Kudu sub-districts were the two sub-districts that have significant spatial autocorrelation; both belong to the low-low quadrant. Low-low quadrant means that the region has low population density and is surrounded by regions with low DHF incidents. This means that two sub-districts are cold spots. Areas with high population density have a greater risk of DHF incidence [12]. The smaller the area or the more densely populated the area, the higher the number of DHF cases [13].

4. Conclusion

There is no global spatial autocorrelation in the incidence of DHF in Jombang district in 2021, but there is local spatial autocorrelation, namely in Kudu sub-district, which is an outlier that requires more attention. Related parties are expected to intervene further in this sub-district so that the surrounding areas are not affected. Spatial autocorrelation between population density and DHF incidence produces a clustered spatial pattern; the higher the population density in a sub-district, the higher the incidence of DHF. Related parties also need to pay attention to areas with high population density to control the incidence of DHF and its distribution.

Compliance with ethical standards

Acknowledgements

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Disclosure of Conflict of interest

No potential conflict of interest was reported by the authors.

Statement of ethical approval

This research utilizes secondary data, which consists of routine reports from relevant agencies (Health Department and Central Bureau of Statistics). Therefore, this study does not involve humans or animals as research subjects.

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