



RESEARCH ARTICLE

URL article: <http://jurnal.fkmumi.ac.id/index.php/woh/article/view/woh9324>

Incidence of Dengue Disease Rate Based on Spatial Analysis in Metro City

Sutarto^{1C}, Ratna Dewi Puspita Sari², Winda Trijayanthi Utama³, Hesti Yuningrum⁴, Suryani Agustina Daulay⁵, Reni Indriyani⁶, Sri Dewi Sumardilah⁷

^{1,3,4,5} Medical Education Study Program, Faculty of Medicine, University Lampung, Indonesia

² Medical Professional Study Program, Faculty of Medicine, University Lampung, Indonesia

^{6,7} Department of Nutrition, Tanjung Karang Health Polytechnic, Bandar Lampung, Indonesia

Email Corresponding Author(^C): sutarto@fk.unila.ac.id
sutarto@fk.unila.ac.id¹, ratna.sari@fk.unila.ac.id², winda.trijayanthi@fk.unila.ac.id³,
hesti.yuningrum@fk.unila.ac.id⁴, suryani.daulay@fk.unila.ac.id⁵, reniindriyani@poltekkes-tjk.ac.id⁶,
dewisrisumardilah@poltekkes-tjk.ac.id⁷

ABSTRACT

Dengue Hemorrhagic Fever (DHF) remains a public health problem in Metro City, Lampung Province. This study aimed to describe the village-level distribution of DHF incidence in Metro City during January–April 2024 and to determine whether DHF cases exhibited a clustered pattern using Average Nearest Neighbour (ANN) analysis. This quantitative study used two data sources: (1) secondary surveillance data from the Metro City Health Office for 2018–2022, used only to describe the historical trend of DHF; and (2) primary data on the residential coordinates of all DHF cases reported from January to April 2024 ($n = 248$), collected using GPS, which served as the main dataset for spatial analysis. Village-level incidence rates were mapped, and the spatial pattern of cases was assessed using Average Nearest Neighbour (ANN) analysis. Historical surveillance data showed fluctuating case numbers, peaking at 192 cases in 2019 and declining to 88 cases in 2022 (IR 51.40 per 100,000 population), with no DHF deaths recorded (CFR 0%; 0 deaths/88 cases). Among the 248 cases in January–April 2024, most occurred in the 6–59-year age group (83.1%), and 54.8% were female. The highest village-level IRs were found in Summersari Bantul, Margorejo, Tejoagung, Yosomulyo, Karang Rejo, and Purwosari. ANN analysis showed a statistically significant clustered pattern ($NNR = 0.013$; $p < 0.01$), indicating that cases were not randomly distributed. This clustered pattern warrants further investigation into environmental, behavioural, and health service-related factors that may contribute to the concentration of cases. These findings can support location-based prioritisation of DHF prevention and control in Metro City.

Keywords: Dengue hemorrhagic fever, Aedes aegypti mosquito, metro city, incidence rate, geospatial information system

PUBLISHED BY :

Public Health Faculty
Universitas Muslim Indonesia

Address :

Jl. Urip Sumoharjo Km. 5 (Kampus II UMI)
Makassar, Sulawesi Selatan.

Email :

jurnalwoh.fkm@umi.ac.id

Phone :

+62 82188474722

Article history

Received 21 April 2026

Received in revised form 7 October 2026

Accepted 15 October 2026

Available online 16 October 2026

licensed by [Creative Commons Attribution-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/).



INTRODUCTION

Dengue is a mosquito-borne viral infection transmitted mainly by *Aedes aegypti* and *Aedes albopictus* and remains a major public health problem in tropical and subtropical countries.¹ In 2024, more than 14.4 million dengue cases and over 11,000 dengue-related deaths were reported worldwide from more than 100 countries, the highest annual number ever recorded.² Indonesia is a dengue-endemic country; by epidemiological week 43 of 2024, the Ministry of Health had reported 210,644 dengue cases and 1,239 deaths, nearly double the 114,720 cases and 894 deaths reported in 2023.³ A similar surge occurred in Lampung Province, where reported cases increased from 2,181 in 2023 to 9,228 in 2024, with 31 deaths; Metro City alone reported 735 cases in 2024.⁴ Metro City is an endemic area for dengue hemorrhagic fever (DHF). The number of dengue cases decreased in 2018 to 59, increased in 2019 to 192, decreased in 2020 to 148, decreased in 2021 to 138, and decreased in 2022 to 88. The Incidence Rate (IR) of dengue in 2018 was 35.7 per 100,000 population, in 2019 it was 114.7 per 100,000 population, in 2020 it fell to 87.3 per 100,000 population, in 2021 it fell to 80.2 per 100,000 population, and in 2022 it fell to 51.40 per 100,000 population. These incidence rates were obtained from the Metro City Health Profile and were calculated as the number of reported DHF cases in a given year divided by the mid-year population of Metro City in the same year, multiplied by 100,000.⁵ Although 50 fewer cases were reported in 2022 than in 2021, this decline should be interpreted with caution. Year-to-year changes in reported cases may reflect changes in population size, surveillance intensity, diagnostic and reporting completeness, and health-seeking behavior, as well as the natural multi-year cyclical pattern of dengue transmission, rather than an improvement in disease control alone. The sharp increase in 2024 indicates that the decline observed in 2022 did not represent sustained control. The Case Fatality Rate (CFR) indicates the severity of a disease and assesses the quality of treatment. No DHF deaths were recorded in Metro City in 2021 or 2022; the CFR was therefore 0% in both years (0 deaths/138 cases in 2021 and 0 deaths/88 cases in 2022). Nevertheless, based on its incidence rate, dengue in Metro City remains a public health problem and requires prompt, appropriate management.⁵

Regarding the prevention and control of dengue disease in Metro City, mapping the incidence area of dengue disease is a necessity. Dengue transmission is spatially heterogeneous because vector breeding sites, population density, and human mobility differ between neighborhoods; city-level indicators such as IR and CFR therefore cannot show where transmission is concentrated.⁶ Spatial analysis of case locations can identify clusters and high-incidence villages, allowing limited vector control resources to be prioritized.⁷ The creation of a dengue incidence mapping using GIS (Geographic Information System) is one of the efforts to support the disease eradication program. GIS has advantages in mapping areas over manual mapping, including several spatial analysis processes, one of which is overlay analysis and scoring.^{8,9}

One of the challenges in planning and developing an area is the existence of disasters, so it is necessary to have policies to integrate into the aspect of disaster mitigation, including in the case of outbreaks or pandemics (KLB) of dengue fever. Non-natural disasters are a threat, so the Metro City

Government in the case of dengue hemorrhagic fever (DHF) needs to mitigate the existence of KLB or dengue disease outbreaks.^{9,10}

From the description above, to determine the effectiveness of intervention by health service units, it is necessary to mitigate the vulnerability of dengue disease for the control and prevention program of dengue disease in Metro City. This study also utilizes information from the dengue disease control and prevention program of the Metro City Health Office, and Metro City geographic data. The purpose of this paper is to explain the distribution map of the incidence rate of dengue disease in Metro City, Lampung Province.

METHOD

Study design and data sources. This was a descriptive observational study with a spatial approach, conducted in the working area of the Metro City Health Office in Lampung Province, comprising 5 sub-districts and 22 villages (kelurahan). Two separate datasets were used. The first was secondary DHF surveillance data for 2018–2022 obtained from the Metro City Health Profile; these data were used only to describe the historical trend of DHF and were not included in the spatial analysis. For these data, the incidence rate (IR) was calculated as the number of cases divided by the mid-year population $\times 100,000$, and the case fatality rate (CFR) as the number of DHF deaths divided by the number of DHF cases in the same year $\times 100\%$. The second dataset, the primary dataset for the spatial analysis, comprised all DHF cases reported from January to April 2024, along with the residential coordinates of each case.

Study population and case definition. The study population comprised all DHF cases among residents of Metro City recorded in the DHF surveillance register of the Metro City Health Office during January–April 2024. A DHF case was defined as a patient reported to the Health Office by a health facility (hospital or primary health centre) with a diagnosis of DHF based on the clinical and laboratory criteria of the national DHF management guidelines of the Indonesian Ministry of Health. Because all reported cases were included ($n = 248$), no sampling was performed; the study used the total population (complete enumeration).

Collection of residential coordinates. The residential location of each case was recorded at the patient's household address using a handheld Global Positioning System (GPS) receiver and documented on a checklist form. Data were collected by a team of enumerators consisting of DHF control program officers who had been trained in the coordinate recording procedure. Coordinates were recorded in decimal degrees (WGS 1984) in front of each patient's house. To ensure geolocation accuracy, each coordinate was checked against the address in the surveillance register and overlaid on the village boundary map; points that fell outside the patient's village of residence were rechecked and corrected. The data were then cleaned, entered, and coded before analysis.

Spatial analysis. Data were processed and analyzed using ArcGIS [version] (Esri, Redlands, CA, USA). Village administrative boundaries were obtained from the Geospatial Information Agency

(Badan Informasi Geospasial). Case coordinates were projected to the WGS 1984 UTM Zone 48S coordinate system (EPSG:32748) so that distances were calculated in meters. Two spatial units were used: (1) the village, for calculating and mapping the incidence rate, defined as the number of DHF cases during January–April 2024 divided by the village population $\times [1,000]$; and (2) the individual case location (point), for the point-pattern analysis. Village IRs were classified into four classes using the natural breaks (Jenks) method and presented as a choropleth map overlaid with case points and primary health center locations.

Average Nearest Neighbor analysis. The spatial pattern of case locations was assessed using the Average Nearest Neighbor (ANN) tool in ArcGIS with the Euclidean distance method. The nearest neighbor ratio (NNR) was calculated as $NNR = \bar{D}_o / \bar{D}_e$, where $\bar{D}_o = \sum d_i / n$ is the observed mean distance between each case and its nearest neighboring case, d_i is the distance from case i to its nearest neighbor, n is the number of cases, and $\bar{D}_e = 0.5 / \sqrt{(n/A)}$ is the expected mean distance under complete spatial randomness, where A is the study area. The study area was set to the administrative area of Metro City (73.16 km²). Statistical significance was assessed using the z-score, $z = (\bar{D}_o - \bar{D}_e) / SE$, where $SE = 0.26136 / \sqrt{(n^2/A)}$. An $NNR < 1$ with $p < 0.05$ indicated a clustered pattern, an NNR close to 1 a random pattern, and an $NNR > 1$ a dispersed pattern.¹¹

Ethical considerations. This study was approved by the Health Research Ethics Committee, Faculty of Medicine, Universitas Lampung (No. 4241/UN26.18/PP05.02.00/2024, dated 26 August 2024), and permission to use the surveillance data was obtained from the Metro City Health Office. Because residential coordinates are potentially identifiable information, patient names and addresses were removed from the analysis dataset after coordinate verification and replaced with study codes. The data were stored on a password-protected computer accessible only to the research team, and the maps were presented at the city scale without names, house numbers, or other information that could identify individual households.

RESULTS

Metro City is one of the cities in Lampung Province, which is about 52 km from Bandar Lampung City. Metro City is geographically located at 105017'-105021' East Longitude and 506'-5010' South Latitude. Metro City has an area of around 73.16 km², by Metro City Regulation No. 5 of 2022 concerning the City Spatial Plan for 2022 – 2041.

According to data from the Central Statistics Agency of Metro City in 2022, it is explained that Metro City, which has 5 sub-districts with a population of 141,872 people and the highest number of residents, is in East Metro District as many as 53,413 people, while South Metro has the lowest population of only 3,255 people, this condition gives an idea that the distribution of the population in each Metro City District is uneven. Then when viewed from population density, in 2022, Metro City has a population density of 1939.2 people/km².

Metro City health service facilities totaling 249 facilities consisting of hospitals, namely general hospitals and special hospitals, Puskesmas and their network consists of the main health center, auxiliary health center, and mobile health center, and other service facilities consist of clinics, individual doctor practices, traditional medicine practices, hospital blood banks, and blood transfusion units, pharmaceutical production and distribution facilities consisting of pharmaceutical wholesalers, pharmacies, drug stores and distributors of medical devices. In the period 2000-2022, the number of health centers (including treatment centers) in Metro City in 2000 was 11 units and the Sumber Sari Bantul Care Center was upgraded to a Type D Hospital. This ratio has met the concept of the working area of the health center, with an average of 1 health center unit serving 20,000 residents.

Furthermore, the incidence of infectious diseases is still high among dengue diseases. Dengue fever is caused by the Dengue virus and is transmitted by *Aedes Aegypti* and *Aedes Albopictus* mosquitoes. The spread of dengue has the potential to cause panic because of its rapid spread and risk of death. Currently, Metro City is an endemic area for Dengue Fever (DHF). The number of dengue cases in 2018 decreased to 59 cases, in 2019 it increased to 192 cases, in 2020 it decreased to 148 cases, in 2021 it decreased to 138 cases, and in 2022 it decreased to 88 cases. The Incidence Rate (IR) of dengue in 2018 was 35.7 per 100,000 population, in 2019 it was 114.7 per 100,000 population, in 2020 it fell to 87.3 per 100,000 population, in 2021 it fell to 80.2 per 100,000 population, and in 2022 it fell to 51.40 per 100,000 population.¹²⁻¹⁵ The number of reported cases in 2022 was 50 lower than in 2021; however, this decline should not be interpreted as necessarily indicating improved disease control without considering population size, surveillance intensity, and reporting completeness.¹⁶ The Case Fatality Rate (CFR) is an indicator of the malignancy of a disease and assesses the quality of prevention and treatment. No DHF deaths were recorded in 2021 or 2022, giving a CFR of 0% in both years (0 deaths/138 cases and 0 deaths/88 cases, respectively). The number of villages affected by dengue during 2018-2022 is spread across 22 villages of 5 sub-districts in Metro City. In 2022, the sub-district with the most dengue cases was East Metro District with 27 cases, and the sub-district with the smallest number of cases was West Metro District with 10 cases.

Furthermore, from the results of data collection, the distribution of dengue sufferers in the Metro city area was obtained by age group, as shown in Table 1.

Table 1. Distribution of DHF Cases by Age Group in Metro City, January–April 2024 (n = 248)

Age group (years)	n	%
1-5	22	8.9
6–59	206	83.1
≥60	20	8.1
Total	248	100.0

Note: Percentages may not total 100% because of rounding.

Table 1 shows the age distribution of the 248 DHF cases reported in Metro City during January–April 2024. Most cases occurred in the 6–59-year age group (206 cases; 83.1%), followed by children

aged 1–5 years (22 cases; 8.9%) and adults aged ≥ 60 years (20 cases; 8.1%). Because the 6–59-year group covers a much wider age range and a larger share of the population than the other groups, its higher number of cases does not, by itself, indicate a higher risk of DHF. Comparing risk between age groups would require age-specific incidence rates.

Furthermore, the following Table 2 presents data on the distribution of dengue cases by gender. The information listed includes the frequency and percentage of each gender in the total incidence of dengue. This analysis is useful for understanding the proportions of men and women among the dengue T-shirts studied, as well as for providing a preliminary overview of the demographic composition of the dengue cases studied.

Table 2 Distribution of Dengue Patients by Gender for the period January to April 2024
in Metro City

Gender	Frequency	Percent
Man	112	45.2
Woman	136	54.8
Total	248	100.0

Table 2 shows the sex distribution of the 248 DHF cases reported in Metro City during January–April 2024: 112 cases (45.2%) were male and 136 cases (54.8%) were female. These figures describe the distribution of reported cases only. Because sex-specific population denominators were unavailable and no statistical comparison was performed, the results cannot be used to infer differences in DHF risk or susceptibility between males and females.

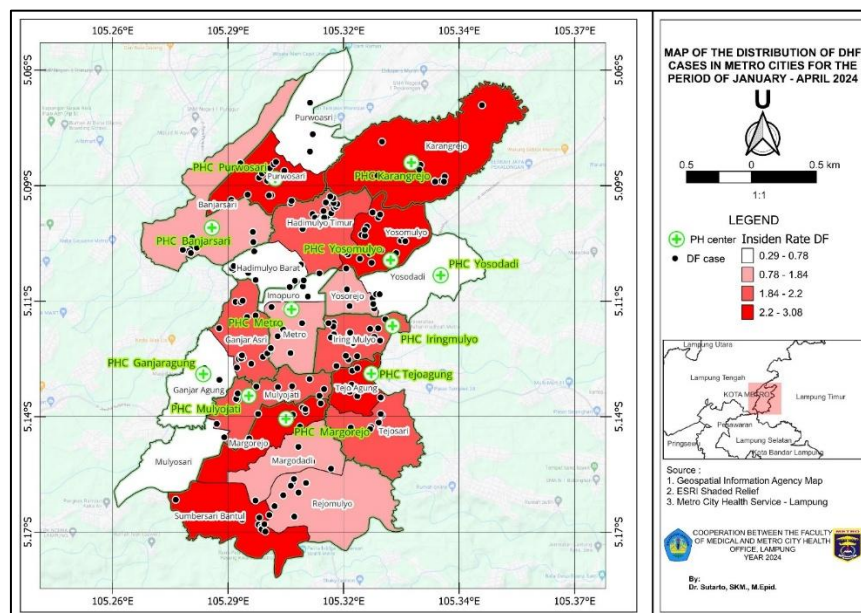


Figure 1. Village-level cumulative incidence rate of dengue hemorrhagic fever (DHF) per 100,000 population and residential locations of DHF cases in Metro City, January–April 2024

Figure 1 shows the village-level cumulative incidence rate (IR) of DHF in Metro City during January–April 2024. The IR was calculated as the number of DHF cases in each village during this four-

month period divided by the population of that village and expressed per 100,000 population. Because each village's own population was used as the denominator, the IR accounts for differences in population size between villages. The IR ranged from 29 to 308 per 100,000 population. The six villages in the highest class (220–308 per 100,000 population) were Summersari Bantul, Margorejo, Tejoagung, Yosomulyo, Karangrejo, and Purwosari, whereas the six villages in the lowest class (29–78 per 100,000 population) were Mulyosari, Ganjar Agung, Imopuro, Hadimulyo Barat, Yosodadi, and Purwoasri. The case points on the map appear concentrated in several high-incidence villages; whether this pattern differed from a random distribution was assessed formally using ANN analysis (Figure 2).

Figure 2 provides clues to the results of the analysis of the incidence pattern using the Average Nearest Neighbor (ANN) for dengue cases in Metro City for the period January - April 2024.

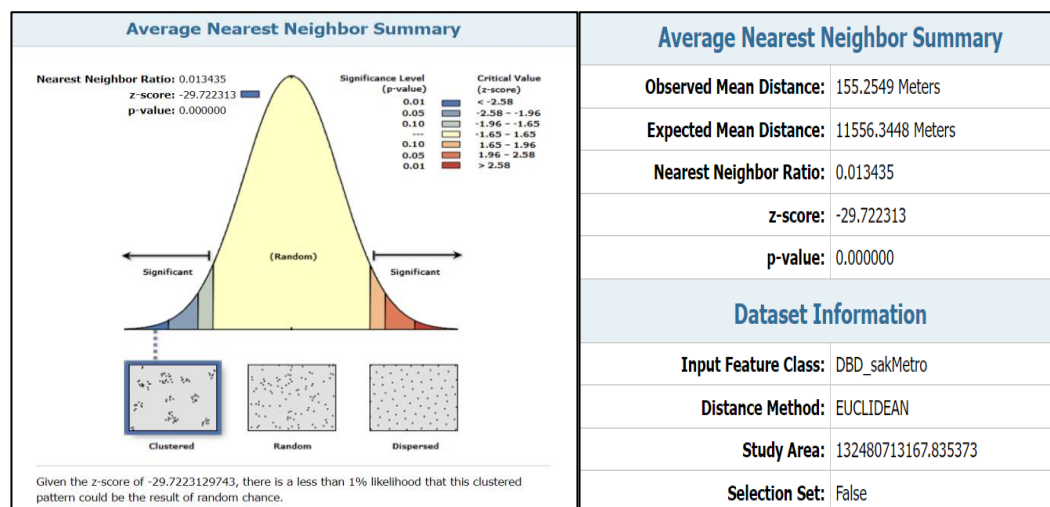


Figure 2. Analysis of Average Nearest Neighbor (ANN) Cases of Dengue Incidence in Metro City for the period January - April 2024

The low NNR value (0.013435) shows that dengue cases in Metro City for the period January - April 2024 are spread unevenly. This means that there are areas in Metro City that have densely populated or clustered dengue cases compared to other areas. The significant value (p-value < 0.01) indicates that the distribution pattern of dengue cases in clusters is unlikely to occur randomly. ANN describes the spatial pattern of cases but does not identify its determinants; this clustered pattern therefore warrants further investigation of environmental, behavioral, and health service-related factors.

DISCUSSION

Metro City, one of the cities in Lampung Province, is located about 52 km from Bandar Lampung City. Geographically, Metro City is located at the coordinates of 105°17'–105°21' East Longitude and 5°06'–5°10' South Latitude, with an area of about 73.16 km² based on Metro City Regulation No. 5 of 2022 concerning the City Regional Spatial Plan for 2022–2041. The city has 5 sub-districts with a total population of 141,872 people in 2022, according to data from the Central Statistics Agency of Metro City. The distribution of the population in this city is uneven, with the highest population in East Metro

District as many as 53,413 people, while the South Metro has the lowest number of residents, only 3,255 people. The population density of Metro City was recorded at 1,939.2 people/km² in 2022, showing a fairly dense population distribution in several sub-districts.¹⁷

Health services in Metro City are supported by 249 health facilities, consisting of general hospitals, special hospitals, main health centers, auxiliary health centers, mobile health centers, as well as various clinics and individual doctor practices. In addition, there are facilities for traditional medicine, hospital blood banks, and blood transfusion units. During the period 2000-2022, the number of health centers including care centers in Metro City increased, with the Summersari Bantul health center being upgraded to a Type D Hospital. This ratio has met the concept of the working area of the health center, where ideally one health center serves 20,000 residents.¹⁸

This data and development show that Metro City has made significant efforts to improve health services for its citizens. However, challenges related to the uneven distribution of the population remain, which affect the effectiveness of health services in each sub-district. With the ratio of health centers that have met the standards, the Metro City government can focus on improving the quality and accessibility of health services, especially in sub-districts with low populations. Infrastructure development and the provision of adequate medical personnel are also important to ensure that all residents of Metro City receive optimal health services. This effort is in line with the goal of sustainable health development, as expected in the city's spatial plan until 2041.^{17,18}

In Table 1, most DHF cases occurred in the 6–59-year age group (206 cases; 83.1%). This large proportion largely reflects the wide age range and large population of this group; because age-specific incidence rates were not calculated, this study cannot determine which age group had the highest risk of DHF. The high number of cases in this group may also be related to high mobility and daytime activities outside the home, such as at schools and workplaces, which increase exposure to *Aedes aegypti*, a day-biting mosquito. Although children aged 1–5 years accounted for only 8.9% of cases, young children are more likely to develop severe dengue because their immune systems are not fully developed, and they therefore require close clinical monitoring.^{19,20}

Furthermore, adults aged ≥ 60 years (8.1% of cases) also need special attention. The elderly tend to have weakened immune systems as they age, and may have comorbidities that can worsen dengue symptoms. Physical weakness and mobility limitations can also hinder their ability to take precautions such as avoiding mosquito bites or ensuring environmental cleanliness. Therefore, prevention and health education programs targeting this age group must be strengthened, including providing information on the importance of using mosquito nets and mosquito repellent, and maintaining the cleanliness of the surrounding environment.^{21,22}

In addition, the high number of sufferers in the age group of 6-59 years reflects the need for a more intensive and comprehensive prevention campaign. Prevention efforts must include counseling on the importance of maintaining environmental cleanliness, such as eliminating standing water that can become a breeding ground for mosquitoes. The use of repellents, the installation of mosquito nets, as

well as increasing awareness of the early symptoms of dengue, are also very important to minimize the spread of this disease. This intervention must be supported by the local government and involve active community participation to ensure its success in reducing the incidence of dengue in Metro City.²³

In Table 2, slightly more of the reported DHF cases were female (54.8%) than male (45.2%). Because sex-specific population denominators were not available and no statistical comparison was performed, this difference cannot be interpreted as evidence that females are more susceptible to DHF. The sex distribution of reported cases may reflect differences in exposure, such as time spent in and around the home, where *Aedes aegypti* commonly breeds, as well as differences in health-seeking behaviour and in the likelihood of being diagnosed and reported.²⁴ Future studies should calculate sex-specific incidence rates to assess whether the risk of DHF differs between males and females. The data shown in Figure 1 shows the distribution of Dengue Hemorrhagic Fever (DHF) incidence rate (IR) in Metro City, -with considerable variation between villages. Villages in the highest IR class (220–308 per 100,000 population) are marked in red and include Summersari Bantul, Margorejo, Tejoagung, Yosomulyo, Karangrejo, and Purwosari. In contrast, villages in the lowest IR class (29–78 per 100,000 population) include Mulyosari, Ganjar Agung, Imopuro, Hadimulyo Barat, Yosodadi, and Purwoasri. This indicates considerable variation in dengue incidence across villages in Metro City, which may be influenced by local factors. However, village-level rates were not smoothed or adjusted for small population sizes; rates in small villages are therefore less stable and should be interpreted with caution.

In Figure 1, DHF case points appear concentrated in villages with high and moderate incidence (the red and dark-pink areas). This grouping pattern is not the result of random distribution, but rather an indication that there are specific factors that cause the concentration of dengue cases in a particular area. These factors can include environmental conditions such as the presence of puddles that breed *Aedes aegypti* mosquitoes, population density, and poor sanitation conditions. In-depth identification and analysis of the factors causing this grouping is essential to designing effective interventions in controlling the spread of dengue. By understanding these factors, health authorities can redirect resources and prevention efforts in a more targeted manner, reducing the incidence of dengue in the most affected areas.^{25–27}

The low Nearest Neighbor Ratio (NNR) value (0.013435) shows that dengue cases in Metro City in the period January - April 2024 are spread unevenly, with a tendency to cluster cases in certain areas. An NNR value close to zero indicates a significant concentration of cases in some areas, which means that dengue cases are not evenly distributed throughout the city. A significant value ($p\text{-value} < 0.01$) supports these findings, indicating that the distribution pattern of dengue cases in clusters does not occur randomly. Because ANN does not assess the determinants of clustering, this study could not identify the factors responsible for this pattern. Previous studies suggest that environmental factors such as sanitary conditions, the presence of puddles that breed *Aedes aegypti* mosquitoes, and community behavior in terms of mosquito bite prevention may play a role in the distribution of dengue cases.²⁸ In addition, access to health services can also affect the distribution of cases; areas with less access to health services

may have slower detection and handling. Understanding these factors is essential for designing effective and location-based interventions to control and prevent the spread of dengue more efficiently in Metro Cities.^{29,30}

CONCLUSIONS AND RECOMMENDATIONS

The conclusion of the data that has been presented shows that the spread of Dengue Hemorrhagic Fever (DHF) cases in Metro City has complex and clustered characteristics. A low and significant Nearest Neighbor Ratio (NNR) value ($p\text{-value} < 0.01$) indicates that dengue cases are not scattered randomly but are concentrated in certain areas. This is supported by data that shows that there are several villages with a very high incidence rate (IR) of dengue, such as Summersari Bantul, Margorejo, Tejoagung, Yosomulyo, Karang Rejo, and Purwosari. This clustered pattern warrants further investigation of environmental (e.g., sanitary conditions and standing water), behavioral, and health service-related factors that may contribute to the concentration of cases.

The analysis of the distribution of cases by age group and gender also provides important insights. Most DHF cases occurred in the 6–59-year age group (83.1%); however, because age-specific incidence rates were not calculated, these proportions do not indicate differences in risk between age groups. Of the reported cases, 45.2% were male and 54.8% female; this distribution describes the reported cases only and does not indicate a difference in susceptibility between the sexes. Thus, to control and prevent the spread of dengue in Metro City, comprehensive interventions are needed, including sanitation improvements, public education on dengue prevention, and increased access to health services in areas with a high incidence of dengue.

ACKNOWLEDGEMENT

Thank you to the University of Lampung for providing grant support. I would also like to express my thanks to the Health Service for granting permission for the research location. Thank you to the University of Lampung for providing grant support. I would also like to express my thanks to the Health Service for granting permission for the research location.

REFERENCES

1. Bhatt S, Gething PW, Brady OJ, et al. The global distribution and burden of dengue. *Nature*. 2013;496(7446). doi:10.1038/nature12060
2. World Health Organization. Dengue : global situation, surveillance and progress – 2024 update. *Weekly Epidemiological Report*. 2025;100(52).
3. Kementerian Kesehatan RI. Waspada Penyakit di Musim Hujan. *Kementerian Kesehatan RI*. Preprint posted online 2024.
4. Tommy Saputra. *Kasus DBD Di Lampung Meningkat, 31 Orang Dilaporkan Meninggal Dunia*. 2025.

5. Dinas kesehatan Kota Metro. *Profil Kesehatan Kota Metro*. Vol 1. 1st ed. Dinas Kesehatan Kota Metro; 2023.
6. Stoddard ST, Forshey BM, Morrison AC, et al. House-to-house human movement drives dengue virus transmission. *Proc Natl Acad Sci U S A*. 2013;110(3). doi:10.1073/pnas.1213349110
7. Louis VR, Phalkey R, Horstick O, et al. Modeling tools for dengue risk mapping - a systematic review. *Int J Health Geogr*. 2014;13(1). doi:10.1186/1476-072X-13-50
8. Ridho Fariz T. Pemodelan Spasial Kerawanan Penyakit Demam Berdarah Dengue (DBD) Menggunakan Logika Fuzzy di Kabupaten Kudus. *Jurnal Geografi*. 2017;14(1). <http://journal.unnes.ac.id/sju/index.php/ujet>
9. Husen OO, Tamburaka E, Hasddin H, Handa I. Tingkat Kerawanan Bencana Biologis Demam Berdarah Dengue (DBD); Studi di Kecamatan Rumbia dan Rumbia Tengah, Kabupaten Bombana. *Sang Pencerah: Jurnal Ilmiah Universitas Muhammadiyah Buton*. 2021;7(3):425-434. doi:10.35326/pencerah.v7i3.1330
10. Vernando Y, Andreswari D. Implementasi Sistem Inferensi Fuzzy Dalam Menentukan Tingkat Kerawanan Penyakit Demam Berdarah Dengue (DBD) dengan Menggunakan Metode Mamdani (Studi Kasus: Kota Bengkulu). *Jurnal Rekursif*. 2018;6(2):91-99. <http://ejournal.unib.ac.id/index.php/rekursif/>
11. Clark PJ, Evans FC. Distance to Nearest Neighbor as a Measure of Spatial Relationships in Populations. *Ecology*. 1954;35(4). doi:10.2307/1931034
12. Astuti SD, Rejeki DSS, Nurhayati S. Analisis Autokorelasi Spasial Kejadian Demam Berdarah Dengue (DBD) di Kabupaten Klaten Tahun 2020. *Jurnal Vektor Penyakit*. 2022;16(1). doi:10.22435/vektorp.v16i1.5817
13. Rau MJ, Nurhayati S. Faktor yang Berhubungan dengan Keberadaan Jentik Nyamuk Aedes Aegypti di Wilayah Kerja Puskesmas Sangurara (Cross Sectional Study di Sulawesi Tengah, Kota Palu). *Media Publikasi Promosi Kesehatan Indonesia (MPPKI)*. 2021;4(2). doi:10.56338/mppki.v4i2.1498
14. Nurhayati N, Pangestu DN, Lahada G. Penerapan Promosi Kesehatan Tentang Protokol Kesehatan Pada saat Pandemi Covid – 19 Dan Lingkungan Sehat Pada Lansia. *JOURNAL OF Public Health Concerns*. 2021;1(4). doi:10.56922/phc.v1i4.153
15. Antarsih NR, Suwarni S. Faktor Risiko Kurang Energi Kronik pada Ibu Hamil di Wilayah Kecamatan Bumi Agung Way Kanan Lampung. *Muhammadiyah Journal of Midwifery*. 2023;4(1). doi:10.24853/myjm.4.1.26-33

16. 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 Res Notes*. 2019;12(1). doi:10.1186/s13104-019-4379-9
17. Metro City Statistics Agency. *Metro City in Figures 2024*. 2024.
18. Bagian Hukum Pemda Kot Metro. *Perda Kota Metro No 5 Tahun 2022 Tentang Rencana Tata Ruang Wilayah Kota Tahun 2022-2041*. 2022.
19. Mahfud R, Basuki B, Savitri S. Pengaruh Ekstrak Tumbuhan *Melastoma malabathricum* sebagai Larvasida Nabati terhadap Mortalitas *Aedes aegypti* L. *BiosciED: Journal of Biological Science and Education*. 2021;2(1). doi:10.37304/bed.v2i1.2839
20. Harapan H, Ryan M, Yohan B, et al. Covid-19 and dengue: Double punches for dengue-endemic countries in Asia. *Rev Med Virol*. 2021;31(2). doi:10.1002/rmv.2161
21. Sutriyawan A, Wirawati K, Suherdin S. Kejadian Demam Berdarah Dengue dan Hubungannya dengan Perilaku 3M Plus: Studi Kasus Kontrol. *Promotif: Jurnal Kesehatan Masyarakat*. 2021;11(2). doi:10.56338/pjkm.v11i2.2024
22. Kusuma MDS, Ayu Yulianti Darmini AA. Gejala Depresi pada Lanjut Usia di Masa Pandemi Covid-19. *Jurnal Ilmiah Kesehatan Sandi Husada*. Published online 2022. doi:10.35816/jiskh.v11i2.817
23. Bancroft D, Power GM, Jones RT, et al. Vector control strategies in Brazil: A qualitative investigation into community knowledge, attitudes and perceptions following the 2015-2016 Zika virus epidemic. *BMJ Open*. 2022;12(1). doi:10.1136/bmjopen-2021-050991
24. Anker M, Arima Y. Male-female differences in the number of reported incident dengue fever cases in six Asian countries. *Western Pacific Surveillance and Response Journal*. 2011;2(2):17-23. doi:10.5365/WPSAR.2011.2.1.002
25. Qu Y, Shi X, Wang Y, Li R, Lu L, Liu Q. Effects of socio-economic and environmental factors on the spatial heterogeneity of dengue fever investigated at a fine scale. *Geospat Health*. 2018;13(2). doi:10.4081/gh.2018.682
26. Iryanti MP, Raharjo M, Martini M, Wahyuningsih NE. Analisis Spasial Kejadian DBD Dengan Faktor Lingkungan Di Wilayah Kerja Puskesmas Sei Panas Kota Batam. *Jurnal Kesehatan Lingkungan Indonesia*. 2024;23(1). doi:10.14710/jkli.23.1.93-100
27. Anker M, Arima Y. Male-female differences in the number of reported incident dengue fever cases in six Asian countries. *Western Pacific Surveillance and Response*. 2011;2(2). doi:10.5365/wpsar.2011.2.1.002

28. Wijayanti SPM, Porphyre T, Chase-Topping M, et al. The Importance of Socio-Economic Versus Environmental Risk Factors for Reported Dengue Cases in Java, Indonesia. *PLoS Negl Trop Dis*. 2016;10(9). doi:10.1371/journal.pntd.0004964
29. Hayee S, Rehman A. Dengue Fever: A Continuous Threat. *Pakistan BioMedical Journal*. 2019;2(1). doi:10.52229/pbmj.v2i1.25
30. Charlesworth SM, Kligerman DC, Blackett M, Warwick F. The Potential to Address Disease Vectors in Favelas in Brazil Using Sustainable Drainage Systems: Zika, Drainage and Greywater Management. *Int J Environ Res Public Health*. 2022;19(5). doi:10.3390/ijerph19052860