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Spatial Clustering and Hotspot Analysis of Dengue Fever in West Java Province, 2020–2024

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Abstract
Introduction: *Dengue fever, a vector-borne disease caused by the dengue virus (DENV) and transmitted by Aedes aegypti and Aedes albopictus mosquitoes, has become a major public health problem in West Java, Indonesia.* ***Objective:*** *This study aimed to map high-risk zones of dengue fever in West Java from 2020 to 2024 using spatial analysis techniques.* ***Method:*** *The study used confirmed dengue case data obtained from the West Java Health Profile and applied ArcMap version 10.5 for spatial mapping and analysis, including Global Moran's Index, Getis-Ord Gi*, Local Indicators of Spatial Association (LISA), and hotspot analysis.* ***Result and Discussion:*** *The results showed a shift in the spatial distribution pattern of dengue cases from random in 2020 to significantly clustered in subsequent years. LISA analysis consistently identified high-high clusters in Bandung Regency, Bandung City, Bogor Regency, Bogor City, Depok City, and Bekasi City, indicating persistent spatial hotspots. Getis-Ord Gi* analysis further confirmed these hotspots with varying levels of statistical significance throughout the study period.* ***Conclusion:*** *These findings indicate the presence of endemic pockets and underscore the need for targeted public health interventions in high-risk areas. This study highlights the value of spatial analysis in understanding disease patterns and in informing evidence-based dengue control strategies in West Java.*

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Introduction

Dengue fever is a vector-borne disease caused by the dengue virus (DENV) and transmitted by female Aedes aegypti and Aedes albopictus mosquitoes (Iryanti et al., 2024). The virus belongs to the genus Flavivirus within the Arbovirus (arthropod-borne virus) group B and consists of four distinct serotypes: DENV-1, DENV-2, DENV-3, and DENV-4. These serotypes cause a spectrum of clinical conditions ranging from dengue fever, dengue hemorrhagic fever, to dengue shock syndrome (Binti Azman & Abdul Karim, 2018).

The highest number of dengue cases was recorded in 2023 across 80 countries in all WHO regions, reaching a historic peak of 6.5 million cases and more than 7,300 deaths attributed to dengue (WHO, 2024). Dengue cases in Indonesia have increased annually. According to the WHO Global Dengue Surveillance report, 114,720 cases with 894 deaths were reported in 2023, followed by a substantial rise in 2024 to 257,271 cases and 1,461 deaths (WHO, 2025). Based on the 2023 Indonesian Health Survey, West Java was classified as a province with a high prevalence of dengue hemorrhagic fever across all age groups, at 0.78 percent (95 percent CI: 0.64–0.94), with a weighted population of 156,977 (Badan Kebijakan Pembangunan Kesehatan et al., 2023). In 2023, West Java reported an incidence rate of 37.77 per 100,000 population and a case fatality rate of 0.69 percent (Kementrian Kesehatan RI, 2024).

The spatial distribution of dengue hemorrhagic fever cases in West Java Province can be structured into identifiable patterns that support the identification of areas with a high potential for dengue endemicity. Disease distribution pattern analysis requires an integrated system, namely a Geographic Information System (GIS). GIS integrates health and geographic data, enabling effective visualization and analysis of spatially related health information (Iryanti et al., 2024). Therefore, this study aims to map high-risk zones for dengue fever in West Java from 2020 to 2024. This approach is expected to generate evidence-based risk maps that can guide area-specific dengue control strategies.

Method

Study Area

West Java Province is one of the provinces in Indonesia located on Java Island. It borders Banten Province and the Special Capital Region of Jakarta to the west, Central Java Province to the east, the Java Sea to the north, and the Indian Ocean to the south. West Java consists of 27 administrative areas, comprising 18 regencies and 9 cities, with a total land area of 3,710,061.31 hectares (Dewi et al., 2025).

Study Design

This study applied a Geographic Information System approach to evaluate the spatial patterns of dengue hemorrhagic fever cases across administrative areas in West Java Province. Spatial analysis was conducted using Global Moran's Index, Local Indicators of Spatial Association (LISA), and hotspot analysis. High-concentration areas were identified based on spatial statistical analysis using the Getis-Ord Gi* method.

Data Sources

Confirmed dengue hemorrhagic fever case data were obtained from the West Java Health Profile, which compiles and publishes official surveillance data. This study used a five-year time frame, analyzing confirmed dengue cases recorded in the West Java Health Profile from 2020 to 2024.

Software

Data mapping and spatial analyses, including Global Moran's Index, Getis-Ord Gi*, LISA, and hotspot analysis, were performed using ArcMap software version 10.5.

Result and Discussion

1. Result

Assessment of Whether The Spatial Distribution of Dengue Cases in West Java is Random?

An analysis of dengue cases in West Java was conducted using Global Moran's Index with a fixed distance conceptualization in ArcGIS. The analysis showed that dengue cases in 2020 had a z-score of 0.379 and a p-value of 0.704, indicating a random spatial distribution.

In 2021, the analysis produced a z-score of 2.183 with a p-value of 0.028, and in 2022 a z-score of 2.049 with a p-value of 0.040. These results indicate a probability of less than 5 percent that the observed clustered patterns occurred by chance, suggesting a significant clustered distribution of dengue cases in both years.

In 2023, the z-score increased to 3.804 with a p-value of 0.000, indicating a probability of less than 1 percent that the clustered pattern occurred randomly, which reflects a strong spatial clustering of dengue cases. In 2024, the analysis yielded a z-score of 2.440 with a p-value of 0.014, confirming that dengue cases in West Java in 2024 also exhibited a significantly clustered spatial pattern.

Local Clusters and Spatial Outliers (LISA)

Spatial analysis using the Local Indicators of Spatial Association (LISA) method produced the following results:

Table 1
Results of LISA Analysis

Year/ Region	LISA Analysis		
	LISA	***p-value***	***Cluster Categories***
2020			
Bandung Regency	4.984	0.001	HH
Bandung City	3.459	0.022	HH
2021			
Bogor Regency	4.440	0.003	HH
Bekasi City	3.353	0.045	HH
Depok City	3.928	0.019	HH
2022			
-			
2023			
Ciamis Regency	3.805	0.045	LL
Bogor Regency	6.563	0.000	HH
Bandung City	4.566	2.581	HH
Bekasi City	4.048	2.297	HH
Bogor City	4.558	0.009	HH
2024			
Cimahi City	-3.689	0.042	LH
Depok City	3.564	0.032	HH

Based on spatial analysis using the LISA approach (Local Moran's I), distinct patterns of dengue disease clusters were identified across regions of West Java during the 2020–2024 period. High-high clusters, indicating areas with a high intensity of dengue cases surrounded by similarly high values, were predominantly observed in Bandung Regency, Bandung City, Bogor Regency, Bekasi City, and Depok City during 2020–2021 and 2023–2024, reflecting persistent spatial hotspot concentrations. Low-low clusters were identified in Ciamis Regency in 2023, indicating areas with consistently low dengue incidence. A low-high cluster detected in Cimahi City in 2024 indicated a spatial outlier, where relatively low dengue case counts occurred within surrounding areas of higher incidence. The results of the LISA analysis are presented in Figure 1.

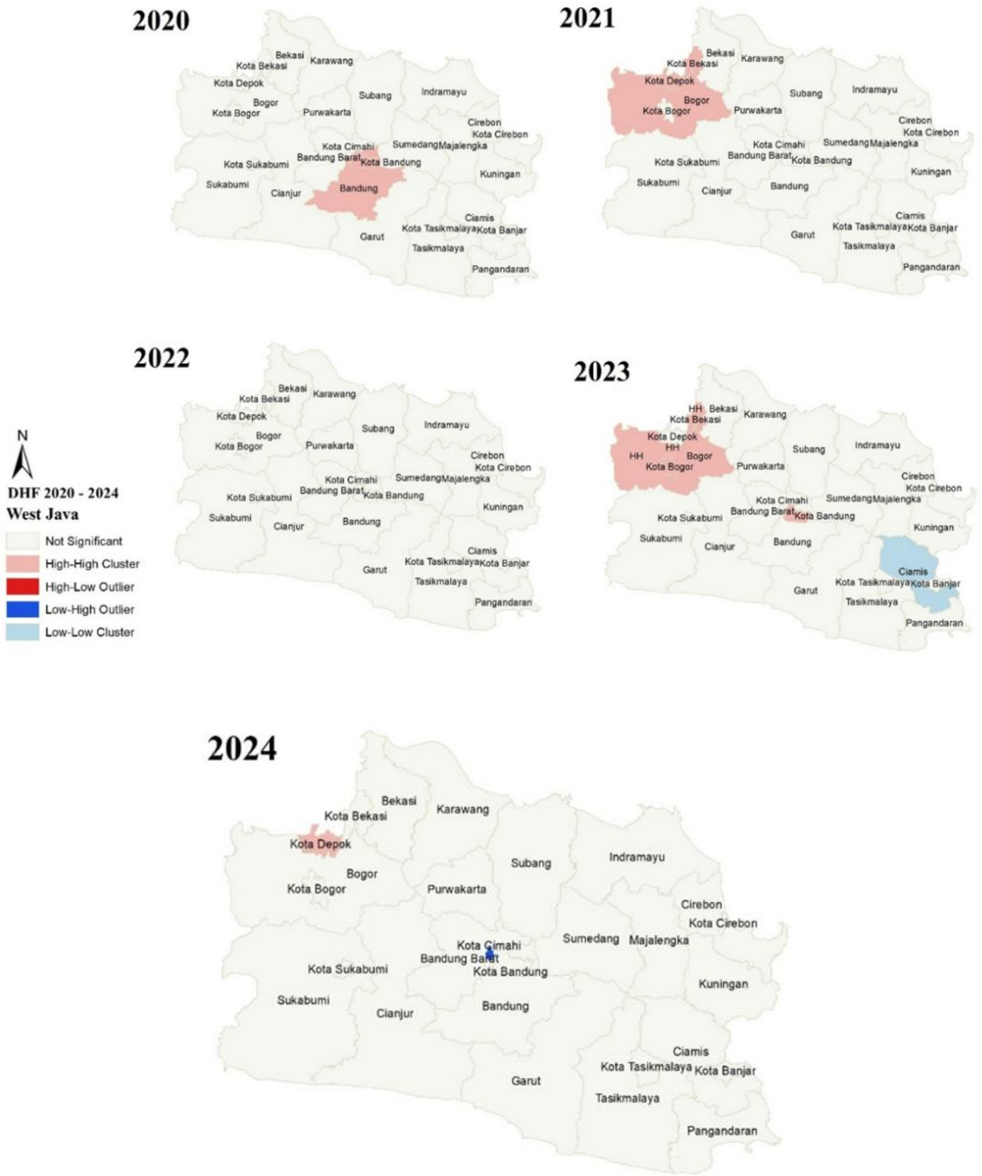

Figure 1. Local Clusters and Spatial Outliers (LISA) Dengue Hemorrhagic Fever in West Java 2020 – 2024

Hotspot Analysis of Dengue Fever in West Java

Dengue cases were analyzed using the Getis-Ord Gi* statistic to identify statistically significant hotspots and cold spots. This analysis detected areas with significantly high or low concentrations of dengue cases, which are visualized in the annual trend maps shown in Figure 2

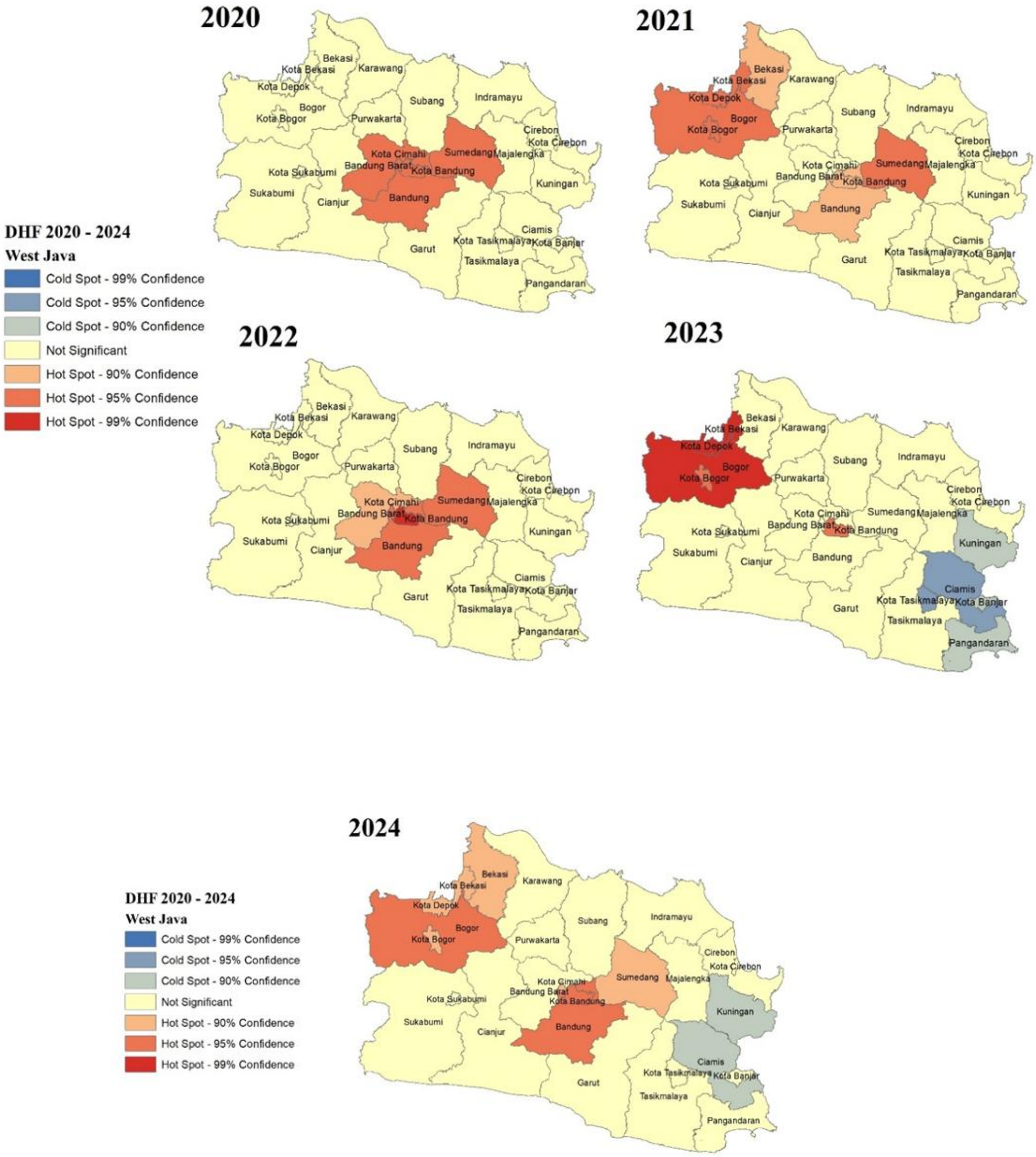

Figure 2. Hotspot Analysis of Dengue Fever in West Java

2. Discussion

Distribution of dengue cases in West Java, 2020–2024

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The analysis of dengue case distribution from 2020 to 2024 using Moran's Index revealed important dynamics that reflect a transition in disease spread patterns from random to significantly clustered. In 2020, a z-score of 0.379 and a p-value of 0.704 indicated the absence of significant spatial autocorrelation. This result shows that dengue cases in 2020 were randomly distributed and did not exhibit spatial clustering.

In 2021, the z-score increased to 2.183 with a p-value of 0.028, indicating that dengue cases began to concentrate spatially. Cases were no longer evenly distributed but started to form clusters. This trend continued in 2022, with a z-score of 2.049 and a p-value of 0.040, demonstrating the persistence of spatial clustering. These findings align with the study by (Fithriyyah et al., 2023), which applied a similar approach and found that dengue case clustering was strongly associated with population density and environmental sanitation. The consistency of clustering in 2022 suggests that areas with high case numbers in previous years tended to remain centers of transmission in subsequent years.

Spatial clustering peaked in 2023, with a z-score of 3.804 and a p-value of 0.000. This pattern reflects the formation of endemicity pockets, defined as areas that consistently function as transmission centers over time. A study by (Saputro et al., 2021) in the Java–Bali region also reported strong and recurrent spatial patterns of dengue cases, with clustering concentrated in densely populated areas with poor sanitation.

In 2024, the z-score of 2.440 and p-value of 0.014 continued to indicate a significant clustered pattern. Although the level of significance was slightly lower than in 2023, the results confirm that dengue cases were not evenly distributed. This variation may indicate a spatial shift in hotspot locations.

Local Clusters and Spatial Outliers (LISA)

Spatial analysis using the LISA approach (Local Moran's I) identified heterogeneous dengue clustering patterns across West Java during the 2020–2024 period. Several areas consistently fell into the high-high cluster category, including Bandung Regency, Bandung City, Bogor Regency, Bogor City, Depok City, and Bekasi City. High-high zones indicate areas with high dengue incidence surrounded by neighboring areas with similarly high incidence. These clusters represent significant spatial concentrations that signal stability of transmission and the urgent need for intensive public health interventions. (Shariati et al., 2020) emphasized that spatial clusters detected through LISA enable more efficient resource allocation through targeted interventions. Such interventions should also involve spatial and urban planning sectors, as highlighted by (Derseh et al., 2024), who demonstrated that physical environmental design plays a critical role in the transmission of infectious diseases.

In contrast, Ciamis Regency in 2023 was classified as a low-low cluster, indicating low dengue incidence surrounded by other low-incidence areas. This zone suggests the effectiveness of local disease control programs and may serve as a learning model or a buffer area within regional control strategies.

Cimahi City in 2024 fell into the low-high cluster category, representing a spatial anomaly in which relatively low dengue case numbers occurred within surrounding high-incidence areas. This zone warrants close attention because it has the potential to experience rapid increases in cases. As described by (Mason et al., 2024), low-high zones often function as sentinels or early indicators of shifts in spatial clustering patterns.

Hotspot Analysis of Dengue Fever in West Java

The results of the spatial hotspot analysis identified significant dengue hotspots in several areas across West Java. In 2020, Sumedang Regency showed a z-score of 2.442 with a p-value of 0.014, Bandung Regency a z-score of 2.354 with a p-value of 0.018, West Bandung Regency a z-score of 2.024 with a p-value of 0.014, Bandung City a z-score of 2.850 with a p-value of 0.017, and Cimahi City a z-score of 2.289 with a p-value of 0.022. These results indicate that these areas constituted statistically significant dengue hotspots at a 95 percent confidence level.

In 2021, significant dengue hotspots at the 95 percent confidence level were identified in Bogor Regency with a z-score of 2.477 and a p-value of 0.013, Sumedang Regency with a z-score of 2.052 and a p-value of 0.040, Bogor City with a z-score of 2.038 and a p-value of 0.041, Bekasi City with a z-score of 1.996 and a p-value of 0.045, and Depok City with a z-score of 1.996 and a p-value of 0.045. Additional hotspots were detected at a 90 percent confidence level in Bandung City with a z-score of 1.896 and a p-value of 0.057, Bandung Regency with a z-score of 1.729 and a p-value of 0.083, and Bekasi Regency with a z-score of 1.654 and a p-value of 0.097.

In 2022, Bandung City was identified as a highly significant dengue hotspot with a z-score of 2.838 and a p-value of 0.004, corresponding to a 99 percent confidence level. This finding indicates an exceptionally high spatial concentration of dengue cases in the area. Other significant hotspots at the 95 percent confidence level were observed in Bandung Regency with a z-score of 2.298 and a p-value of 0.021, and Sumedang Regency with a z-score of 2.064 and a p-value of 0.038. West Bandung Regency was also identified as a hotspot at the 90 percent confidence level, with a z-score of 1.742 and a p-value of 0.081.

In 2023, both dengue hotspots and cold spots were identified in West Java. Ciamis Regency recorded a z-score of −2.349 with a p-value of 0.018, indicating a significant cold spot at the 95 percent confidence level, characterized by a spatial clustering of low dengue case counts. Significant hotspots at the 99 percent confidence level were identified in Bogor Regency with a z-score of 2.087 and a p-value of 0.004, and in Depok City with a z-score of 2.577 and a p-value of 0.009. These areas exhibited high dengue case concentrations both locally and in surrounding regions.

In 2024, multiple hotspots and cold spots were detected. Bandung Regency with a z-score of 2.338 and a p-value of 0.019, Bandung City with a z-score of 2.047 and a p-value of 0.040, and Bogor Regency were identified as hotspots at the 95 percent confidence level. Hotspots at the 90 percent confidence level were observed in Bekasi City with a z-score of 1.883 and a p-value of 0.059, Depok City with a z-score of 1.883 and a p-value of 0.059, Bogor City with a z-score of 1.801 and a p-value of 0.071, Bekasi Regency with a z-score of 1.741 and a p-value of 0.081, Cimahi City with a z-score of 1.682 and a p-value of 0.092, and Sumedang Regency with a z-score of 1.649 and a p-value of 0.098. Cold spots at the 90 percent confidence level were identified in Ciamis Regency and Kuningan Regency, each with a z-score of −1.676 and a p-value of 0.093.

Conclusion

This study shows a clear transition in the spatial distribution of dengue fever in West Java from a random pattern in 2020 to a significantly clustered pattern during 2021–2024, indicating increasingly localized transmission. Spatial analyses consistently identified persistent high-risk clusters in Bandung Regency, Bandung City, Bogor Regency, Bogor City, Depok City, and Bekasi City, confirming the presence of stable endemic pockets. Hotspot detection further demonstrated that dengue risk concentrates and shifts across years rather than spreading evenly, emphasizing the importance of geographically targeted control measures. These findings highlight the practical value of spatial analysis for guiding evidence-based, area-specific dengue prevention and resource allocation strategies in West Java.

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