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Spatial Analysis and Risk Factors of Regional Vulnerability to Dengue Fever Incidence in Semarang City 2018-2020

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ABSTRACT

The high number of dengue hemorrhagic fever cases in Semarang City from year to year without being able to know the main cause and from a fairly high level of rainfall, the dominant case attacks men, affects the ages of children to adolescents, and the level of diverse population density is quite several variables according to the data studied. The purpose of this study was to determine the vulnerability of each sub-district area to dengue hemorrhagic fever in the Semarang city. This study used an descriptive method with a Cross Sectional approach. The research data uses secondary data which is then processed and analyzed with the QGIS application and uses statistical tests to determine the strength of the relationship. The results showed that there was no relationship between population density, gender, age and rainfall with cases of dengue hemorrhagic fever (P<0.070), it can be concluded that all districts in Semarang City are endemic areas that are vulnerable to dengue hemorrhagic fever events. For the people of Semarang City, they should pay more attention to personal health and environmental health by implementing 3M plus, in order to avoid dengue hemorrhagic fever.

Keywords: Population density, gender, age, rainfall

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INTRODUCTION

Dengue Hemorrhagic Fever (DHF) occurs when the dengue virus causes significant bleeding and dehydration. This disease, transmitted by *Aedes* mosquitoes, is the fastest-growing insect-borne illness, affecting nearly 390 million people worldwide each year, making it the most common mosquito-borne disease. The dengue virus can also be transmitted by several species of mosquitoes. Similar to Dengue Fever, DHF can cause symptoms such as persistent abdominal pain, bleeding from the respiratory tract or mouth, bleeding gums, or bruising. Dengue fever is primarily transmitted through mosquito bites.(1)

Dengue Hemorrhagic Fever cases spread and are transmitted through a chain of infection influenced by environmental factors. The presence of mosquitoes in an area can either facilitate or inhibit dengue virus epidemics. Diseases like dengue fever are transmitted through various factors, including physical factors such as housing density, the presence or absence of potted plants or containers in yards; biological factors such as ornamental plants or gardens; social factors like population mobility and density; and biological factors such as the presence of mosquito larvae (PSN).[(2)]

Spatial analysis is part of area-based disease management, involving the analysis and description of disease data geographically in relation to population. Geographic Information Systems (GIS) with spatial approaches and analysis are important tools because they can determine the frequency of dengue fever cases or mosquito larvae density related to dengue fever occurrences.[(3)]

Using GIS can produce additional information about spatial data sets, such as graphical information (mapping, charts), tabular information (tables), and text, all of which can be used to illustrate locations or areas on thematic maps. GIS has the ability to track dengue vectors, which can help identify regions highly vulnerable to the disease. With quality case record data, GIS can also be used to predict future dengue fever outbreaks.[(4)]

When discussing density, it refers to the number of people living in a certain area, for example, 100 people per hectare. A large population in an area can be used to determine whether the area is still suitable and comfortable for human habitation, allowing residents to carry out daily activities efficiently.[(5)]

Rainfall is the amount of rainwater falling in an area, regardless of timing. A rain gauge is an instrument used to measure the amount of rainfall. Rainfall is measured daily, monthly, and annually.[(6)]

In 2018, there were 103 dengue fever cases, a decrease from 299 cases in 2017. The number of recorded cases in 2018 was the lowest since 1994. However, dengue fever infections rose again to 440 cases in 2019 before declining to 320 cases in 2020. In 2020, male DHF patients numbered 182 (57% of total cases), while female patients were 138 (43%). The mortality rate from dengue fever in Semarang City decreased by four deaths in 2020, representing a 1.3% reduction in the case fatality rate (CFR).[(7)]

Children are one of the age groups vulnerable to dengue transmission. Dengue fever is most commonly contracted by school-aged children and young adults traveling in groups. Consequently, the most active biting times for *Aedes aegypti* mosquitoes are between 9:00–10:00 AM and 4:30–5:00 PM, coinciding with when children are at school.[(8)]

Furthermore, dengue fever cases mostly affect children aged 5–14 years, with 10 cases reported in the Mijen health center area, Mijen subdistrict, where these cases originated from the Semarang city population. In general, dengue fever cases more frequently affect individuals aged 20–24 years, with 40 cases reported. The incidence of dengue fever may be influenced by various factors, including population density and mobility, individual behavior and socioeconomic status, as well as geographic considerations.

Based on this data, the author aims to study and evaluate the incidence of dengue fever with several factors, one of which is population density in relation to community behavior towards the surrounding environment. Besides this factor, other factors such as rainfall may also play a role because high rainfall can

increase mosquito populations, which are the cause of dengue fever. Age and gender of patients may also influence susceptibility and infection due to their effects on immune system strength.

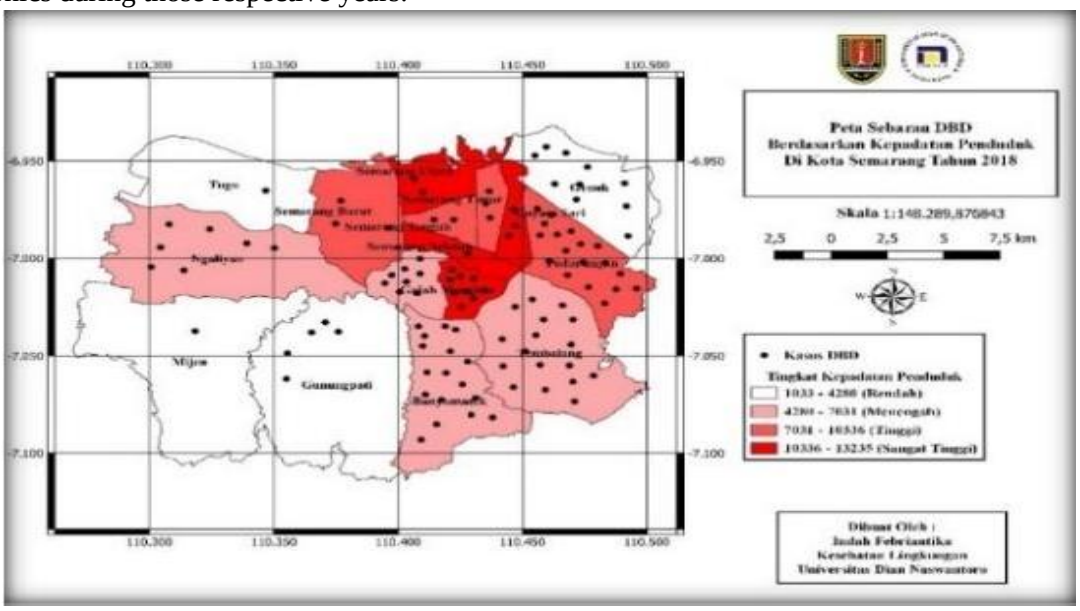
Given these background issues, it is necessary to conduct research on the vulnerability of certain areas to dengue fever outbreaks so that the community can be more alert to the disease and prevent mosquito proliferation.

METHOD

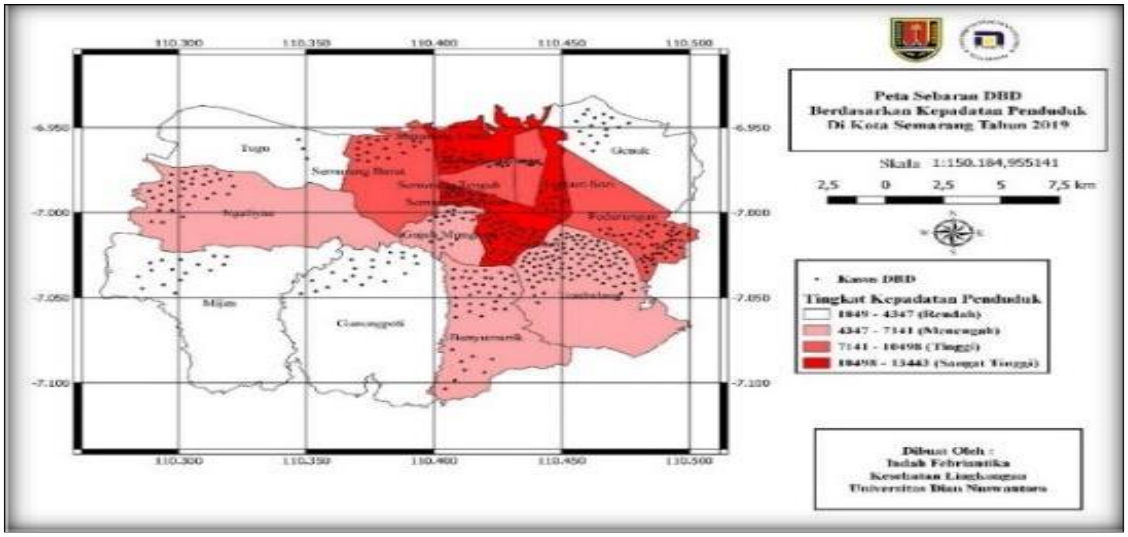
This study is descriptive with a cross-sectional approach, utilizing spatial analysis and bivariate analysis with four variables: population density, gender, age, and rainfall. Spatial analysis was used to map the vulnerability of areas to dengue fever incidence based on each variable from 2018 to 2020. Statistical tests were applied to analyze whether these variables age, gender, population density, and rainfall are related to dengue fever incidence. Secondary data were obtained from the Semarang City Health Office, the Semarang Central Statistics Agency, and the Meteorology, Climatology, and Geophysics Agency, Semarang Climatology Station.

RESULTS AND DISCUSSIONS

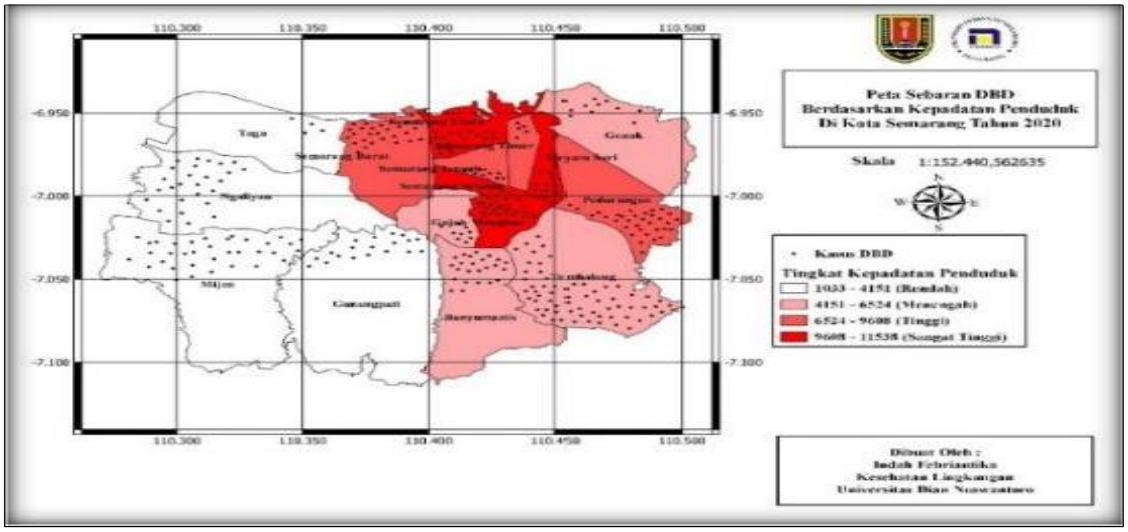
In 2018, a total of 103 dengue fever (DBD) cases were reported, followed by 440 cases in 2019 and 320 cases in 2020. The data below presents an overview of dengue fever incidence in relation to the population demographics during those respective years.



Picture 1 Dengue Fever Distribution Map Based on Population Density in 2018



Picture 2 Dengue Fever Distribution Map Based on Population Density in 2019



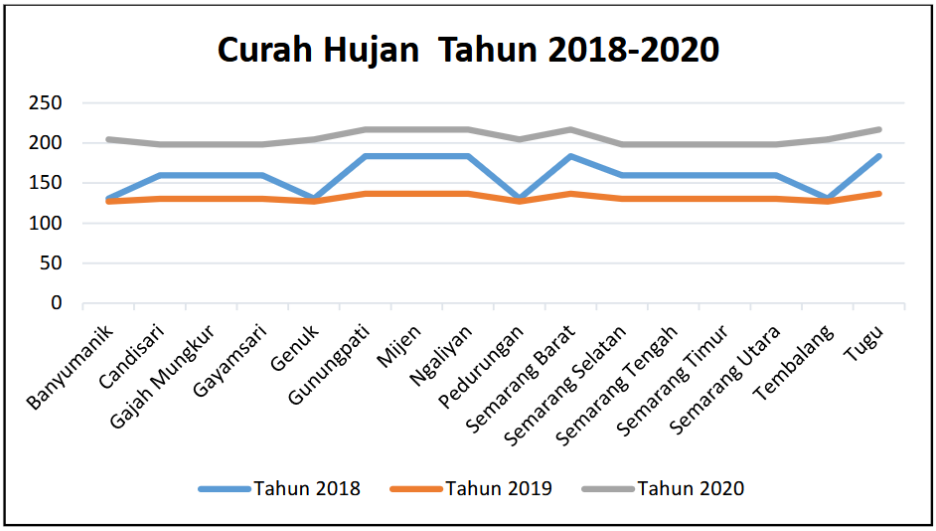
Picture 3 Dengue Fever Distribution Map Based on Population Density in 2020

Based on Figures 1, 2, and 3, the spatial distribution of dengue fever (DBD) cases in Semarang City indicates that while the overall pattern remained relatively consistent, the district with the highest number of cases changed over the years. In 2018, the highest incidence was reported in Pedurungan District, whereas the lowest number of cases occurred in Tugu District. By 2019, the highest number of cases had shifted to Tembalang District, a trend that continued in 2020, with Tugu District consistently recording the lowest number of cases across all three years.

This shift suggests a notable change in the area most affected by DBD, from Pedurungan in 2018 to Tembalang in 2019 and 2020. The maps illustrating this distribution were developed based on population density data for each year. In these visualizations, darker color gradients represent higher population densities. However, it is important to note that a higher population density does not necessarily correlate with a higher incidence of DBD cases.

Furthermore, age distribution analysis revealed that in 2018, the highest number of DBD cases occurred among children aged 5–11 years. In contrast, during 2019 and 2020, the majority of cases were found in the

12–25 age group, indicating a shift in the age demographic most affected by the disease. Meteorological data for the same period indicate that rainfall levels in Semarang City were classified as moderate, which may also contribute to the dynamics of disease transmission



Picture 4 Rainfall in Semarang City

Table 1 Correlation between variabels

Population density	Pearson Correlation	-.011
	Sig. (2-tailed)	.750
	N	863
Age	Pearson Correlation	.003
	Sig. (2-tailed)	.927
	N	863
Gender	Pearson Correlation	.050
	Sig. (2-tailed)	.143
	N	863
Rainfall	Pearson Correlation	.a
	Sig. (2-tailed)	.
	N	863

Based on the correlation analysis conducted, the population density variable showed a weak negative correlation with the incidence of dengue fever, with a correlation coefficient of -0.011. The gender variable had a correlation coefficient of 0.05, indicating a very weak positive correlation, while the age variable showed a correlation coefficient of 0.003, also indicating a negligible relationship. In contrast, rainfall was found to have no correlation with the incidence of dengue fever during the study period.

Disscussion

The findings of this study from 2018 to 2020 indicate that the correlation between population density and the incidence of dengue fever (DBD) is very weak and negative, with a correlation coefficient of -0.011, and P < r-table (-0.011 < 0.070). This result suggests that there is no significant relationship between population density and dengue incidence. In fact, areas with the highest number of DBD cases were not the ones with the highest population density; instead, the highest case numbers were observed in districts with low to medium population densities.

This finding aligns with the study by Budi Setiawan, who reported a p-value of 0.99 (>0.05) using a chi-square test, indicating no significant relationship between population density and DBD incidence. Furthermore, research by Widayanti Ratna Safitri also supports this result, suggesting that population density is a non-causative factor in certain zones due to the lack of proper case reporting and notification systems. She further argued that other contributing factors include migration rates, human activity, environmental sanitation, the presence of containers (breeding sites), vector gatherings, public knowledge, behavior, and the community's response to DBD.

Additionally, the study results from 2018–2020 show no significant relationship between DBD cases and gender, although a very weak positive correlation was observed (r = 0.050 < r-table 0.070). This indicates that DBD incidence is not strongly influenced by gender, as both males and females exhibited almost equal case numbers throughout the observed years, with fluctuations from year to year. However, males may be slightly more at risk due to their higher likelihood of engaging in outdoor activities and being exposed to mosquito habitats.

This finding is consistent with Ernyasih's research, which also found that gender does not significantly affect DBD incidence, as infection may result more from incidental exposure rather than biological differences. In contrast, Nur Arifatus Sholihah reported a correlation between gender and DBD, where females were 0.443 times less likely to contract DBD than males. This suggests that female gender acts as a protective factor, likely due to behavioral or environmental differences. Regarding age, this study also found no significant correlation with DBD incidence (r = 0.003 < 0.070), although a very weak positive correlation was observed. This indicates that no specific age group consistently dominated DBD cases across the three years. However, in 2018, the majority of DBD cases occurred in children aged 5–11 years, while in 2019 and 2020, the 12–25 age group had the highest case numbers. This could be attributed to increased outdoor activity among adolescents and young adults, leading to higher exposure to mosquito bites.

A study conducted at Tugurejo General Hospital in Semarang also found no significant relationship between age and DBD, emphasizing that the human immune system plays a significant role in resisting infection. Children under five are not necessarily more vulnerable, as the presence of a well-developed immune system can provide effective protection, and antibody levels alone are not the sole indicator of susceptibility.

With regard to rainfall, the study found that the relationship between rainfall and DBD cases could not be accurately assessed due to constant rainfall data across the study period. However, the analysis showed a

perfect correlation coefficient of 1.0, which simply reflects the total DBD cases (863 cases) across all years, and does not indicate a statistical relationship with rainfall levels.

This is consistent with findings by Gustina Fajarwati Sihombing, who reported a p-value of 0.92, indicating no significant association between rainfall levels and annual DBD incidence. The study concluded that variations in rainfall did not align with the rise or fall of DBD cases when analyzed yearly or monthly. Nevertheless, rainfall and temperature can still influence mosquito development and population growth, as higher rainfall may create more breeding sites. Yulia Iriani also stated that increased rainfall could potentially increase vector-borne diseases by expanding breeding grounds. However, this could also present an opportunity for implementing vector control strategies in these new breeding locations.

Therefore, the effects of rainfall on DBD prevalence remain an important area for further investigation, as a better understanding is required to explore the complex interactions between climate factors and vector-borne disease outbreaks.[15]

CONCLUSION

Based on bivariate analysis, there is no significant relationship between dengue hemorrhagic fever (DHF) cases and population density, with a negative or inverse correlation (P = -0.011), which is less than the r-table value (0.070). Similarly, there is no significant relationship between DHF cases and gender, although the correlation is positive or in the same direction (P = 0.050 < r-table 0.070). There is also no significant relationship between DHF cases and the age of patients, despite a positive or direct correlation (P = 0.003 < r-table 0.070).

Furthermore, no relationship was found between DHF cases and rainfall levels, as the results remained constant with P (α) < r-table (0.070). Based on spatial mapping, the entire city of Semarang is considered an endemic area, with the disease spreading evenly across all districts.

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