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Article

Spatial Analysis of Nearest Neighbors in Dengue Disease in Metro City

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A B S T R A C T

Dengue Hemorrhagic Fever (DHF) poses a significant public health challenge in Metro City, Lampung Province, characterized by fluctuating case numbers. This study aims to analyze the spatial patterns of DHF using Geographic Information System (GIS) techniques and identify associated risk factors. Data were collected from DHF patients recorded between January and April 2024, revealing geographic variations in case distributions, with Iring Mulyo village reporting the highest incidence. The analysis indicates that most cases occur in individuals aged 6-59, although children aged 1-5 are notably at higher risk. Additionally, the distribution of cases shows a higher prevalence among females, likely due to environmental and behavioural factors. Vulnerability mapping highlights areas with elevated risk, particularly in densely populated regions. The findings underscore the necessity for targeted interventions, including community empowerment and vector control efforts. Recommendations are made for health authorities to employ data-driven strategies tailored to each area's unique demographic and environmental contexts. This study emphasizes the importance of continuous monitoring and adaptive strategy to control and prevent DHF effectively across different population segments.

I. INTRODUCTION

Dengue Hemorrhagic Fever (DHF) is a disease caused by the dengue virus and transmitted through the bites of the Aedes Aegypti and Aedes Albopictus mosquitoes (Widodo et al., 2020). This disease has become a severe public health problem in many tropical countries, including Indonesia. Metro City, located in Lampung Province, is one of the dengue-endemic areas. Data shows that the number of dengue cases in

Metro City has fluctuated significantly recently. In 2018, the number of dengue cases was recorded at 59 cases, increasing to 192 cases in 2019 and then decreasing to 148 cases in 2020 and 138 cases in 2021. However, in 2022, the number of cases again reduced to 88. Despite the decline, this figure still shows that dengue is a health threat that must be dealt with seriously (Metro City Health Office, 2023).

The Incidence Rate (IR) of dengue in Metro City also shows a striking variation. In 2018, IR was recorded at 35.7 per 100,000 population, increased to 114.7 per 100,000 in 2019, and then decreased to 51.4 per 100,000 in 2022. This decrease in IR shows the government and health agencies' efforts to control the spread of the disease. However, the Case Fatality Rate (CFR), which shows the death rate due to dengue, must also be considered. CFR in Metro City decreased from 80.2% in 2021 to 51.4% in 2022, reflecting improved handling of dengue cases (Metro City Health Office, 2023).

The importance of mapping areas prone to dengue fever is very crucial in efforts to prevent and control this disease (Yasin & Saputra, 2013). Mapping using the Geographic Information System (GIS) and remote sensing data can provide a clearer picture of the distribution of dengue cases in an area (Widodo et al., 2020). GIS has advantages in mapping compared to manual methods, as it can perform more complex analyses, such as overlay and scoring analyses, to determine the level of vulnerability of an area to dengue (Husen et al., 2021). Using GIS, governments can identify high-risk areas and plan more effective interventions (Lessy et al., 2018)

One of the challenges in regional planning and development is the existence of disasters, including disease outbreaks. Therefore, it is essential to integrate disaster mitigation policies into dengue control efforts. Research by Nugraha (2021) shows that non-natural disasters, such as dengue outbreaks, require special attention from local governments to reduce the impact. Appropriate mitigation can help reduce the risk of occurrence of Extraordinary Events (KLB) caused by dengue (Nugraha et al., 2021)

In this context, this study aims to analyze the spatial pattern of dengue in Metro City using the nearest-neighbour approach. By utilizing geographic data and satellite imagery, this study will produce a map of dengue vulnerability that can be used in health service units' decision-making. This mapping is expected to provide helpful information for dengue control and prevention programs in Metro City.

In addition, this study will utilize information from the Metro City Health Office's dengue control and prevention program. By combining epidemiological and geospatial data, it is hoped that this study can provide a more comprehensive picture of the factors that affect the spread of dengue in Metro City. The results of this study are expected to provide concrete recommendations for the government and health agencies to control and prevent the spread of dengue in the region.

II. METHODS

This research was carried out in the work area of the Metro City Health Office, Lampung Province, from April to September 2024. Using a quantitative approach based on the Geospatial Information System (GIS), this study aims to understand the distribution and risk factors of Dengue Hemorrhagic Fever (DHF) in the area. The research subjects consisted of all dengue patients recorded from January to April 2024, domiciled in Metro City and surrounding villages.

Primary data was collected through direct observation at the patient's residence and assessment of environmental risk factors using a checkpoint sheet. A team of trained enumerators is responsible for filling out checkpoint sheets, determining location coordinate points, and observing risk factors around the sufferer. The data collection process is carried out systematically to ensure the accuracy and reliability of the information obtained.

After data collection, the processing stages include checking, clearing, entry, and coding. The analysis was carried out using GIS, while the interpretation of the research results was based on the latest literature from the last five years. It is hoped that the results of this study can provide an in-depth understanding of the risk factors for dengue fever in Metro City and practical recommendations for disease prevention and control efforts in the region.

III. RESULT

Metro City is one of the cities in Lampung Province, about 52 km from Bandar Lampung City. It 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 Regional Spatial Plan for 2022 – 2041).

Metro City health service facilities totalling 249 facilities consisting of hospitals, namely general hospitals and exceptional hospitals; Health Centres and their network consists of the leading health centre, auxiliary health centre and mobile health centre, 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. From 2000 to 2022, the number of health centres (including treatment centres) in Metro City 2000 was 11 units, and the Sumbersari Bantul treatment centre was upgraded to a Type D Hospital.

In 2022, the ratio of health centres to 20,000 residents was 1.30, meaning that, on average, 1 to 2 health centre units served every 20,000 residents. This ratio meets the health centre's working area concept, with an average of 1 health centre 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. 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 dropped to 87.3 per 100,000 population; in 2021, it dropped to 80.2 per 100,000 population, and in 2022 it fell to 51.40 per 100,000 population. The incidence rate of dengue in 2022 decreased from 2021, which decreased by 50 cases. The Case Fatality Rate (CFR) is an indicator of the malignancy of a disease and assesses the quality of prevention and treatment. Metro City's CFR decreased in 2021, namely 80.2%, to 51.40% in 2022. The number of villages affected by dengue from 2018 to 2022 is spread across 22 villages out of 5 sub-districts in Metro City. In 2022, the sub-district with the most dengue cases is East Metro District, with 27 cases, and the sub-district with the smallest number of cases is West Metro District, with 10 cases (Antarsih & Suwarni, 2023; Rau & Nurhayati, 2020, 2021). Analysis of Dengue Hemorrhagic Fever (DHF) vulnerability maps and demographic risk factors in Metro City, as well as providing recommendations for preventing and controlling dengue fever. An overview of the distribution of Dengue Hemorrhagic Fever (DHF) in Figure 1.

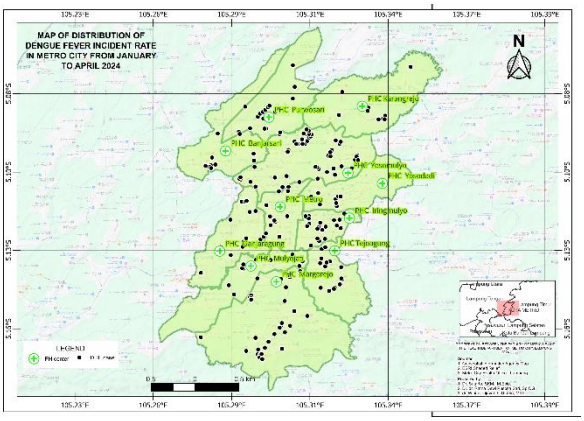

Fig. 1 Distribution of Dengue Hemorrhagic Fever (DHF) in Metro City for the period January to April 2024

Based on the data shown in Figure 1, the distribution of Dengue Hemorrhagic Fever (DHF) cases in Metro City during the period from January to April 2024 shows significant variations between urban villages. Iring Mulyo Village recorded the highest number of cases, with 27 individuals (10.9%), followed by Yosomulyo with 25 individuals (10.1%). On the other hand, Mulyosari Village recorded the lowest number of cases with only 1 individual (0.4%). This variation in distribution shows the existence of factors that affect the vulnerability of each village to the spread of dengue, such as population density, environmental conditions, and the effectiveness of vector control programs implemented in each region (Aswi & Sukarna, 2022; Choiruni & Kusnanto, 2019).

The total number of cases recorded in Figure 1 is 248 individuals, with a varied distribution across villages. This uneven distribution indicates the need for a more focused approach to areas with high case numbers, such as Iring Mulyo and Yosomulyo, to improve the effectiveness of dengue control programs. Studies that use spatial approaches in epidemiological analysis, such as those conducted by Kadarsih (2017) and Khikmah (2018), have shown that spatial analysis can help identify high-risk areas and implement appropriate interventions. In addition, strategies involving community empowerment, sanitation improvement, and comprehensive vector control must be considered to reduce the incidence of dengue in vulnerable areas (Kadarsih & Caesar, 2017; Khikmah & Pawenang, 2018)

Table 1 below presents data on the distribution of dengue disease incidence based on risk level by age group. The data shows the number of individuals suffering from dengue in each age group and the percentage and valid percentage of the total incidence of dengue in Metro City. This analysis helps understand the proportion and distribution of risks in the incidence of dengue disease studied (Fadlirahman et al., 2022)

Table 1 Distribution of Dengue Patients Based on Age Groups from January to April 2025 in Metro City

Age Groups at Risk	Frequency	Per cent	Valid Percent
Age 1-5 years (high risk)	22	8,9	8,9
Age 60-100 years old (Medium Risk)	20	8,1	8,1
Unisa 6-59 years old (Low Risk)	206	83,1	83,1
Total	248	100,0	100,0

Based on Table 1, most Dengue Hemorrhagic Fever (DHF) cases in Metro City from January to April 2025 occurred in the age group of 6-59 years with a frequency of 206 individuals or 83.1% of the total cases. Although this group is classified as low-risk, a significant number of cases in this age group indicates the presence of other factors that affect vulnerability to dengue, such as high mobility, wider environmental exposure, and more intense outdoor activities than other age groups. Research conducted by Widiarti et al. (2017) in Semarang City shows that in addition to age factors, environmental conditions such as rainfall and population density also play an essential role in the spread of dengue (Darmastuti et al., 2021).

Meanwhile, the age group of 1-5 years with a high risk recorded a case frequency of 22 individuals or 8.9%. This is consistent with the findings of Hisyam (2024), which highlights that children in this age group are more susceptible to dengue fever because their immune systems are not fully developed and are more often in the house; there is the potential for waterlogging as a breeding ground for Aedes aegypti mosquitoes (Hisyam Ar Rafi et al., 2024). The age group of 60-100 years, which has a moderate risk, recorded a case frequency of 20 individuals or 8.1%. Based on a study by Yasin and Saputra (2020), the elderly group is also susceptible to dengue fever due to decreased immune function and health conditions that are generally more vulnerable (Yasin & Saputra, 2013). This distribution shows that dengue prevention and control efforts need to be focused on all age groups, although the strategies applied may differ according to the level of risk owned by each age group (Retroningrum et al., 2024).

Furthermore, 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 helps understand the proportion of men and women in the dengue T-shirts studied and provides a preliminary overview of the demographic composition of the dengue cases taken.

Table 2 Distribution of Dengue Patients by Age Group for the period January to April 2025 in Table City.

Gender	Frequency	Per cent
Man	112	45,2
Woman	136	54,8
Total	248	100,0

Table 2 shows the distribution of dengue patients in Table City from January to April 2025 by gender. Of the 248 infected individuals, were 112 males (45.2%) and 136 females (54.8%). This percentage difference indicates that women are more dominant in dengue cases than men. Several national studies, such as those conducted by Hisyam (2024), show that these differences can be caused by biological and behavioural factors, where women are more often exposed to the home environment that is the primary habitat of the Aedes aegypti mosquito (Hisyam Ar Rafi et al., 2024).

Another study by Kurniawati (2015) also supports these findings, showing that socio-economic factors and gender roles in the household affect women's vulnerability to dengue (Kurniawati, 2015). Women often spend more time indoors and engage in domestic activities that increase the risk of contact with mosquitoes. Meanwhile, research by Faizah (2022) found that although the difference in incidence between men and women was insignificant, this variation could impact the planning of more gender-specific interventions (Faizah & Hariri, 2022).

Although the data show a relative balance between male and female sufferers, it is essential to emphasize that further analysis is needed to understand the factors that influence these differences. Maydianasari (2021) suggested the importance of a gender-based approach in dengue prevention programs, considering the different roles and responsibilities of men and women in society (Maydianasari & Ratnaningsih, 2021). In addition, a Symond (2020) study shows that understanding the distribution of cases by gender can help develop more effective health communication strategies that are responsive to the specific needs of specific gender groups (Symond et al., 2020)

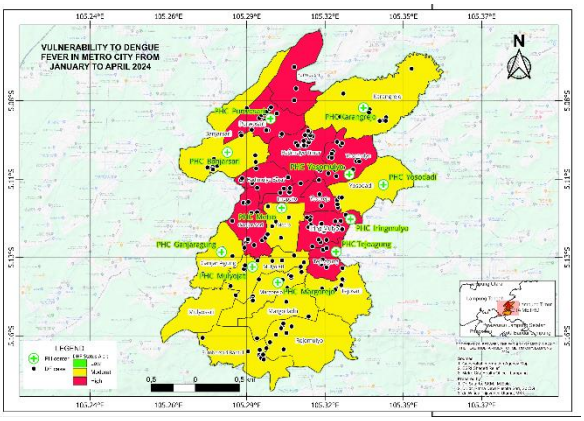

Fig. 2 Metro City Dengue Vulnerability Map in 2024

Figure 2 shows the formation of clusters of dengue-prone areas with high categories in Metro City, especially in adjacent villages such as Purwosari, Purwoasri, East Hadimulyo, and West Hadimulyo. This cluster analysis aligns with research published in the Journal of Public Health, which identified that population density, environmental conditions, and climate change are the main factors driving the increased risk of dengue (Atta-Ur-Rahman et al., 2022). The Journal of Environmental Health study also emphasizes the importance of risk mapping in directing more effective public health interventions (Irfan Rizki et al., 2022).

Other research supports using spatial analysis to identify high-risk areas that require immediate intervention (Hidayati et al., 2023). In this context, spatial data allows for more efficient resource allocation, such as implementing fogging programs and community education in high-vulnerability areas. By using this approach, preventive measures can be more focused and effective in reducing dengue cases in Metro City, ensuring that prevention and control efforts can be tailored to the specific needs of each region.

IV. DISCUSSION

Dengue Hemorrhagic Fever (DHF) continues to be a significant public health challenge in Metro City, Lampung Province. The fluctuations in dengue cases from 2018 to 2022, with a marked increase in 2019 followed by a decrease, highlight the dynamic nature of dengue epidemiology (Zhao et al., 2023). Despite a decrease in total cases, the persistent threat of dengue indicates the ongoing need for effective vector control and community awareness campaigns to mitigate the disease (Hill & O'Donnell, 2023).

The presence of health service facilities in Metro City is relatively adequate, with a ratio of 1.30 Health Centres per 20,000 residents in 2022. This aligns with health standards but underscores the importance of improving health service functionality to handle outbreaks (Amin et al., 2019). As the study shows, the increase in Health Centres from 11 in 2000 to 249 facilitates greater access to care and prevention efforts. However, continued enhancements in service delivery, particularly related to infectious disease management, are crucial.

The geographic distribution of dengue cases from January to April 2024 reveals that areas like Iring Mulyo and Yosomulyo require focused intervention strategies. The significant variations in case prevalence among villages suggest that population density, environmental conditions, and vector control effectiveness play critical roles in dengue transmission dynamics (Zhao et al., 2023). This indicates the need for strategies that address local risk factors, such as improved sanitation and better vector management, as demonstrated in previous studies which link community participation to successful control measures (Wong et al., 2023).

Table 1's distribution of DHF cases among age groups shows that most cases occur in individuals aged 6-59 years, a finding consistent with earlier studies indicating increased vulnerability due to social behaviors such as outdoor activities (Morisot et al., 2018). The significant number of cases in younger children (1-5 years) emphasizes the susceptibility of this demographic due to their developing immune systems and frequent indoor exposure to mosquito breeding sites (Rodríguez et al., 2011). Therefore, interventions should target both younger children and the adult population, considering their mobility patterns and exposure risks.

The gender distribution of dengue cases indicates higher prevalence among women,

which aligns with findings that suggest environmental and behavioral exposures are influential (Eleftheriou et al., 2021). Women's roles often place them in environments where they are more susceptible to mosquito bites, suggesting that public health campaigns should be tailored to address these gender-specific risks (Taylor & Glowacki, 2023). Understanding the socio-economic conditions that affect health outcomes can inform more effective prevention strategies (Wigham et al., 2023).

Figure 2 illustrates the clustering of dengue-prone areas and highlights the need for enhanced spatial analysis in public health planning. Identifying high-risk clusters supports prior findings suggesting an integrated approach combining environmental data, social determinants of health, and vector ecology to inform responsive health planning (Wilke et al., 2019). This spatial analysis enables better resource allocation for interventions such as targeted fogging and community education, which effectively reduce dengue transmission rates (Zeng et al., 2021).

Given these findings, the study underscores the critical role of comprehensive data-driven interventions in managing DHF in Metro City. Continual assessment of risk factors and health service sufficiency will bolster public health responses, aligning with the recommendations from the World Health Organization (WHO) for integrated vector management.

V. CONCLUSION

Dengue Hemorrhagic Fever (DHF) presents a persistent public health challenge in Metro City despite a recent decrease in incidence rates. The fluctuations in dengue cases from 2018 to 2022 illustrate the need for ongoing vigilance and innovative strategies for disease management. The significant geographic variations in case distribution necessitate targeted interventions tailored to high-risk areas, such as Iring Mulyo and Yosomulyo, where population density and environmental conditions exacerbate the spread of the virus. Public health authorities need to implement comprehensive vector control measures and enhance community awareness programs to mitigate risks associated with dengue transmission effectively.

Furthermore, the demographic analysis indicated a higher susceptibility to DHF among women and individuals aged 6-59 years, emphasizing the need for gender-sensitive and age-specific prevention strategies. The data-driven approach showcased in this study highlights the importance of ongoing spatial analysis and resource allocation to respond adequately to outbreaks. Sustainable interventions focused on improving sanitation, community engagement, and health service functionality will be crucial in controlling DHF in Metro City. By continually assessing and adapting strategies based on epidemiological data, local health authorities can enhance their preparedness and response capabilities to combat dengue and protect public health effectively.

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