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Spatial Mapping of Dengue Fever Cases Using Quantum GIS in Kendari City Indonesia

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ABSTRACT

Introduction: The increasing number of Dengue Hemorrhagic Fever (DHF) cases in Kendari City indicates the need for more effective spatial data-based control efforts. This study aims to conduct Spatial Mapping of Dengue Fever Cases Using Quantum GIS in Kendari City, Indonesia.

Method: This type of research is descriptive quantitative with an observational approach. The study population includes all 15 Community Health Centers under the auspices of the Kendari City Health Office, with DHF case data for the 2022–2024 period obtained from the Kendari City Health Office. Data were analyzed using spatial methods with Quantum GIS software to display case distribution trends, case detection rates, and treatment outcomes.

Result: The results show that the trend of cases in Kendari City experienced a significant increase from 2022 to 2024, with the highest spike in 2024 of 1,689 cases. The community health centers with the highest number of cases were in Lepo-Lepo, Poasia, and Mokoau, while the lowest number of cases were in Mata and Nambo.

Conclusion: The distribution map shows that areas with high population density and poor sanitation conditions are at greater risk of dengue transmission. It is recommended that the Kendari City Health Office utilize the results of this mapping as a basis for determining priority intervention areas and improving the GIS-based surveillance system for sustainable dengue control.

Introduction

Dengue Hemorrhagic Fever (DHF) is an infectious disease transmitted by the Aedes aegypti mosquito through the virus it carries, namely the dengue virus, from sufferers to other people through their bites.[1] This virus reproduces in the salivary glands at the base of the mosquito's proboscis and thrives in human blood.[2]

Dengue Hemorrhagic Fever (DHF) is an endemic disease throughout tropical and some subtropical regions.[3] The disease transmitted by the Aedes aegypti mosquito is a frightening threat because it can spread quickly within an area.[4] Even in one month, the number of dengue fever

cases in endemic areas can reach tens of people infected with the dengue virus.[5]

Geographic Information System (GIS) is a system that can be used for data input, data storage and retrieval, processing, analyzing, and producing data or spatial information related to geographic data.[6] Mapping is done using a Geographic Information System (GIS), which is a computer-based system that can be used to enter data, process data, store, manipulate and analyze geographic information for various purposes.[7]

Quantum GIS is a free and open source GIS that is user friendly and runs on several operating systems such as Linux, Unix, Mac OS X, GIS software that is licensed under the General Public License is equipped with read-write functionality for raster, vector, and database formats.[8] GIS also supports plugins to perform special functions such as displaying the track results of GPS receiver observations.[9]

Kendari City is the region with the highest number of dengue fever cases in Southeast Sulawesi Province in 2024, based on the data, 3 dengue fever cases have become a very serious problem in Kendari City because the number of dengue fever cases has increased significantly. Based on the profile data from the Kendari City Health Office, there was a significant increase in dengue fever cases from 2023 to 2024. Dengue fever cases in 2023 with a population of 351,058,000 people and 253 dengue fever cases with a prevalence of 72/100,000 population and 5 deaths (CFR = 1.9%). Dengue fever cases in Kendari City are dominated by the 5–9-year age group and according to gender, dengue fever sufferers are dominated by men. Meanwhile, the incidence of dengue fever in 2024, with a population of 355,655,000, jumped to 1,689 cases, with a prevalence of 474 per 100,000 and 13 deaths (CFR = 0.76%). Dengue fever cases in Kendari City are predominantly in the age group > 19 years, and the gender is predominantly male.

A Geographic Information System (GIS) is a computer-based information system used to process and store geographic data or information. In general, GIS is defined as a component consisting of hardware, software, geographic data, and human resources that work together effectively to input, store, correct, update, manage, analyze, and display geographic-based information.

Based on the case data, GIS plays a crucial role in this case, as it can create maps of risk zones for endemic diseases. Research processed spatially using GIS can be utilized in the evaluation of service coverage and health institutions.[10] So that Community Health Centers and other health service institutions can make decisions more quickly in promotive and preventive actions.[11]

The aim of this study is to determine the mapping of dengue fever based on the working areas of health centers throughout Kendari City.

Method

This type of research is descriptive quantitative research using spatial analysis, conducted on May 23, 2025. The population in this study were all 15 Community Health Centers in the Kendari City Health Office. This study used total sampling where all data on DHF sufferers in all Kendari City Community Health Centers will be analyzed spatially. The data collection method is secondary data based on the number of DHF cases and DHF cases per community health center in 2022-2024, which are processed according to research variables using the Quantum GIS application to create digital maps.

Result

Figure 1 shows that the distribution of pulmonary dengue fever cases per 100,000 population in 2022-2024, there is 1 Community Health Center, namely Puuwatu, which is included in the fluctuating category of dengue fever cases (grey zone) and there are 6 Community Health Centers, namely Labibia, Kemaraya, Benua-benua, Mata, Nambo, and Abeli which are included in the moderately increasing category (Orange zone). The highest number of cases is in the Lepo-Lepo Community Health Center with 326 cases per 100,000 population and the lowest cases are in the Benua-benua and Mokoau Community Health Centers with 2 cases per 100,000 population.

Figure 2 shows that the distribution of pulmonary dengue fever cases per 100,000 population in 2022, there are 12 Community Health Centers namely Benu-Benua Community Health Center, Kandai Community Health Center, Wua-Wua Community Health Center, Lepo-Lepo, Poasia,

Mata, Mokoau, Jati Raya, Benua-Benua, Puuwatu, Mekar, Mekar, and Labibia which are included in the Low category of dengue fever cases (green zone) and there are 3 Community Health Centers namely Abeli, Kemaraya and Nambo Community Health Centers, and Abeli which are included in the No case category (grey zone). The highest number of cases is in Puuwatu Community Health Center with 56 cases per 100,000 population and the lowest case is in Mokoau Community Health Center with 2 cases per 100,000 population.

Figure 3 shows that the distribution of pulmonary dengue fever cases per 100,000 population in 2022, there are 14 Community Health Centers namely Kandai, Wua-Wua, Lepo-Lepo, Poasia, Mata, Mokoau, Jati Raya, Puuwatu, Mekar, Abeli, Kemaraya, Perumnas, Nambo and Labibia Health Centers which are included in the Low category of dengue fever cases (green zone) and there is 1 Community Health Center namely Benua-Benua, Kemaraya and Nambo Health Centers which are included in the No case category (grey zone). The highest number of cases is in Puuwatu Health Center with 56 cases per 100,000 population and the lowest case is in Mokoau Health Center with 2 cases per 100,000 population.

Figure 4 shows that the distribution of pulmonary dengue fever cases per 100,000 population in 2022, there are 6 Community Health Centers namely Labibia, Kemaraya, Kandai, Mata, Abeli, and Nambo which are included in the very Low category of dengue fever cases (green zone) and there are 2 Community Health Centers namely Lepo-Lepo and Poasia Community Health Centers which are included in the very High category (red zone). The highest number of cases is in Lepo-Lepo Community Health Center with 326 cases per 100,000 population and the lowest case is in Nambo Community Health Center with 21 cases per 100,000 population.

Figure 5 shows that the results of patient deaths in 2024, there are 3 Community Health Centers namely Lepo-lepo, Kemaraya and Wua-Wua Health Centers which are included in the very Low category of DHF cases (Pink zone) and there is 1 Community Health Center namely Poasia Health Center which is included in the very High category (red zone). The highest number of patients who died was in Poasia Health Center with 7 cases per 100,000 residents and the lowest cases were in Lepo-lepo, Kemaraya and Wua-wua Health Centers with 2 cases per 100,000 residents.

Figure 1. Map of Dengue Hemorrhagic Fever Cases Based in the Distribution Trend 2022-2024 Working Area of Kendari City

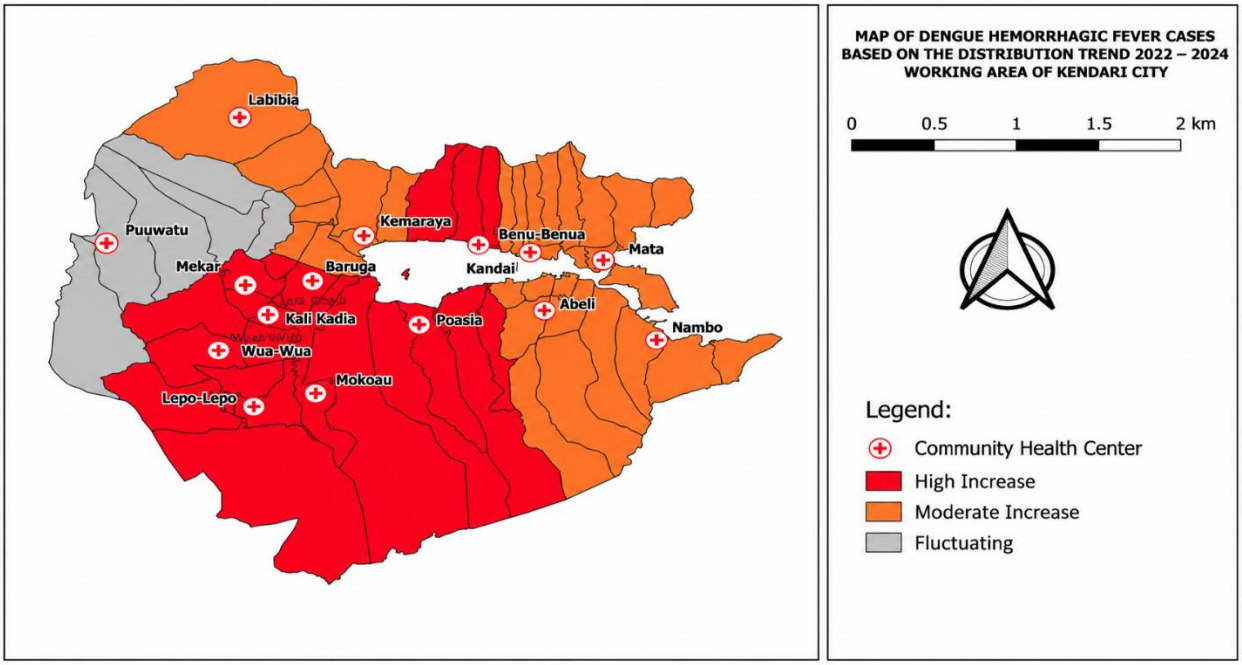


Figure 2. Number of Dengue Hemorhagic Fever Cases in 2022 Based on Case Finding Rate at Dengue Health Service Units in the Working Area of Community Health Centers in Kendari City

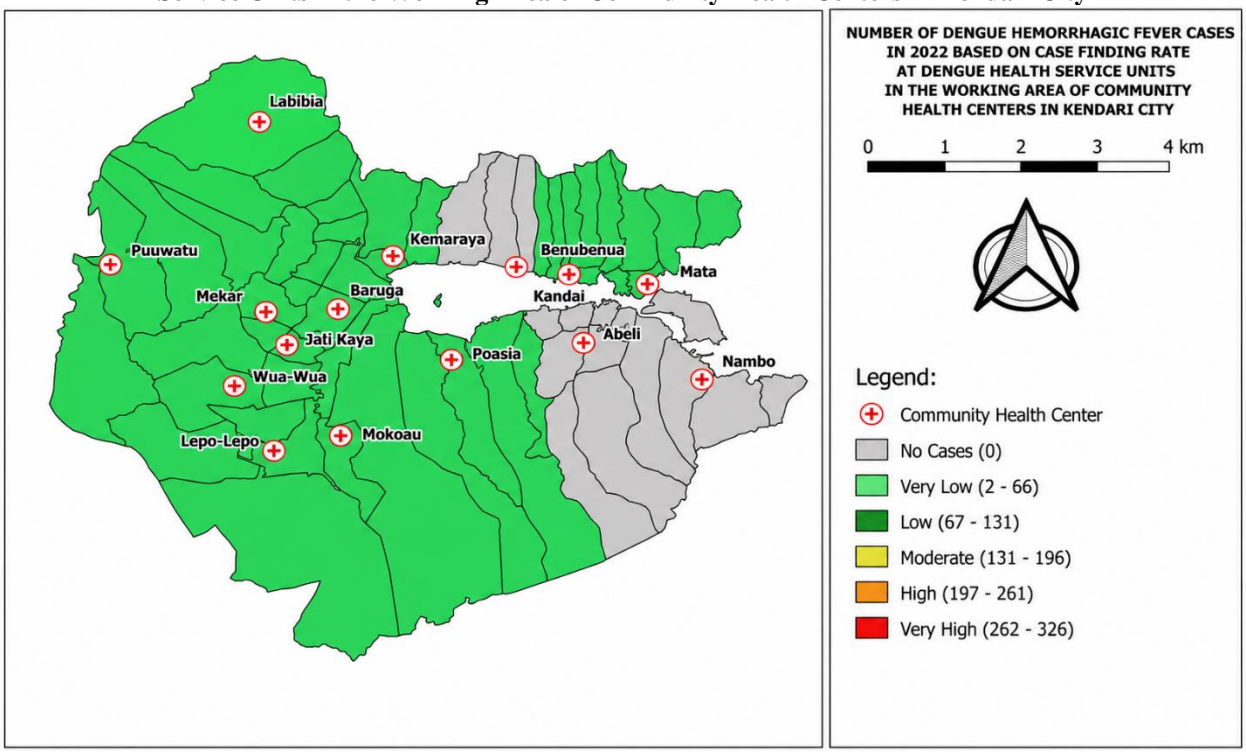


Figure 3. Number of Dengue Hemorhagic Fever Cases in 2023 Based on Case Finding Rate the Working Area of Community Health Centers in Kendari City

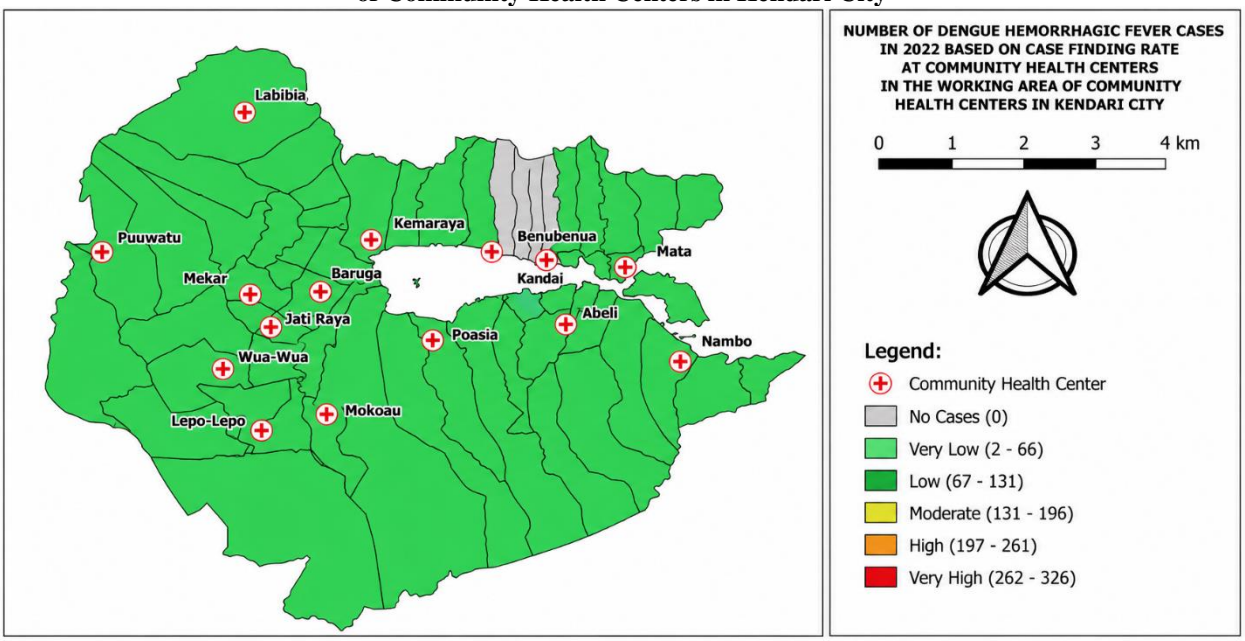


Figure 4. Number of Dengue Hemorhagic Fever Cases in 2024 Based on Case Finding Rate in the Woking Area of Community Health Centers in Kendari City

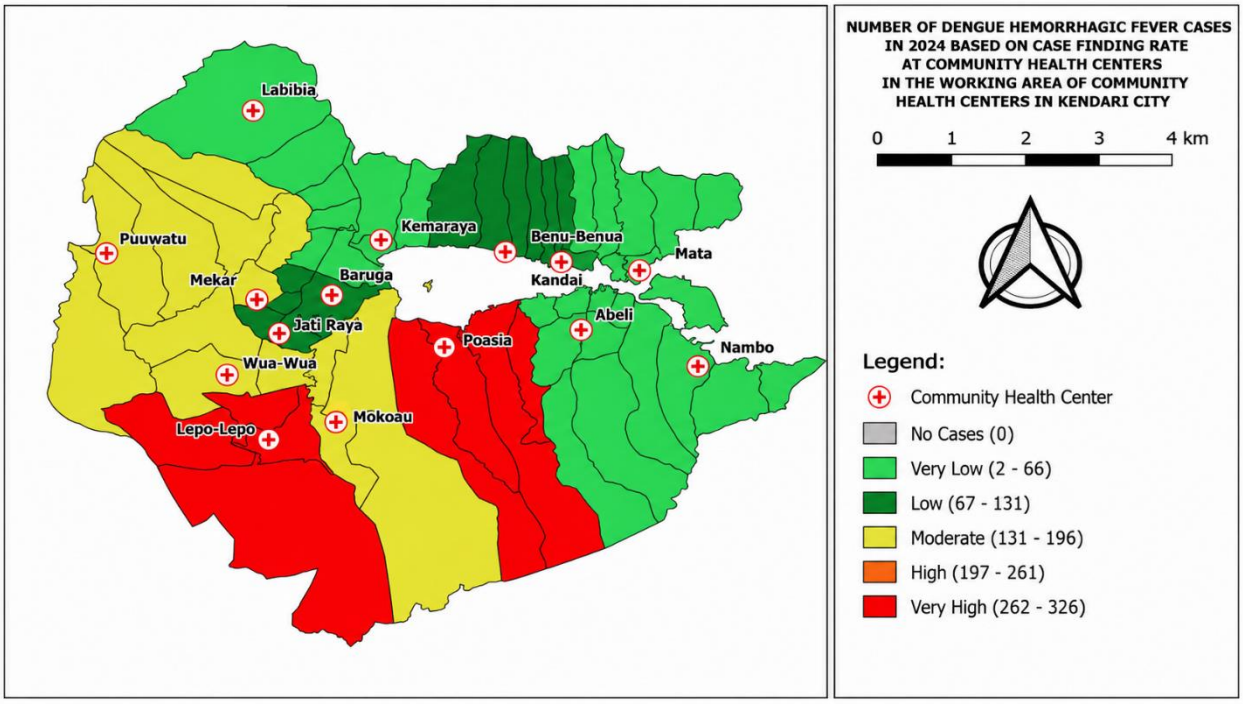
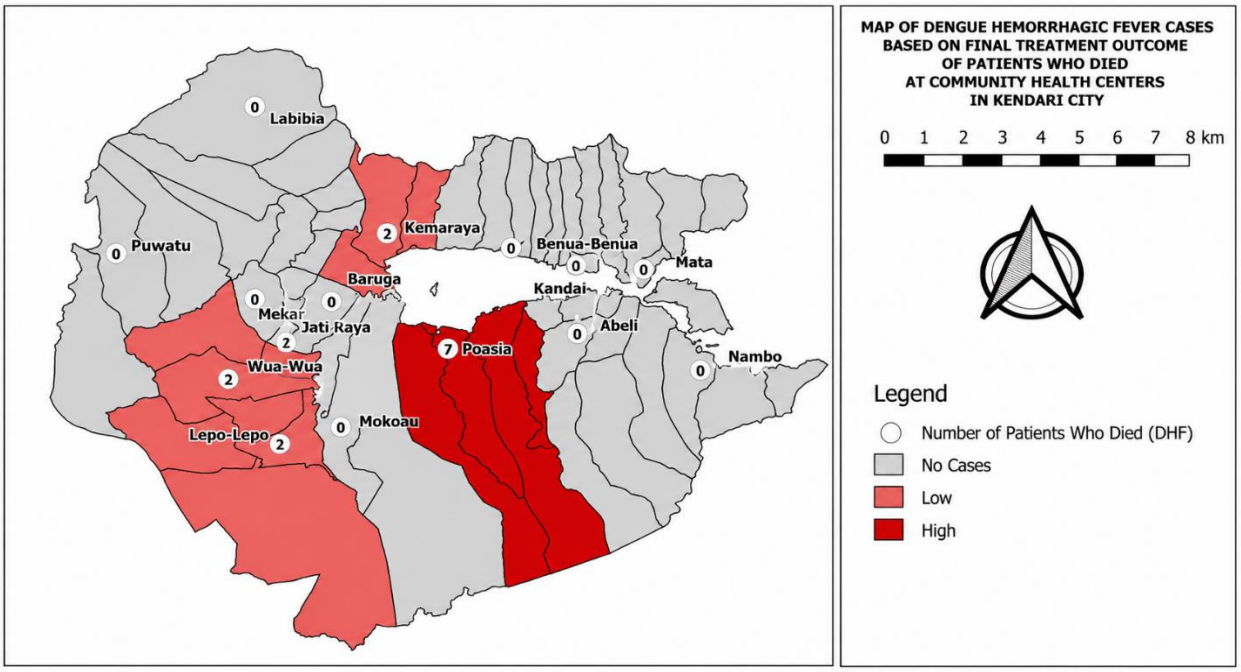


Figure 5. Map of Dengue Hemorrhagic Fever Cases Based on Final Treatment Outcome of Patients Who



Discussion

Trends in the Distribution of Dengue Fever Cases

Disease mapping is a strategic tool for developing more targeted interventions, as it can provide a visual representation of areas with high caseloads. With this information, governments and health agencies can create more evidence-based policies and design targeted prevention and control programs.[12]

Through spatial analysis, areas at high risk of dengue fever transmission can be identified early, allowing interventions to be focused on priority areas.[13] This supports the implementation of more efficient and sustainable dengue control strategies. Spatial data generated from dengue case mapping is also useful for measuring the impact and scope of existing prevention programs and serves as an evaluative indicator for future planning.[14] Thus, mapping dengue cases is an important component of a regional-based health information system that supports the achievement of national targets in reducing morbidity and mortality due to dengue fever.[15]

Based on spatial analysis of dengue fever distribution trends in several Kendari City Community Health Centers over the past three years, there are variations in the increasing trend of cases, classified into five categories: fluctuating (gray), decreasing (blue), slightly increasing (yellow), moderately increasing (orange), and sharply increasing (red). In 2022, most areas were in the low to moderate category. However, in 2023, there was an increase in the number of areas falling into the high category (red zone), indicating an increased risk of transmission in several areas.

The Poasia Community Health Center recorded a high number of dengue fever cases due to its dense population and rapid urbanization. Dense settlements with poor air circulation and numerous stagnant water reservoirs provide ideal breeding grounds for the Aedes aegypti mosquito. Furthermore, Poasia serves as a health referral center, resulting in a relatively high number of patient visits, including from outside Kendari City. This is consistent with research, who found that population density and urban activity were closely related to the increase in dengue fever cases in urban areas.[16]

The Kemaraya Community Health Center also shows a high trend in cases, influenced by suboptimal drainage, inadequate sanitation, and high levels of community activity in the city center. Dense settlements with clogged drains increase the risk of stagnant water, which can become breeding grounds for mosquitoes. This is supported by research.[17] (Which proves that drainage quality and high House Index (HI) and Container Index (CI) are closely related to the increase in dengue fever cases. The Mekar Community Health Center is experiencing a fluctuating but relatively high trend in dengue fever cases. This is due to the mixed housing conditions, both permanent and semi-permanent, with uneven sanitation quality. This environmental variation creates risk pockets that serve as habitats for mosquito larvae. Research results emphasized that areas with high humidity and uneven environmental quality are more vulnerable to increased dengue fever cases.[18]

The Wua-Wua Community Health Center recorded a high number of cases, closely related to the intensive trade, education, and public service activities in the area. High population mobility increases the potential for community exposure to mosquito vectors in public areas. Other research explains that high mobility is an important factor in the spread of vector-based diseases such as dengue fever, especially in urban areas with dense social interaction.[19] The Mokoau Community Health Center also reported a sharp increase in dengue fever cases, influenced by densely populated residential areas, poor drainage systems, and frequent waterlogging in yards. These environmental factors create an ideal breeding habitat for the Aedes aegypti mosquito.[20] States that areas with suboptimal drainage are at high risk of dengue fever transmission because they facilitate vector reproduction.

Jati Raya Community Health Center is located in an area with high socioeconomic activity, including trade and educational facilities. High population mobility is a dominant factor contributing to the spread of dengue fever in this area.[21] In Jambi shows that the density of community activities and population mobility have a strong relationship with the increase in dengue fever cases. The Perumnas Community Health Center reported high dengue fever cases due to its densely populated and unplanned residential area.

This situation creates numerous potential breeding grounds for mosquitoes, such as open water tanks, used cans, and poorly managed plastic containers.[22] Found that high larval index (HI and CI) in densely populated residential areas was directly related to the increase in dengue fever cases.

Finally, the Lepo-Lepo Community Health Center also reported a high number of dengue fever cases. As a large community health center with a wide coverage area and its status as an inpatient health care center, the number of patients visiting the community daily is relatively high, including those from outside the area. Furthermore, suboptimal drainage and sanitation issues increase the risk of mosquito breeding. Research by Hadi et al. confirms that poor drainage and population density are important determinants of the distribution of dengue fever cases.[23]

The results of this study align with a number of previous studies that utilized Geographic Information Systems (GIS) to map dengue fever based on community health center work areas. One relevant study was conducted by TW and Agustina, which mapped dengue fever cases in Magelang Regency. The study utilized Quantum GIS to identify the distribution of cases based on community health centers and categorize areas with high and low case numbers. The resulting spatial map successfully assisted in determining priority areas for dengue fever control interventions.[24] This aligns with your research, which mapped the increasing trend of dengue fever cases from 2022 to 2024 in Kendari City.

Achievement of Dengue Fever (DHF) Case Detection Figures

The number of dengue fever (DHF) cases detected is a crucial indicator in Indonesia's disease control efforts. Active and timely case detection is the first step in breaking the chain of transmission and preventing an outbreak.[25] Based on data, Indonesia has one of the highest dengue fever burdens in Southeast Asia. Therefore, increasing dengue case detection coverage is a key focus of the national dengue control program.[26]

Based on the results of a spatial analysis of the distribution of dengue fever cases in Kendari City Community Health Centers over the past three years (2022–2024), it shows a year-on-year increase in dengue fever cases. Most community health centers have varying case prevalence, ranging from no cases (grey zone), very low (green zone), low (green zone), moderate (yellow zone), to high (orange zone), and very high (red zone). This indicates an increased risk of transmission in several urban areas.

The results of the spatial analysis of dengue fever case detection rates also indicate a geographic shift in the distribution of cases. One significant finding is that the Lepo-lepo and Poasia Community Health Centers were classified as high (red zone) for two consecutive years, in 2023 and 2024, after previously being in the low category in 2022-2023. This indicates a significant increase in dengue fever cases in the region. Vulnerability to infectious diseases such as dengue fever is strongly influenced by physical environmental conditions (drainage, standing water, sanitation), community behavior, and population mobility.[27]

A significant increase in dengue fever cases was also seen in the Puuwatu, Mekar, Wua-wua, and Mokoau Community Health Centers, which experienced a shift in status from the low category (green zone) in 2022 and 2023, to the moderate category (yellow zone) in 2024. The high number of cases in these areas is closely related to population density, rapid urbanization, and unequal sanitation. Dense environmental conditions with many water reservoirs support the breeding of Aedes aegypti mosquitoes. This finding is supported by previous research which shows that densely populated areas with a high mosquito larvae index (ABJ, HI, CI) are at greater risk of experiencing an increase in dengue fever cases.[28]

Overall, the results of this spatial analysis show that the majority of the increase in dengue fever cases in Kendari City occurred in areas with high population density, poor drainage, inadequate sanitation, and high community mobility. These factors are consistent with previous research, which emphasizes the role of the environment and mobility in increasing the risk of dengue transmission.[29] Therefore, dengue control interventions in Kendari City need to focus on improving basic infrastructure, strengthening the 3M Plus National Health Program and ongoing spatial-based epidemiological monitoring.

Final Result of DHF Patient Died

In the case of Dengue Hemorrhagic Fever (DHF), it is a patient who dies for any reason before or during treatment.[30] Based on the number of dengue fever deaths in each community health center in Kendari City, the recorded figures vary. The highest number was found in Poasia Community Health Center with 7 cases, followed by Wua-Wua, Lepo-lepo, and Kemaraya Community Health Centers with 2 cases each. This difference indicates an imbalance in the handling and control of dengue fever in the working areas of each community health center.

The high mortality rate, particularly at the Poasia Community Health Center, may be influenced by several key factors. The first is delayed diagnosis and medical referral. Many patients arrive in severe condition, such as dengue shock, severe bleeding, or a drastic drop in platelets. Lack of public awareness of the early symptoms of dengue fever, such as sudden high fever, headache, muscle and joint pain, and the appearance of red spots on the skin, leads to delays in seeking medical attention. This contributes to the increased risk of death, especially at community health centers like Lepo-Lepo and Mokoau. Research by Bur et al. also showed that late diagnosis and management of shock were the main causes of the high DHF mortality rate in Indonesia.[31]

Furthermore, limited healthcare facilities contribute. Not all community health centers have complete laboratory testing facilities to monitor platelets and hematocrit, or adequate intensive care facilities. As a result, patients with serious conditions are often referred to hospitals with more comprehensive services late. This is likely one of the causes of the high mortality rate in Puskesmas areas with the highest number of cases, such as Poasia.

In terms of health service quality, the role of medical personnel and patient monitoring systems is also crucial. Community health centers with strict monitoring systems, rapid referrals, and health workers trained in the management of severe dengue fever (DHF) can reduce mortality rates. This is evident in the Labibia and Wua-Wua Community Health Centers, which recorded no dengue deaths. These two centers are thought to have good referral coordination, active mosquito larvae monitoring, and more intensive public education.

Thus, the dengue fever mortality rate in Kendari City is influenced not only by the patient's medical condition but also by community behavioral factors, the quality of healthcare services, and environmental and socioeconomic conditions. A comprehensive approach is needed to reduce mortality, including increasing public education, strengthening early detection and referral systems, and improving sanitation and environmental infrastructure.

This research is in line with Badawi et al. which confirms that deaths from dengue fever are closely related to late diagnosis, low public awareness of early symptoms, and the presence of comorbidities.[32] Furthermore, other research shows that the role of health workers, patient monitoring, and family support plays a major role in the success of DHF treatment and reducing mortality rates.[33]

Conclusion

Based on spatial analysis from 2022 to 2024, dengue fever cases in Kendari City showed an increasing trend, with categories ranging from low (green zone) to very high (red zone). The Poasia and Lepo-lepo Community Health Centers were consistently in the high category from 2023 to 2024, indicating these areas are priority control areas. Environmental factors such as population density, poor drainage, and inadequate sanitation play a significant role in the increase in cases.

Case detection rates vary between community health centers. Some areas with low case detection rates indicate weak early detection, either due to suboptimal reporting or limited surveillance. Conversely, areas with high case detection rates (e.g., Poasia and Lepo-lepo) demonstrate increased detection efforts but also reflect a high disease burden that requires immediate intervention.

Treatment outcomes showed significant differences between community health centers. Poasia Community Health Center recorded the highest mortality rate (7 cases), while several other community health centers, such as Wua-Wua, Lepo-lepo, and Kemaraya, each recorded two cases. Most other community health centers recorded no deaths. This indicates inequities in

dengue fever management, where delayed diagnosis, comorbidities, and quality of healthcare services all influence treatment outcomes.

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