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A SPATIAL ANALYSIS OF DENGUE HEMORRHAGIC FEVER (DHF), HYGIENE, AND LATRINES IN DEPOK CITY IN 2020

Salsabila Naim[1]*, Sutanto Priyo Hastono[1], Sukma Rahayu[1], Martina Puspa Wangi[2]

[1]Department of Biostatistics and Population Studies, Faculty of Public Health, Universitas Indonesia, Depok City 16424, Indonesia
[2]Department of Nutrition, Faculty of Public Health, Universitas Airlangga, Surabaya 60115, Indonesia

Corresponding Author:
*) salsabila.naim@ui.ac.id

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Abstract

Introduction*: Depok is one of the areas in West Java with an increasing Dengue Hemorrhagic Fever (DHF) trend. In 2017, 548 DHF cases were reported, and this increased to 1,276 cases in 2020. It is necessary to control and map influencing factors on DHF incidence to detect endemic areas and reduce its spread.* ***Methods:*** *This study was conducted to identify a spatial autocorrelation between DHF, hygiene, and clean latrines in Depok in 2020. The data were obtained from the Depok City's Health Profile published in 2020. The Moran's I and local indicator of spatial association (LISA) univariate and bivariate analysis methods were performed using the GeoDa application.* ***Results and Discussion:*** *DHF (Moran's I = 0.32), hygiene (Moran's I = 0.25) and clean latrines (Moran's I = 0.24) had a significant positive autocorrelation with the clustered pattern. This indicated that data patterns clustered had similar characteristics in the area. Villages in the high-high DHF incidence quadrant were Kukusan, East Beji, Beji, Tanah Baru, Kemirimuka, Depok, Pancoran Mas, and Depok Jaya. In general, there was no spatial autocorrelation neither between DHF and hygiene, nor DHF and clean latrines. However, in some urban villages, significant autocorrelations between these variables were discovered.* ***Conclusion:*** *DHF incidence in this study formed a clustered pattern. Influencing factors, such as hygiene and clean latrines, followed the same pattern. Besides that, a spatial autocorrelation was also apparent between DHF and hygiene, as well as DHF and clean latrines in several urban villages in Depok.*

INTRODUCTION

Dengue hemorrhagic fever (DHF) is caused by dengue viruses transmitted by mosquito bites such as *Aedes aegypti* and *Aedes albopictus*. DHF is mostly found both in tropical and subtropical countries, for example, Indonesia, which has geographic characteristics such as rainfall intensity, temperature, and urbanization that may support vector growth and development (1). In December 2020, the Indonesian Ministry of Health reported that 73.35% of Indonesian districts/cities reached DHF incident rates of less than 49 per 100,000 of the population (2). Depok, an area in West Java, also experienced an increasing DHF trend. In 2017, 548 DHF cases occurred, and the incidence increased to 1,276 cases in 2020. The majority of the DHF cases were found in the Pancoran Mas sub-district with 232 cases, while the Cinere sub-district had the lowest number of cases as many as 43 cases (3).

Poor community behavior and environmental conditions that do not meet health requirements are risk factors for diseases with environment-based transmission, one of which is dengue fever (4). Some of DHF's environmental factors are hygiene and clean latrines. Hygiene has a vital influence on dengue fever incidence (5). Research in Pendukuhan Wonocatur found a significant correlation between hygiene knowledge at the household level and DHF prevention with a p-value of <0.05 (6). In the Kedungkandang sub-district, families who had poor hygiene had 6.57 times the risk of contracting DHF than those who complied with hygiene standards (7). Clean latrines are also part of the hygiene related to DHF prevention (6). Research in Bandung found that dirty latrines significantly affected the increment of dengue cases with a p-value of <0.05 (5). Research using the SAR method also showed a significant correlation between clean latrine ownership and DHF incidence.

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Healthy latrine ownership percentage in the area had a negative influence on the dengue case percentage in West Sumatera (8). Every household must use a clean latrine.

According to ecosystem aspects, DHF can vary from one area to another, and thus may cause spatial components in health problem handling. Spatial analysis is usually done to review some disease management that has been performed in an area. It inspects demographics, spread, environment, people's behavior, social economy, disease incidence, and association between the disease and its variables from geographical aspects (9). Dengue epidemics need to be monitored and planned by using a validated measurement because it holds an important influence in controlling disease outbreaks. Creating a simulation model and mapping disease incidence can help with early detection in high-risk locations (10). A spatial distribution analysis of DHF in Depok using LISA aimed to identify whether the DHF case distribution occurred randomly or was influenced by cases around the neighboring areas. This study also looked into the spatial autocorrelation of DHF incidence with hygiene and clean latrines in Depok in 2020. The present results could be references for DHF prevention and countermeasures.

METHODS

This ecological study of spatial analysis aimed to analyze DHF incidence distribution in Depok at the urban village level. Depok consists of 11 sub-districts and includes 63 urban villages. The location map is presented in Figure 1. The data were primarily obtained from the Depok City's Health Profiles in 2020 and partially from the Depok City's Department of Population and Civil Registration in 2020 (11). The dependent variable used was the DHF incidence, and the independent variables were hygiene and clean latrines.

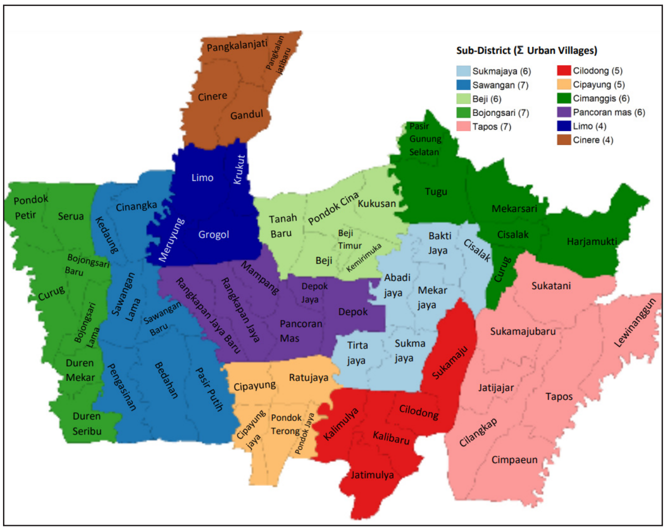

Figure 1. Mapping Areas of Depok City

Further details can be seen in Table 1. The Moran's I and LISA univariate and bivariate analysis methods were performed using the GeoDa application. The weighting in this study used queen contiguity, a weighting matrix based on the side-angle tangent relationship (12).

Table 1. Operational Definition

Variable	Descriptions	Sources
Dependent Variable		
DHF	DHF Incidence = number of DHF cases/resident population x 1,000	Depok City's Department of Population and Civil Registration (*Disdukcapil*) 2020 Depok City in Numbers 2020 Bojongsari Ward in a Numbers 2020
Independent Variables		
Hygiene	Percentage of households who apply proper hygiene	Health Profile of Depok City in 2020
Clean latrines	Percentage of families who can access proper sanitary facilities (clean latrines)	Health Profile of Depok City in 2020

Moran's I

From the Pearson correlation, Moran's coefficient is developed in univariate series data. The Pearson correlation formula between variables X and Y is as follows:

$$\rho = \frac{\sum_{i,=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i,=1}^{n}(x_i - \bar{x})^2 \sum_{i,=1}^{n}(y_i - \bar{y})^2}}$$

Moran`s I is one of the methods to check for autocorrelation. Moran's I is a correlation coefficient utilized to measure the general spatial autocorrelation of the formerly gathered data. Moran's I measures the similarity of one item to other items. The Moran's I formula between observations i and j is as follows:

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

The Moran's I index is between -1 and 1. If a Moran's I is more than E(I), there is a positive autocorrelation, indicating perfect clustering of similar values. If a Moran's I is less than E(I), there is a negative autocorrelation, indicating perfect clustering of dissimilar values or dispersion (12). E(I) is the expected value of Moran's I, which is formulated as follows:

$$E(I) = I_0 = \frac{-1}{n-1}.$$

Hypothesis testing on parameters was carried out as follows:

H0: 1 = 0 (No correlation existed between areas)

H1: 1 ≠ 0 (Correlation existed between areas)

$$Z_{hitung} = \frac{I - I_o}{\sqrt{\text{var(I)}}} \sim N(0,1)$$

H0 is rejected if |Counted Z| value is more than Z(α/2) or p-value is less than α (13).

Local Indicator of Spatial Autocorrelation (LISA)

The LISA statistic was advanced from Local Moran's I by Anselin in 1995. The LISA for each observation showed the quantity of tremendous spatial clustering of comparable values across the observation. The measurements' values were obtained through the Local Moran Index. Moran's I on LISA indicated a local autocorrelation (14). The Local Moran's I spatial association statistic is as follows:

$$I_i = \frac{x_i - \bar{X}}{S_i^2} \sum_{j=1, j\neq i}^{n} w_{i,j}(x_j - \bar{X})$$

The pattern of distribution was analyzed using LISA within a smaller scale. If the statistical test did not show significant results, then there would have been no spatial autocorrelation in that area. If the statistics showed a significant value, then there would have been four possible spatial patterns in the area. High-high quadrants are urban villages with high indicator proportions surrounded by other urban villages which also have high indicator proportions. Low-low quadrants are urban villages with low indicator proportions surrounded by other urban villages that also had low indicator proportions. High-low quadrants are urban villages with high indicator proportions surrounded by other urban villages with low indicator proportions. Low-high quadrants describe urban villages with low indicator proportions surrounded by other urban villages with high indicator proportions (12). The sum of LISA for all observations is proportional to a worldwide spatial association indicator (15).

Bivariate LISA

Bivariate LISA, a correlation of one variable in an area with another variable in a neighboring area was almost similar to that resulted from local univariate Moran's I.

$$I_B = \frac{\sum_i (\sum_j w_{ij}(d) x_i \times y_j)}{\sum_i x_i^2}$$

Local bivariate Moran's I can be visualized within the Moran bivariate scatterplot and map. The Moran bivariate scatterplot showed a correlation between the first surveillance variable and the second surveillance variable spatially arranged into four quadrants (16).

RESULTS

Description of DHF, Hygiene, and Clean Latrine

Table 2 shows the DHF incidence in the areas. The highest incidence was found in Sawangan Lama at 1.82, while the lowest incidence was in Cimanggis, Curug at 0.08. Figure 2a demonstrates that, besides Sawangan Lama, 13 urban villages were classified as having high DHF incidence. The Beji sub-districts (Beji Timur, Kukusan, Pondok Cina, Beji, and Tanah Baru), Tirtajaya, Depok, Kalimulya, Duren seribu, Sukmajaya, Krukut, and Cipayung were classified as having high DHF incidence in the dark brown areas at intervals of 1.194-1.821%.

Table 2. DHF, Hygiene, and Clean Latrine

Variables	Max	Min	Mean	Deviation Std
DHF	1.82	0.08	0.7	0.46
Hygiene	91.7	23.4	70.23	14.48
Clean Latrines	100.1	43.6	92.27	11.57

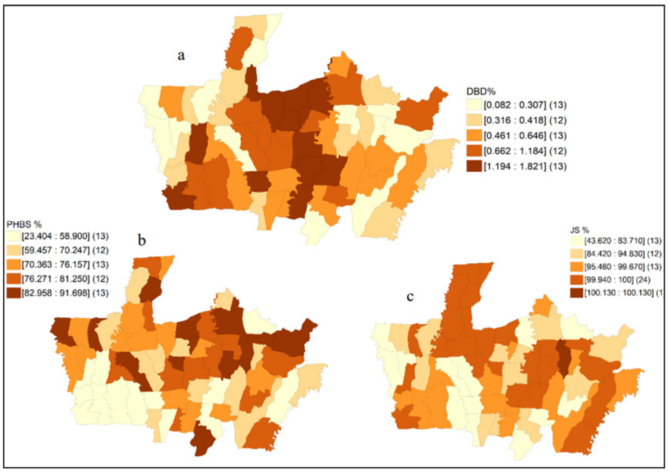

Figure 2. Distribution Map (a) Incidence of DHF, (b) Percentage of Hygiene, and (c) Percentage of Clean Latrines

Hygiene coverage was at 70.23% with a standard deviation of 14.48%. The highest hygiene coverage was in Cisalak, Sukmajaya at 91.70%, and the lowest was in Sukmajaya at 23.4% (Table 2). Based on Figure 2b, 13 urban villages classified with the lowest hygiene include Sukmajaya, Bojongsari Lama, Duren Seribu, Pasir Putih, Pengasinan, Kalibaru, Cipayung, Bojong Pondok Terong, Duren Mekar, Sawangan Lama, Bedahan, Mekarsari, and Tapos. These villages were classified as having the lowest hygiene coverage in the bright yellow areas at intervals of 23.404-58.900%.

The clean latrine coverage was at 92.27%, and its deviation standard was at 11.57%. The highest clean latrine coverage was found in Cisalak at 100.1%, and the lowest was found in Rangkapan Jaya at 43.62% (Table 2). Based on Figure 2c, 13 urban villages classified as having low clean latrine coverage are Rangkapan Jaya, Jatijajar, Pondok Cina, Bojongsari Baru, Rangkapan Jaya Baru, Pondok Petir, Curug, Mekarsari, Cipayung Jaya, Cilodong, Jatimulya, Pasir Putih, and Cipayung located in the bright yellow areas at intervals of 43.620-83.710%.

Spatial Pattern Analysis

Table 3 shows the Moran Index is related to DHF, hygiene, and clean latrines ($p < 0.05$). It indicates one area to another was correlated with the other variables. Since the variables were greater than E(I), a positive autocorrelation or clustered data pattern was found. Additionally, the areas had similar characteristics to one another. DHF's Moran's I (Moran's I = 0.32) was greater than that of hygiene (Moran's I =0.25), and hygiene's value was greater than clean latrines' (Moran's I = 0.1126). Results showed that the DHF's clustered data pattern was greater than hygiene and clean latrines.

Table 3. Results of Moran's Index

Variables	I	E(I)	p-value
DHF incidence	0.3200	-0.0161	0.001
Hygiene	0.2505	-0.0161	0.004
Clean latrines	0.1126	-0.061	0.004

Interpretation of LISA Map

Figure 3a shows that out of 63 urban villages, 18 urban villages had shown a significant spatial autocorrelation to other urban villages in terms of DHF incidence. Eight urban villages were classified into the high-high quadrant. This implied DHF incidence was high in these areas surrounded by other urban villages with a similarly high classification. Urban villages in the high-high quadrant include Kukusan, Beji Timur, Beji, Tanah baru, Kemirimuka, Depok, Pancoranmas, and Depok Jaya.

The bivariate Moran's I analysis results showed DHF had an insignificant correlation with hygiene ($p = 0.281$) and clean latrines ($p = 0.144$). Overall, there was no spatial autocorrelation between DHF, hygiene, and clean latrines. However, 11 urban villages showed a significant spatial autocorrelation of DHF with hygiene (Figure 3b) and clean latrines (Figure 3c). Interpretation was focused on quadrants with high DHF incidences.

The bivariate LISA of DHF with hygiene (Figure 3b) mapped Cilodong (Moran's I = -1.358521; $p < 0.01$), Durenseribu (Moran's I = -1.971659; $p < 0.05$), and Pangasinan (Moran's I = -0.688331; $p < 0.001$) in the high-low quadrant. This means they had a high DHF incidence, and they were surrounded by other urban villages with low hygiene coverage. Beji (Moran's I = -1.241543; $p < 0.01$) and Pondok Cina (Moran's I = 1.317646; $p < 0.01$) were classified into the high-high quadrant, meaning they had high DHF incidence, and they were surrounded by urban villages with high hygiene coverage.

Regarding DHF and clean latrines (Figure 3c), Cipayung (Moran's I = -1.133403; $p < 0.01$) was categorized in the high-low quadrant, which means it had high DHF incidence around other urban villages with low clean latrine coverage. Tanah Baru (Moran's I = 0.609998; $p < 0.05$), Cinere (Moran's I = 0.138003; $p < 0.05$), and Krukut (Moran's I = 0.902109; $p < 0.05$) were categorized into the high-high quadrant. It showed they had high DHF incidence and were surrounded by villages with high clean latrine coverage.

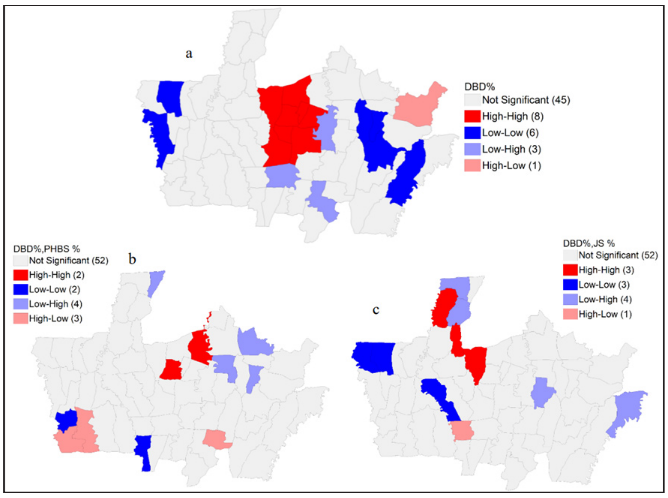

Figure 3. Cluster Map (a) LISA of DHF Incidence, (b) Bivariate LISA of DHF with Hygiene, and (c) Bivariate LISA of DHF with Clean Latrines

DISCUSSION

Description of DHF Cases, Hygiene, and Clean Latrines

The highest DHF incidence found in Sawangan Lama is supported by previous research in the Sawangan Primary Healthcare Center, specifically in Community Unit No. 03, Sawangan Lama, which found that the highest disease incidence was DHF at 55%. The high DHF incidence in Sawangan Lama is due to the lack of preventive measures, such as draining (brushing) bathtubs and closing water reservoirs (jars, drums, and others). The study results also showed a correlation between mosquito larvae presence, closing ventilation, hanging clothes, and using anti-mosquito drugs with DHF incidence (17). All urban villages in Beji were classified as having high DHF incidence. Research in Beji found that there was a relationship between residents' knowledge level about DHF prevention and DHF incidence rates (18). The cause of the high DHF incidence is difficult to trace because of the Beji community's high mobility. The source of the disease may emerge not only at home, but also at school or work (19).

The lowest DHF hygiene coverage was found to be 23.4% in Sukmajaya. In the same sub-district, Cisalak had the highest hygiene coverage at 91.7%. Poor hygiene may be due to the absence of a disposal system. People dispose of their household wastewater through sewers, which causes water puddles to form in front of the houses, especially those in the lower plains. Stagnant water can cause mosquito larvae to breed. A valuable relationship between knowledge about hygiene and its implementation was also found at a family level in Cisalak (20). This was most likely also due to instrumental support. Instrumental support in this context is defined as the availability of tools and facilities to execute a proper hygiene practice. Other factors include emotional support, information support, and appreciation (21). The Sukmajaya government promoted hygiene and three COVID-19 prevention measures (mask usage, social distancing, and regular handwashing) to achieve the Healthy City Development Program (*Pengembangan Program Kota Sehat*/ PPKT) goals (22). Unfortunately, these efforts are considered not enough to tackle infectious disease issues if local governments do not provide hygiene facilities in urban villages. Additionally, research related to hygiene in Sukmajaya is still very lacking in comparison to Cisalak.

The lowest clean latrine coverage was found in Rangkapan Jaya at 43.62%. Especially in Community Unit No. 01, there were still many residents who did not have clean sanitation in the form of either latrines or septic tanks (23). In the same sub-district, Rangkapan Jaya Baru was classified as having low clean latrine coverage at 74.8%. Families with unsanitary latrines tend to have higher illness proportions than families with clean latrines (24). A factor that likely correlates with unsanitary latrines in specific areas is the unavailability of proper houses with sanitary and social behavior. These factors can be handled by giving an aid or financial support in these areas and promoting the importance of clean latrines to solve social and behavioral issues (25).

The Depok City Government has sought to improve access to proper latrines or sanitation for all its citizens through the Open Defecation Free (ODF) declaration. For ODF to be successful, access to healthy latrines must reach 100% in all communities (26). There are several criteria for obtaining the Urban Village Open Defecation Free (*Kelurahan Bebas BABS*) status. All families in the related urban villages must have a healthy latrine equipped with a septic tank (27).

Spatial Pattern Analysis

The spatial pattern of DHF, hygiene, and clean latrines in Depok in 2020 showed a positive autocorrelation. The results showed that the first strongest clustered classification pattern was found in DHF (Moran's I = 0.32), followed by hygiene (Moran's I = 0.25), and clean latrines (Moran's I = 0.11). Previous research in Depok in 2019 showed that DHF incidence was concentrated in certain areas (28). The DHF case distribution in Seksyen 7 Shah Alam, Malaysia also showed a spatial autocorrelation with the clustered pattern (29). However, the autocorrelation analysis results from Samarinda showed a spatial autocorrelation within the DHF distribution areas across healthcare centers. Based on the negative Moran's I value (Moran's I = -0.045), the DHF distribution within the areas tended to unfold or disperse (30). The case spread pattern tended to follow the population density and other environmental factors (28). A spatial autocorrelation in DHF cases can be influenced by a location's history of previous DHF events. The dengue virus of the *Aedes aegypti* mosquito originates from a previous dengue patient, and it is then transmitted to other humans in the immediate environment. Areas with greater DHF case factors usually have a greater chance of getting a spatial autocorrelation. More DHF cases in densely populated areas normally have a greater chance of having a spatial autocorrelation (30). Research in Nigeria found a good spatial clustering of public toilets (latrine) ($p < 0.01$) (31). The examination evaluation held in Ethiopia was primarily based on characteristics of places. There was a significant spatial autocorrelation for unimproved water insurance worldwide (Moran`s I = 0.174; p-value < 0.0001) (32). In India, research found that statistically significant Moran's I implied a strong positive spatial association between districts with similar Water-Sanitation-Hygiene (WaSH) infrastructural traits (33). However, the healthy latrine ownership percentage in West Sumatera had a negative autocorrelation (Moran's I = -0.112), meaning that the data pattern was spread out (8).

LISA Map Interpretation

Out of 63 urban villages, 18 urban villages had a significant spatial autocorrelation to others regarding DHF incidence. Those villages in the high-high quadrant include Kukusan, Beji Timur, Beji, Tanah Baru, Kemirimuka, Depok, Pancoran Mas, and Depok Jaya. This means DHF incidence was high in these areas surrounded by other urban villages with a similarly high category. Some reports have elaborated that neighboring urban villages/ sub-districts/districts have similarities associated with ecology, human behavior, social patterns, and lifestyle. Those traits can also provide an upward push for an advantageous or poor affiliation with the DHF incidence in neighboring areas (34).

Generally, there was no spatial autocorrelation between DHF, hygiene, and clean latrines. However, 11 urban villages had a significant spatial autocorrelation between these three variables. Cilodong, Duren Seribu, and Pengasinan were in the high-low quadrant due to having high DHF incidence and being surrounded by other villages with low hygiene coverage. Another study found a significant correlation between hygiene knowledge at the household level and DHF prevention measures in Pendukuhan Wonocatur (6). In Kedungkandang, families who had poor adherence to hygiene had 6.57 times the risk of contracting DHF than those who complied with hygiene standards (7).

Moreover, Tanah Baru, Cinere, and Krukut were in the high-high quadrant for having high DHF incidence and being surrounded by other villages with high clean latrine coverage. Research in Central Java brought some findings that poor water quality influences on DHF incidence (35). That study explains that *Aedes aegypti* likely develops better in artificial water containers, and their life cycle is strongly related to human activities. For example, Wiggler's habitat is increasing rapidly in urban areas. Since curative medication for DHF has not been developed, environmental and ecosystem management is expected to be more relevant and applicable. However, in some places, insecticide spray has intangible and short-term effects on eliminating DHF (36). Based on studies in Putat Jaya Primary Healthcare Center, network including knowledge, attitude, and societal movement has a significant relationship with the Maya Index level. The Maya Index is a hallmark to the number of water reservoirs used for mosquito breeding grounds. An excessive Maya Index level impacts the DHF transmission hazard degree (37). Only one urban village, Cipayung, was categorized in the high-low quadrant for high DHF incidence. It was surrounded by other villages with low clean latrine coverage. Research using the SAR method showed a significant correlation between clean latrine ownership and DHF incidence. The healthy latrine ownership percentage in West Sumatera negatively influenced the dengue case percentage (8). It is recommended that the community regularly attempt to eliminate mosquito nests independently in addition to eradication efforts by boom network experts with the assistance of medical institution network (37). It is anticipated that the community can actively take part in manipulating and retaining DHF vectors, particularly the housewives as representative of alternate withinside the family (38). There are clear barriers to this study. This study did not have data on neighborhood mosquito density; therefore, the impact of vector management intervention for disorder management was not able to be investigated. Another limitation of this study is the primary elements, including climate change, population growth, and socioeconomic situation, which have not been given much attention within the dengue incidence in this study. The last limitation is that this study also only included data from a single year.

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CONCLUSION

The spatial pattern of DHF distribution in Depok showed a positive spatial autocorrelation, suggesting the case density in the area was highly influenced by geographical distribution and attributed factors such as community health behaviors and environmental conditions. It indicated that data patterns clustered had similar characteristics in the areas. Urban villages in the high-high quadrant in terms of DHF incidence include Kukusan, East Beji, Beji, Tanah Baru, Kemirimuka, Depok, Pancoran Mas, and Depok Jaya. Overall, there was no spatial autocorrelation between DHF, hygiene, and clean latrines. However, a spatial autocorrelation was apparent between DHF incidence, hygiene, and clean latrines in several urban villages in Depok.

The government is recommended to use local research addressing on interventions that efficiently and significantly impact DHF eradication. Then, the collaboration between health workers and the community needs to be improved in handling DHF. Future research is recommended to explore spatial modeling of DHF with other potential risk factors such as larva or mosquito distribution and their breeding sites at the urban village level with poor health coverage.

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