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Spatial-temporal distribution of dengue in Banjarmasin, Indonesia from 2016 to 2020

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ABSTRACT

Dengue hemorrhagic fever (DHF) is an acute febrile disease caused by four serotypes of dengue virus (DENV) and transmitted by the *Aedes aegypti* mosquito. This article aims to analyze monthly trends in cases and climates as well as spatial analysis and autocorrelation in 52 urban villages of Banjarmasin city. Laboratory-confirmed dengue cases from 2016 to 2020 were analyzed for trends in malaria cases. Decomposition analysis was performed to assess seasonality. The annual spatial grouping of incidents, identified by Moran's I. The result shows the annual dengue incidence decreased significantly to 72% in 2017 and lasted until 2020. Dengue infection is more common in men with an age range of 15-64 years. The monthly dengue season is highest from January to May along with increased rainfall. The high incidence is spatially clustered which is identified in the east and borders neighboring districts, especially six urban villages. A trend and spatially explicit decision support system are needed to support surveillance and control programs in identified high-risk areas to succeed in dengue eradication goals.

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1. INTRODUCTION

Dengue hemorrhagic fever (DHF) is an acute febrile disease caused by four dengue virus (DENV) serotypes. Dengue fever is caused by the transmission of the *Aedes aegypti* (*Ae. aegypti*) female infected with dengue virus [1]. DHF cases were found in all provinces and 398 districts/cities (out of a total of 514 districts/cities). DHF cases in Indonesia according to data from the Indonesia Ministry of Health (MoH) in January 2019 increased by 121% compared to 2018. Data for DHF cases in January 2018 were 6,167 cases and 43 were declared dead, 2019 in January, dengue cases increased to 13,683 cases and 132 died [2]. Data from the Banjarmasin city health office shows that the incidence of DHF over the last five years tends to increase. In 2016 there were 58 cases and one death, in 2017 it decreased to 17 cases, in 2018 it increased again to 28 cases with two deaths, in 2019 it increased to 41 cases with one death and in 2020 there were 42 cases and one death [3]. The occurrence of case fluctuations in Banjarmasin city is estimated to be due to climatic factors and increasing population.

Climate influences dengue ecology by influencing vector dynamics, agent development, and mosquito/human interactions [4]. Geographically, Indonesia has a tropical climate that is divided into several specific ecological areas, which are suitable places for vector breeding, especially *Ae. aegypti* and *Ae. albopictus* [5]. Temperature is one of the most important environmental factors that affect the biological processes of mosquitoes, including their interaction with the dengue virus [6]. Humidity affects the incidence of dengue fever, where the lower the humidity, the higher the incidence of dengue fever, rainfall affects the incidence of dengue fever, where the higher the rainfall, the higher the incidence of dengue fever, this is due to the large number of mosquito breeding habitats that are formed both naturally and artificially [7]. Other studies also show that humidity, temperature, and rainfall have a strong enough effect on dengue transmission in Mataram city [8]. DHF cases in Ternate city were found to be relatively higher in the wet months, namely the range of rainfall >200-412 mm, temperature 23-27°C, and humidity 67-82 mmHg. Temperature and humidity were stated to have a significant effect on dengue cases in Ternate city (p-value<0.005). Rainfall although it is not proven to affect DHF cases, based on the path diagram, rainfall has a positive effect on the incidence of DHF by 8.4% which means that the high and low incidence of DHF is influenced by rainfall by 84%. This is because rainfall has a direct effect on the existence of a breeding ground for dengue vector mosquitoes [9].

Efforts to solve the problem of DHF, among others, can be done by using analytical techniques as an effort to manage area-based disease mitigation by mapping spatially. The existence of an information system regarding mapping the spread of disease is the right solution to help overcome problems regarding disease in an area. Spatial aspects (regions) are important to study because one area to another has different characteristics, such as land surface elevation, soil type, population density and behavior, environmental cleanliness level, and so on. A geographic distribution map is very useful for studying the relationship between geography and disease empirically and useful to help implement intervention plans [10]. The device used in collecting, storing, displaying, and connecting spatial data from these geographical phenomena is a geographic information system (GIS) [11]. GIS can be used to monitor the development of DHF that requires special and rapid treatment. A spatial approach using GIS is important because by using the analysis in GIS, it is possible to know population density and larvae with the frequency or number of dengue cases [11]. This is by research conducted by Naim *et al.* shows the results that the average distance of cases with other DHF cases is less than 55 meters with cluster patterns concentrated in two areas, has an artificial neural network (ANN) value of 0.264, and explains that areas with cluster patterns occur in areas with a high population in Seremban, Malaysia [12].

Based on these problems, regional-based mitigation efforts are needed. This article aims to analyze case and climate trends, perform spatial analysis and autocorrelation in 52 urban villages in Banjarmasin city to see the distribution of DHF incidence. The results of this study are important to identify areas classified as endemic to DHF.

2. RESEARCH METHOD

2.1. Study area

The city of Banjarmasin is one of the two cities and nine districts in the South Kalimantan Province, Indonesia; Banjarmasin is the capital of the province as shown in Figure 1. Banjarmasin has a tropical climate, with an average rainfall of 2584 mm/y, relative humidity ranging from 81 to 88%, and temperature ranging from 25.9 to 27°C. Banjarmasin is situated in the east of South Kalimantan Province. To operationalize public health measures, including dengue control programs, a total of 26 public health centers (PHCs) are defined.

2.2. Data collection

Monthly data for laboratory-confirmed dengue cases reported during 2016–2020 were obtained from the City Health Office (CHO) of Banjarmasin. All dengue cases must be reported by the local PHCs to the CHO through the dedicated national reporting system for dengue. The notification data consist of age, gender, date of onset, diagnosis confirmed by the laboratory, and geolocation (village information or the PHC). The community health workers (CHWs) in each PHC compile and send a monthly report form to the provincial level to be validated before sending it to the national MoH. The population data for each village were collected from the local Bureau of Statistics report. Rainfall data is obtained from the Central Statistics Agency (CSA) of Banjarmasin.

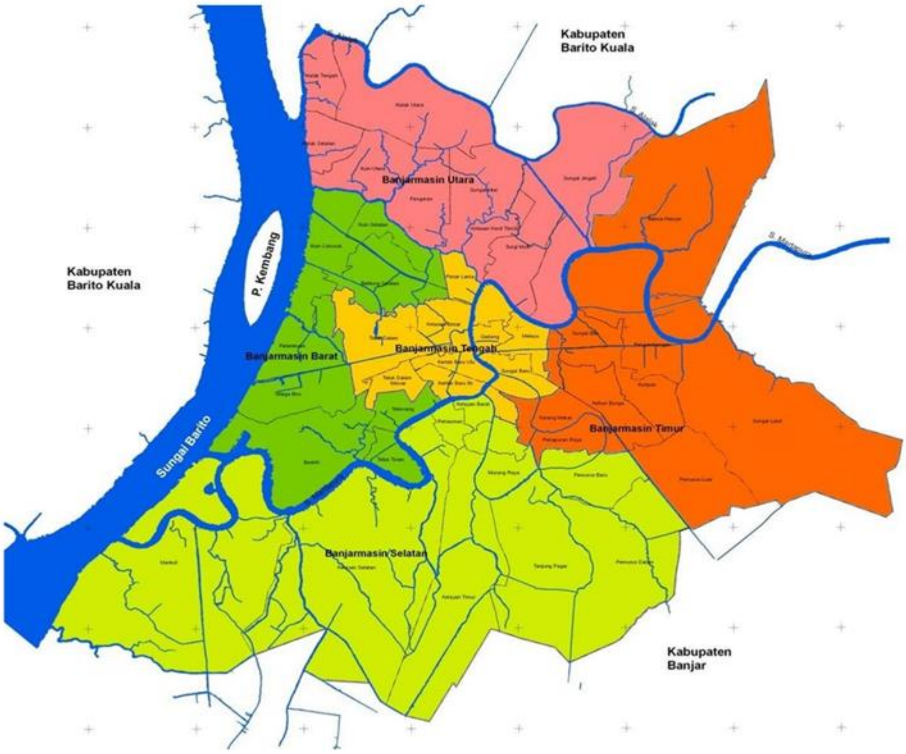

Figure 1. Map of the study site, Banjarmasin city, South Kalimantan, Indonesia. Blackline polygons represent the administrative boundaries of the village

2.3. Data analysis
2.3.1. Descriptive and temporal analysis

A retrospective analysis of dengue notifications in Banjarmasin from 2016 to 2020 was performed. Descriptive analysis was conducted to summarize the number of cases by age group (<5, 5–9, 10–14, 15–54, and ≥55y), gender, and type of dengue infection. Multiplicative seasonal decomposition analysis was conducted using statistical product and service solutions (SPSS) version 21 to decompose the monthly incidence of dengue (Yt) into a combined trend (Tt), a seasonal component (St), and an error or residual component (Et). The relationship between the different decomposition terms and dengue incidence is Yt=Tt+St+Et [13].

2.3.2. Examining spatial patterns

For spatial analysis and operational purposes, the study defined a village (when finer spatial data were available) or PHC working area as the spatial unit of analysis. The analysis was restricted to the mainland of Banjarmasin, as dengue cases are much more prevalent on the mainland. The centroids (the latitudes and longitudes) for each village were estimated by using GIS software. The dengue cases were linked to the identifier of the polygon of the village. Global spatial clustering of dengue incidence was estimated using Moran's I statistic [14]. Furthermore, to locate high-risk villages in mainland Banjarmasin, a local indicator of spatial association (LISA) analysis was performed [15]. Spatial weight was constructed based on a first-order Queen contiguity matrix. Spatial analyses were performed by using GeoDA version 1.8 software (center for spatial data science, Chicago, IL, USA) [16]. Spatiotemporal API and cluster maps were then generated by using ArcGIS version 10.5 (Esri, Redlands, CA, USA) [17].

3. RESULTS AND DISCUSSION
3.1. Dengue case situation in Banjarmasin

The number of dengue cases in Banjarmasin city with the category (DF/dengue fever, DHF, and Death) was 2,659 cases from 2016-2020. Based on sex, most cases were male (60%), with an age range of 15-64 (49.2%) but not much different from those in children aged 5-14 years (44.3%). The highest incidence rate compared to the total population was in 2016 (8.48) as presented in Table 1. The results of the study in China also stated that there were more cases of dengue in males when compared to females with an age range of 20-50 [18], [19]. The sex distribution of dengue cases may be related to the sex distribution of people at risk of dengue infection. The results also show that male and female individuals are all susceptible to the dengue virus in Banjarmasin city.

In dengue-endemic areas, most cases of dengue fever occur in children or young adults because of the high seroprevalence of dengue antibodies in the elderly [20]–[22]. Although the mean age of cases differed slightly throughout the study years. The results also revealed that individuals of various ages are all susceptible to the dengue virus in Banjarmasin city due to a lack of immunity to dengue fever.

Figure 2 (a) describes the fluctuating increase in dengue fever cases starting from January to March, then decreasing from April to December. Then in Figure 2 (b) it is explained that there is an increase in dengue cases with rainfall. The seasonal factor every month for 5 years is the dominant increase in the incidence of DHF. The incidence of DHF can be seen in January, April and October every years. Rainfall also affects dengue fever in Sri Lanka, in addition, cases of dengue fever also increase with increasing rainfall [23]. Rainfall also affects the incidence of dengue fever in Bangkok, Thailand. Spearman correlation analysis shows that rainfall and humidity play a role in the transmission of dengue fever with correlation efficiency of 0.396 and 0.388, respectively. rainfall is the most important factor, a 1% increase in rainfall corresponds to a 3.3% increase in dengue cases in Bangkok, Thailand [24].

Table 1. Annual dengue cases and the proportion of cases by sex, age, and type of infection, Banjarmasin city, South Kalimantan, Indonesia (2016-2020)

Variable	No. of dengue case (DHF)											
	Total	%	2016	%	2017	%	2018	%	2019	%	2020	%
Case category												
DF	2,467	92.8	653	91.7	288	94.4	705	95.9	670	94.1	151	77.4
DHF	185	7.0	58	8.1	16	5.2	28	3.8	41	5.8	42	21.5
Death	7	0.3	1	0.1	1	0.3	2	0.3	1	0.1	2	1.0
Sex												
Male	111	60.0	30	51.7	13	81.3	21	7.5	26	63.4	21	50
Female	74	40.0	28	48.3	3	18.8	7	2.5	15	36.6	21	50
Age (years)												
<5	12	6.5	3	5.2	0	0.0	2	7.1	4	9.8	3	7.1
5-14	82	44.3	27	46.6	7	43.8	15	53.6	18	43.9	15	35.7
15-64	91	49.2	28	48.3	9	56.3	11	39.3	19	46.3	24	57.1
>64	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	185	100	58	100	16	100	28	100	41	100	42	100
Total population	3,502,154		684,183		692,793		700,869		708,606		715,703	
IR/100,000 population			8.48		2.31		4.00		5.79		5.87	

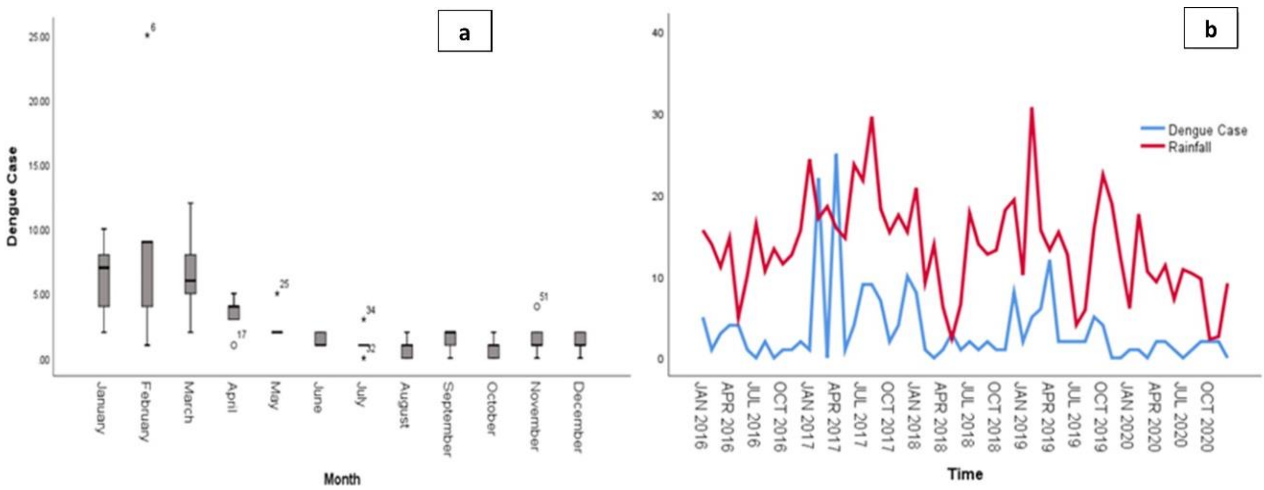

Figure 2. Trend dengue in Banjarmasin (a) Boxplot monthly of dengue distribution and (b) monthly of dengue and rainfall in Banjarmasin city, South Kalimantan during 2016–2020

3.2. Seasonal seasonal decomposition of monthly dengue cases

The results of the forecasting analysis with Seasonal decomposition get an analysis in the form of an image of the trend cycle and seasonal factors of DHF incidence in the city of Banjarmasin. Based on Figure 3, it can be seen that the trend from a certain month each year is the occurrence of dominant DHF and which has a high potential for an increase in DHF cases. In 2016 there was an increase in the incidence of DHF, in 2017-2018 there was a decrease in cases, then again there was an increase in the incidence of DHF in 2020. The seasonal factor every month for five years was the dominant increase in the incidence of DHF. The incidence of DHF can be seen in January, April, and October every year.

The increase in cases occurred probably because efforts to eradicate DHF did not occur optimally, this was suspected to be due to the influence of climate, namely increased rainfall so that there were many breeding sites for mosquito breeding habitats, that the climate could also affect the development of the virus in terms of ecology and seasonal patterns [25]. Another study in Brazil also showed that daily temperature analysis showed a significant correlation (R=0.70 and p>0.99), and there was a good correlation between the end of the rainy season and the peak of the epidemic. The results demonstrate the complexity of the disease, the close relationship between the environment, the circulation of various serotypes, the disposal of solid waste, debris, and abandoned ponds, which put the population itself at risk and susceptible to disease [26]. Patterns of detection and identification of the relationship between climate and dengue have the potential to be useful in combating the high risk of dengue and strengthening public health systems and reducing the increasing burden of dengue [27], [28].

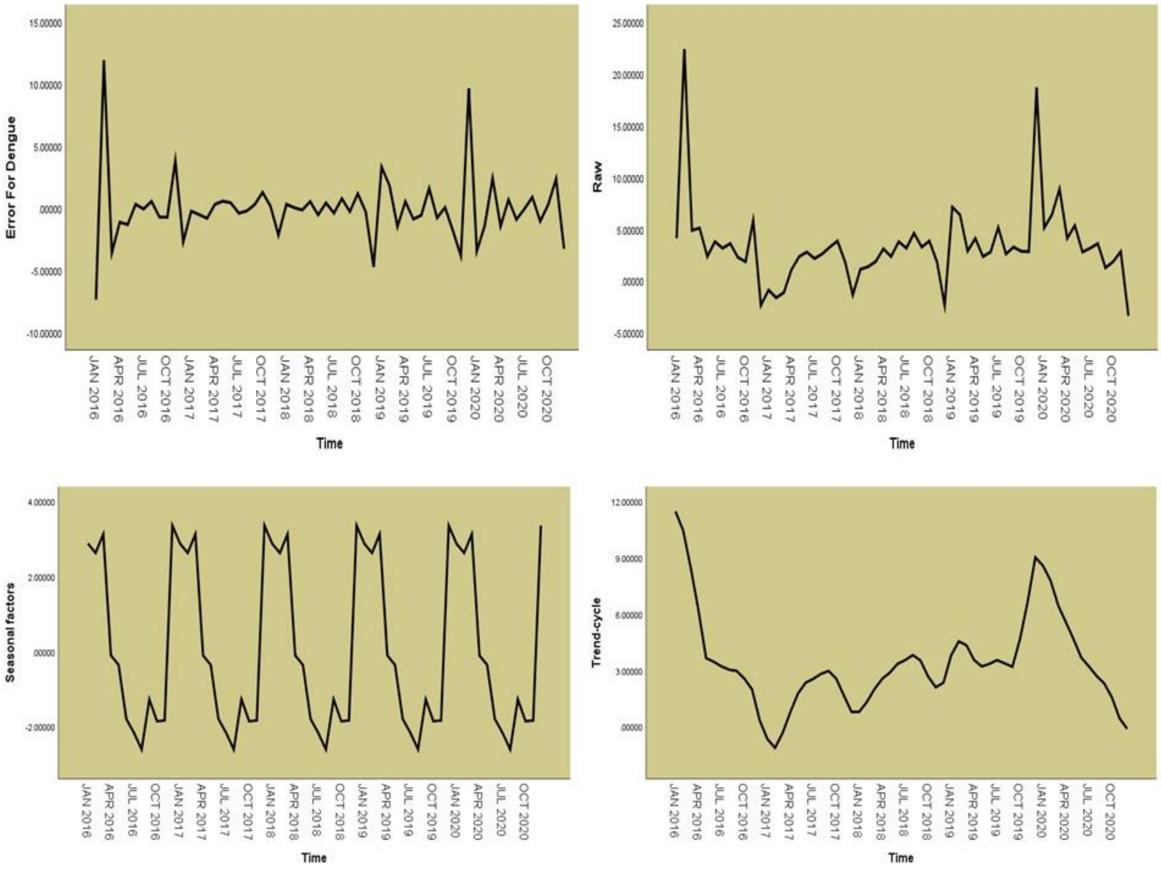

Figure 3. Seasonal decomposition of monthly dengue cases (2016-2020), Banjarmasin city, South Kalimantan

3.3. Distribution and autocorelation of dengue cases in Banjarmasin

Spatial analysis from the descriptive maps shows that the distribution of dengue cases in 52 Banjarmasin villages tends to fluctuate up and down in 52 villages in the last five years (2016-2020). The distribution of cases showed an increase in 2016 as many as 58 cases and a decrease in the incidence of DHF in 2017 as many as 16 cases, but in 2018-2020 there was a sharp increase in the incidence of DHF cases, respectively 28 cases, 41 cases, and 42 cases. The number of cases per villages varies each year. In 2016 there were 25 sub-districts reporting cases of dengue fever. However, in 207 cases of DHF decreased by 11 villages.

The increase in cases of dengue fever increased in 2018-2020 with sub-districts reporting 16 sub-districts, 19 sub-districts, and 21 sub-districts related to dengue cases. Based on the number of cases in each village, it can be seen that in five years the number of DHF cases per urban villages each year is different, but some urban villages are always in the number of DHF incidences as presented in Figure 4.

Urban village in Banjarmasin city is one of the dengue-endemic areas in South Kalimantan Province. This is because cases of DHF always appear every year and have spread in almost all villages. The discovery of the incidence of dengue fever in the city of Banjarmasin experienced an increasing trend in the number of dengue cases over the last five years (2016-2020). The spike in the number of dengue cases has started to appear in 2018. In 2020 the spike in dengue cases is increasing. In general, the pattern of increasing the number of dengue cases nationally began to surge since 2019 after the previous year showed a downward trend in cases [29]. The results of the Moran's I index test show that there is a positive autocorrelation spatially between adjacent urban village to dengue cases in Banjarmasin city every year for the last five years (2016-2020). The test results show that (I>I0 then the pattern of clustering or positive autocorrelation) is 0.226>-0.083, this indicates that there are similarities in the characteristics of DHF cases in villages that are adjacent to or related to DHF cases tend to be spatially clustered.

The spatial cluster map of cumulative DHF Cases 2016-2020 with local indicator of spatial autocorrelation (LISA) can be seen in Figure 5. Spatial autocorrelation with the Global Moran Index approach only analyzes the relationship between DHF occurrences in the city administration space, not locally or in the kelurahan. Therefore, Figure 5 (a) describes the analysis followed by the local indicator of LISA approach to determine the spatial relationship between DHF events based on the local village or kelurahan. Our analysis found that the sub-districts with the high to high (HH) group type that need attention are the Kelurahan Kebun Bunga, Kuripan, Banua Anyar, Pemurus Luar, Pemurus Baru, and Pangambangan. There is 1 low-high (LH) village, namely Mantuil Village. The six kelurahan are areas bordering Banjar Regency. The HH indicator shows that the three kelurahan are areas with high DHF cases, and are surrounded by several kelurahan which also have high DHF cases. Thus, the six kelurahan are areas that are considered vulnerable or prone to experiencing a high spike in DHF cases, which can even trigger the emergence of extraordinary cases of DHF as described in Figure 5 (b). An even more interesting finding is that kelurahan with the high-high (HH) indicator trend to cluster in the central part of the Banjarmasin city area, while kelurahan with the low to low (LL) indicator are located on the outskirts of Banjarmasin city.

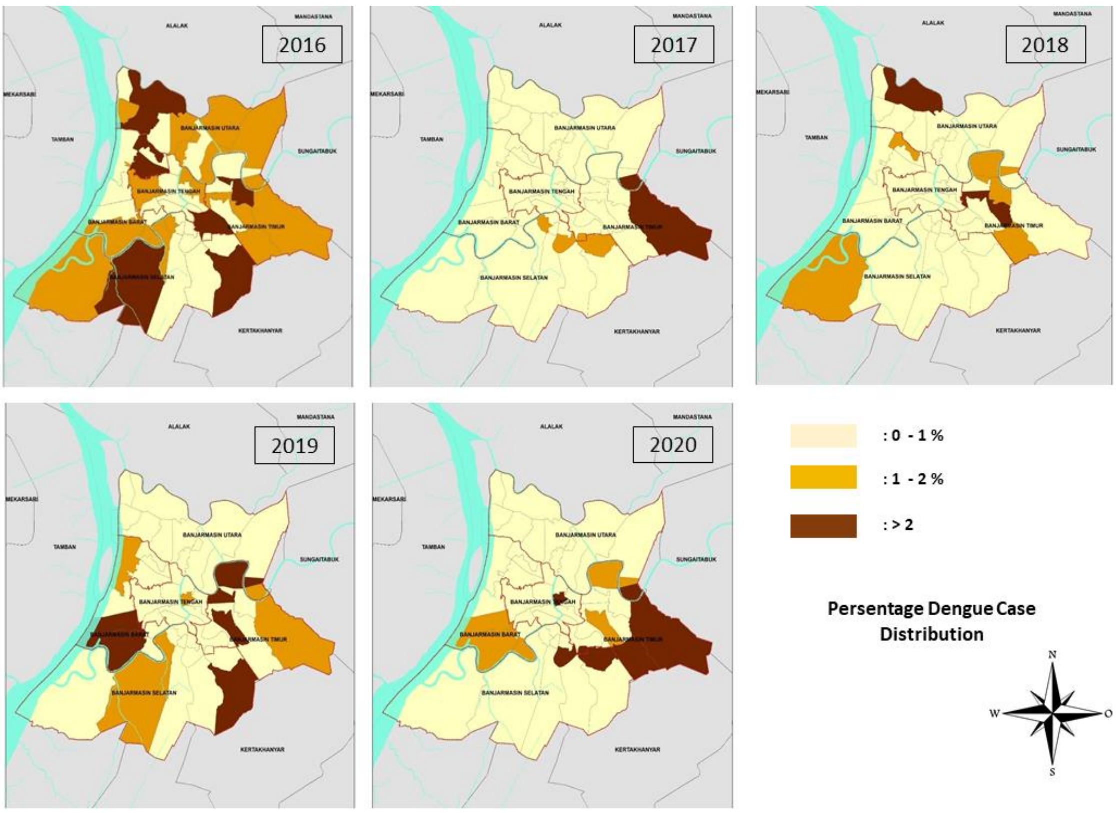

Figure 4. Distribution of dengue cases in Banjarmasin city by percentage of number of cases from 2016-2020

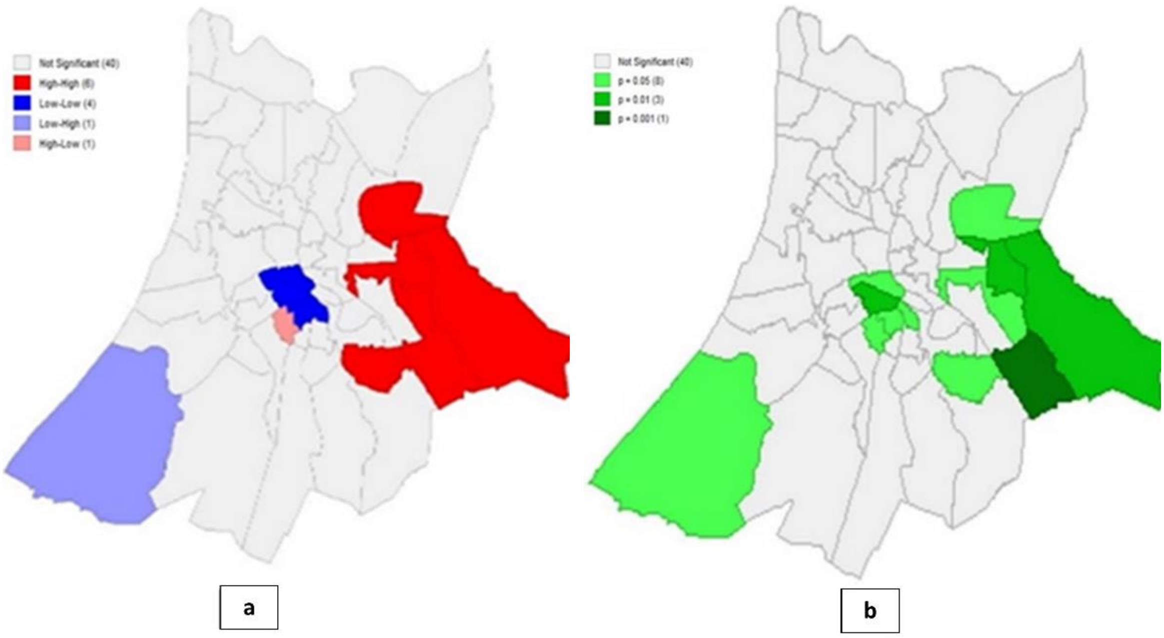

Figure 5. Spatial cluster maps of cumulative dengue case 2016-2020 as identified by LISA analysis. (a) LISA cluster map and (b) LISA significance map in Banjarmasin city

This finding indicates that the increase in dengue cases over the last five years has mostly occurred in areas bordering other regencies which are satellite areas with large and new residents and housing, in addition to many housing units that are not inhabited, while the urban village is located in the center of Banjarmasin city. tend to have a low number of dengue cases. These results are in line with research in Guangzhou, China that the cluster with the highest DHF relative risk (RR) is due to the very high intensity of population mobility in urban areas, thus supporting the occurrence of dengue transmission between regions [30]. In addition, in Thailand, 60% of dengue cases living less than 200 meters are from the same chain of transmission, compared to 3% of cases separated by 1 to 5 kilometers [31]. The problem of DHF knowing no regional boundaries, efforts to communicate with border areas, especially with the high incidence of dengue fever, need to be carried out. Vector flight distance, the existence of health facilities, and population mobilization are also factors that support the increase in cases [32].

4. CONCLUSION

Although there was a significant declined case, the remaining high endemic sub-districts still clustered on the border of Banjar Regency, indicating the need to strengthen supervision and cooperation with neighboring districts. Local intervention strategies, such as larva eradication, draining water reservoirs, and closing open water bodies, are needed. GIS-based spatial analysis and trends can be explored further to develop a spatial dengue shock syndrome (DSS) for dengue. It is important to assist local health authorities in implementing effective hotspot-targeted interventions in Banjarmasin to achieve dengue eradication goals.

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