ARTÍCULO ORIGINAL

Gac Méd Caracas 2024;132(2):420-427
DOI: 10.47307/GMC.2024.132.2.13

Spatial analysis and correlation study of dengue hemorrhagic fever in Palopo city, Indonesia

Análisis espacial y estudio de correlación de la fiebre hemorrágica del dengue en la ciudad de Palopo, Indonesia

Roswati A[1a], Arsunan Arsin[2a], Andi Zulkifli[3a], Ansariadi[4a], Hasnawati Amqam[5b], Anna Khuzaimah[6c]

SUMMARY

Background: *Dengue Hemorrhagic Fever (DHF) is a tropical disease still a global public health problem. Dengue fever is found worldwide, especially in tropical and subtropical countries.* **Objective:** *The study aims to analyze the spatial correlation of dengue incidence in Palopo City, Indonesia, in 2022.* **Methods:** *It was quantitative research using ecological studies.* **Results:** *Spatial analysis showed that high DHF incidence was found in very high population density (401-1 000 people), high coverage of healthy houses (≥80 %), moderate poverty (143-218 people), close to health care facilities (<1 000 m), low elevation (7.0-16.70 m above sea level), high mobility (67-73 people). There was a significant correlation between DHF incidence and population density (r=0.444; p=0.001), health service facilities (r=0.541; p=0.0001), elevation (r= -0.293; p=0.043), mobility (r=0.306; p=0.033). There was no correlation between DHF incidence and the coverage of healthy houses (r=0.135; p=0.359) and poverty (r=0.123; p=0.402).* **Conclusion.** *Population density, distance to healthcare facilities, elevation, and population mobility influence DHF incidence in Palopo City, Indonesia, 2022.*

Keywords: *GIS, dengue, overlay, buffering.*

RESUMEN

Fondo: *La fiebre hemorrágica del dengue (FHD) es una enfermedad tropical que sigue siendo un problema mundial de salud pública. La fiebre hemorrágica del dengue se encuentra en casi todo el mundo, especialmente en los países tropicales y subtropicales.* **Objetivo:** *El estudio tiene como objetivo analizar la correlación espacial de la incidencia de FHD en la ciudad de Palopo, Indonesia, en 2022.* **Métodos:** *Fue una investigación cuantitativa utilizando estudios ecológicos.* **Resultados:** *El análisis espacial mostró que la alta incidencia de la fiebre del dengue*

DOI: https://doi.org/10.47307/GMC.2024.132.2.13

ORCID: https://orcid.org/0009-0004-5914-5244[1]
ORCID: https://orcid.org/0000-0003-3311-6686[2]
ORCID: https://orcid.org/0000-0003-4437-6811[3]
ORCID: https://orcid.org/0000-0003-4961-8517[4]
ORCID: https://orcid.org/0000-0002-9692-6136[5]
ORCID: https://orcid.org/0009-0006-2729-643X[6]

[a]Department of Epidemiology, Faculty of Public Health, Hasanuddin University - Indonesia.

[b]Department of Health Environment, Faculty of Public Health, Hasanuddin University - Indonesia.

[c]Department of Nutritionist, Faculty of Public Health, Hasanuddin University – Indonesia.

*Corresponding author: Roswati; Email: roswati22k@student.unhas.ac.id

Recibido: 26 de marzo 2024
Aceptado: 13 de abril 2024

hemorrágico se encontró en densidades de población muy altas (401-1 000 personas), alta cobertura de viviendas saludables (≥80 %), pobreza moderada (143-218 personas), cerca de centros de atención médica (<1 000 m), baja elevación (7,0-16,70 m sobre el nivel del mar), alta movilidad (67-73 personas). Hubo correlación significativa entre la incidencia de fiebre hemorrágica del dengue y la densidad de población (r=0.444; p=0.001), instalaciones de servicios de salud (r=0,541; p=0,0001), elevación (r=-0,293; p=0,043), movilidad (r=0,306; p=0,033). No hubo correlación entre la incidencia de dengue hemorrágico y la cobertura de viviendas saludables (r=0,135; p=0,359) y pobreza (r=0,123; p=0,402). **Conclusión:** *La densidad de población, la distancia a los centros de atención médica, la elevación y la movilidad de la población influyen en la incidencia de dengue hemorrágico en la ciudad de Palopo, Indonesia, en 2022.*

Palabras clave: *SIG, dengue, cubrir, almacenamiento en búfer.*

INTRODUCTION

Dengue Hemorrhagic Fever (DHF) has become a major public health concern in tropical and subtropical countries worldwide in recent years (1). The disease is increasing in line with growing mobility and population density. World Health Organization *(*WHO) estimated that approximately 390 million infections occur yearly, with approximately 3.9 billion people at direct risk of the disease,especially those living in urban areas in tropical and sub-tropical countries (2).

Health authorities reported roughly 114 435 dengue fever cases nationwide in Indonesia in 2023, 142 294 cases in 2022, 73 518 cases in 2021, and 108 303 cases in 2020. In 2020, the incidence of DHF in Indonesia was 38.15 per 100 000 population, decreasing to 27 per 100 000 in 2021. However, this figure doubled to 59 per 100 000 population in 2022. By week 40 of 2023, there were 68 996 cases of DHF, with an incidence rate of 25.10 per 100 000 population that resulted in 498 deaths, or a death rate of 0.72 percent (3).

Dengue fever is an acute febrile illness caused by the dengue virus, a single-chain RNA virus belonging to group B Arbovirus (Arthropoda Borne Virus), family Flabviviridae. Dengue virus (DENV) is a species that includes four serologically related but genetically distinct viruses, DENV serotype-1, DENV-2, DENV-3, and DENV-4, which are members of the family Flaviviridae, genus Flavivirus. Dengue Hemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS) are caused by dengue viruses transmitted by mosquito bites such as *Aedes aegypti* and *Aedes albopictus* (4).

Palopo, or Kota Palopo, is a city in South Sulawesi, Indonesia, and the second-largest city in the province. In 2021, the DHF incidence in Palopo City was 161 per 100 000 population, making it one of the ten cities in Indonesia with the highest DHF incidence in 2021. 2022, the recorded DHF incidence was highest at 132 per 100 000 people. Palopo city has the third highest number of DHF cases out of 24 districts/cities in South Sulawesi province (5).

To overcome this increase, it is necessary to know the factors that influence the incidence of dengue fever. The main factors influencing several Provinces in Indonesia include population density, coverage of healthy homes, access to health services, poverty, elevation of the area, and mobility (6).

Dengue fever often has a spatial distribution pattern showing that certain areas tend to differ from others. Apart from that, differences in regional conditions and changes in time that cause a reduction in the number of dengue fever incidents in a region cannot be analyzed using the same analytical approach. Therefore, spatial and temporal methods are used to identify the components that contribute to the influence at a location over time. Spatial analysis in area-based disease management can be formulated as a description and analysis of disease occurrence linked to all spatial data that become health risk factors, including environmental and sociodemographic factors and local community behavior in a spatial area (7). Health risks can also be estimated based on determinant factors using spatial analysis to prioritize interventions and formulate prevention policies (8).

Therefore, this study aims to analyze the spatial correlation of dengue incidence in Palopo City, Indonesia, in 2022.

METHODOLOGY

This type of research is quantitative, using ecological studies. The study population and sample included individuals infected with Dengue Hemorrhagic Fever (DHF) in Palopo City, Indonesia, in 2022. The study used aggregated data, which is secondary data. Data on the DHF and healthy home coverage were obtained from the Palopo City Health Office. Population density, mobility, and elevation data were obtained from the Central Bureau of Statistics. Poverty data was obtained from Palopo's Social Service.

The dependent variable in this study was the incidence of dengue fever. The independent variables were population density, coverage of healthy homes, poverty, availability of health facilities, elevation, and mobility.

Data Processing and Statistical Analysis. This study used statistical tests, a correlation test (Spearman), and STATA version 17, and the data was presented in tables and graphs. Quantum GIS (*QGIS),* a geographic information system (GIS) software, was used for spatial analysis techniques. Spatial analysis carried out includes overlay analysis and buffering. After the analysis was carried out, a p-value was obtained to indicate whether there was a relationship between variables. The strength of the correlation between variables was classified into four categories:

$r = 0 \rightarrow$ no correlation

$r = 0 – 0.25 \rightarrow$ low correlation

$r = 0.26 – 0.50 \rightarrow$ moderate correlation

$r = 0.51 – 0.75 \rightarrow$ strong correlation

$r = 0.76 – 1.00 \rightarrow$ very strong correlation or perfect correlation

Research Ethics Approval. This study was approved by the Health Research Ethics Committee of Hasanuddin University with a recommendation for ethical approval number 6499/UN4.14.1/TP.01.02/2023.

RESULTS

A total of 247 dengue fever incidents in Palopo City were found, with 102 (41.3 %) male and 145 (58.7%) female patients. The ages in years were: 3 (1.21 %), 2-5 (7.29 %), 6-14 (38,82 %), 15-44 (122 (49.39 %), >45 (7.29 %) (Table 1). Figure 1 shows the distribution of DHF by Urban Village in Palopo City, where most DHF cases were in Benteng and Temmalebba urban villages (10.5 %). The peak incidence of DHF in Palopo City in 2022 was at the beginning of January (28 %) (Figure 2).

Table 1. Demographic Characteristics of DHF Patients in Palopo City in 2022

Variable	n (%)
Gender	
Male	102 (41.3)
Female	145 (58.7)
Total	247 (100)
Age Group	
0-1 Year	3 (1.21)
2-5 Year	18 (7.29)
6-14 Years	86 (38.82)
15-44 Years	122(49.39)
>45 Years	18 (7.29)
Total	247 (100)

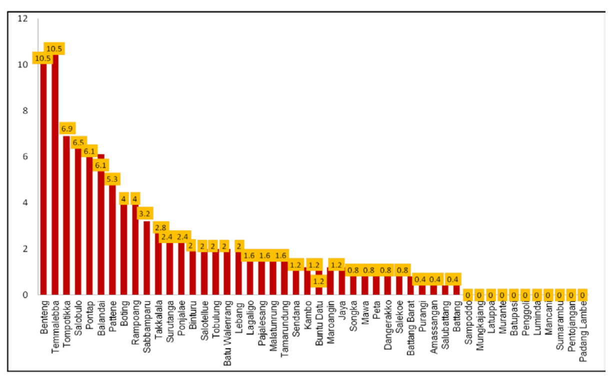

Figure 1. Distribution of DHF by Urban Village in Palopo City in 2022.

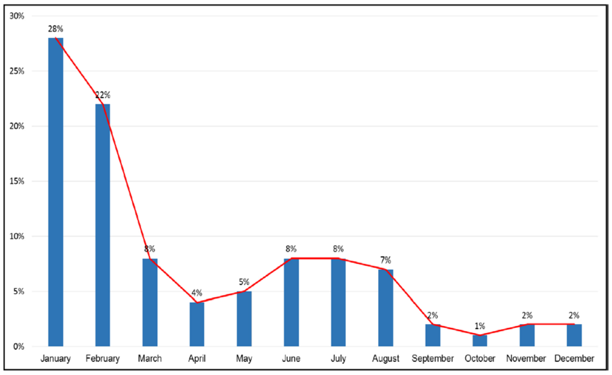

Figure 2. Percentage of DHF per month in Palopo City in 2022.

There was a significant correlation between population density and dengue fever incidence (p=0.001), and the strength of the relationship was moderate with a positive pattern (r=0.444). A positive correlation indicates that the incidence of DHF follows an increase in density. There was no significant correlation between DHF incidence and healthy homes coverage (r=0.135; p=0.359). There was also no significant correlation between poverty and DHF incidence (r=0.123; p=0.402). Health facilities significantly correlated with DHF incidence (p=0.0001) and a strong relationship with a positive pattern (r=0.541). The positive correlation indicates that the longer the distance to health facilities, the higher the DHF incidence. Area elevation had a significant relationship with DHF incidence (p=0.043), and the strength of the relationship was moderate with a negative pattern (r=-0.293). The negative correlation indicates that the higher the area, the lower the incidence of DHF. Population mobility had a significant relationship (p=0.033) and a moderate relationship with a positive pattern. A positive correlation indicates that DHF incidence follows increased mobility (Table 2).

Table 2. Correlation between Population Density, Healthy Home Coverage, Poverty, Health Facilities, Elevation, and Mobility with the DHF incidence in Palopo City in 2022

Variables	Dengue Hemorrhagic Fever	
	R Spearman	p-value
Population Density	0.444	0.001
Healthy Home Coverage	0.135	0.359
Poverty	0.123	0.402
Health Facilities	0.541	0.0001
Elevation	-0.293	0.043
Mobility	0.306	0.033

Figure 3 shows the distribution pattern of dengue fever in areas with very high population density, high population density, medium population density, and low population density. High density influences the incidence of dengue fever, as seen in the map of dengue fever distribution patterns, which tend to be high at very high-density levels (Figure 3a).

There was no effect of dengue fever incidence in areas with high and low coverage of healthy homes. However, the distribution pattern of cases tended to be higher in areas with high coverage of healthy homes (Figure 3b).

The distribution pattern of DHF cases in areas with low, medium, and high poverty rates is the same. Cases tended to be evenly distributed between regions with low, medium, and high poverty rates (Figure 3c).

The buffer on this map is the location of health facilities, namely the Public Health Centre. The analysis results show the distribution pattern of the incidence of most DHF cases located close to the Public Health Centre within a radius of <1 km (Figure 1d)-the pattern of DHF incidence distribution in high, medium, and low altitude areas. There is a tendency for the distribution of DHF incidence to be more prevalent in areas with low elevation categories (Figure 1e).

Figure 1f shows that the incidence of DHF is most prevalent in areas with medium and high levels of mobility.

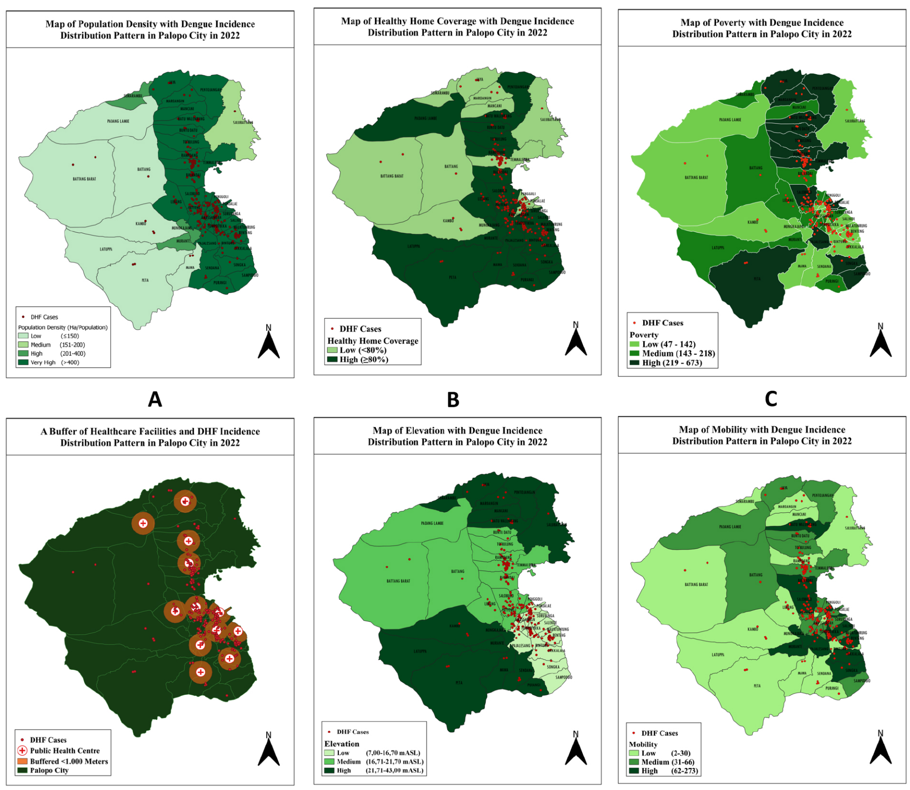

Figure 1. (a) Mapping Population Density with DHF (b) Mapping Poverty with DHF (c) Mapping Healthy Home Coverage with DHF (d) Buffering Map of DHF with Health Facilities (e) Mapping Elevation with DHF (f) Mapping Mobility with DHF Spread Pattern in Palopo City in 2022

DISCUSSION

Of the 247 DHF patients, a higher proportion of females admitted for dengue infection is 145 (58,7 %). This might be attributed to variances in healthcare-seeking habits. Women are known to frequent healthcare providers more often, potentially resulting in a greater detection rate. The increased dengue cases for females are reflected by a study in Tengku Ampuan Rahimah Hospital, Malaysia, which showed that females made up a slight majority of adult dengue cases (9). The highest age groups were 15-44 (49.39 %), which have high levels of mobility compared to other age groups due to work, school, and dense social activities, thus increasing exposure to dengue virus-carrying vectors (10). These results are supported by Mia et al., 2020 (11), a retrospective secondary-data-based study and collected annual data on reported cases of DHF and patients' socio-demographic information in Seremban from 2003-2011 who found incidence rate of dengue was highest in the young adult and the adult group (15-44 years).

These results show that the increase in dengue cases tends to occur at the beginning of the year, which aligns with the Ministry of Health's statement that dengue fever cases often appear in the transitional season, especially in January at the beginning of the year. Climate change is also the cause of high cases at the start of the year when that month is the peak of rainfall, which impacts the discovery of many larvae, which are the source of dengue transmission (12).

Density correlates with the incidence of DHF, where there is a tendency for DHF to be found in areas with high population density. Houses close to each other can facilitate the transmission of DHF disease due to the flight distance of the *Aedes aegypti* mosquito, which is estimated to be around 50-100 meters (13). Population density is followed by a population explosion and increasing housing development, which tends to make places more crowded with water reservoirs (14).

A healthy home is a shelter and a place to rest to foster a perfect physical, spiritual, and social life (15). A healthy house is a house that meets the minimum criteria for access to drinkingwater, suitable flooring, adequate lighting, ventilation, and access to a toilet (16). This study suggests no significant correlation exists between the coverage of healthy homes and the incidence of DHF. The incidence of DHF was found to be high in areas with high coverage of healthy homes (≥80 %). This is due to the complexity of measuring healthy housing coverage indicators. The examination was less than optimal because it did not measure lighting and humidity as the indicators. Similar findings are reported by Nguyen-Tien et al., 2022 (17), who found that patients living in peri-urban districts were less likely to suffer from dengue fever than patients residing in central urban districts. Their study could not find any association with occupation, water storage habits, knowledge, attitude, or practice on dengue prevention.

Poverty is important in causing tropical diseases such as DHF (18). The distribution of DHF in Palopo City is evenly distributed at all poverty levels. This study found that poverty was not associated with the incidence of DHF. This result is similar to the research of Mulligan et al., 2015 (19), a systematic review study found that there is no consistent evidence supporting that poverty is a predictor of dengue occurrence. Although poverty is not adirect factor, it indirectly contributes to the transmission of DHF in an area characterized by poor environmental conditions, inadequate drainage, and poor wastemanagement that supports mosquitoes' breeding as dengue fever vectors.

Distance to health facilities had a significant association with DHF incidence. Buffering of DHF incidence based on the presence of the Public Health Centre showed that most cases were in areas close to health services (<1 000 meters). This study aligns with Susianti et al., 2023 (20), who found from the spatial analysis that DHF patients in the Purwosari District prefer health facilities with comprehensive infrastructures, multiple health centers, and shorter distances from their homes. Pearson correlation analysis highlights distance, duration, and the completeness of health facilities and service quality as the variables with the strongest correlation values (0.629, 0.629, and 0.607, respectively) by the census-based interviews were conducted on individuals who suffered from DHF between 2012 and 2017 in Purwosari District, Gunungkidul Regency. Accessibility to Health care is one of the most important measures in determining the quality of life. With recent aging demographic trends, the need to enhance geospatial analysis capabilities and monitor the accessibility of its citizens to healthcare services has increased. The accessibility to healthcare is determined not only by geographic distances to service locations but also by travel time, available modes of transportation, and departure time. Access to the latest and accurate information regarding healthcare accessibility allows the municipal government to plan for improvements, including expansion of healthcare infrastructure, effective labor distribution, alternative healthcare options for the regions with low accessibility, and redesigning the public transportation routes and schedules. From a social justice perspective, everyone should have the opportunity to access these services equally (21).

Elevation showed a moderate correlation with DHF incidence. The distribution pattern of DHF was mainly found in regions far from sea level. This result has similarities with research by Gyawali et al., 2020 (22), who assessed 25 000 laboratory-confirmed dengue cases from 2010 to 2019 and found a significant negative relationship between dengue incidence and increasing elevation (meters above sea level) driven by temperature, with dengue risk being most significant below 500 m. The risk was moderate between 500 and 1 500 m and decreased substantially above 1 500 m. Altitude variation affects the ecological conditions required by disease vectors (14). *Aedes aegypti*, a vector of dengue hemorrhagic fever, lives at altitudes 0-500 meters from the surface with high vitality (12).

Mobility facilitatestransmission from one place to another. Rapid and uncontrolled urbanization leads toincreased contact with vectors (12). This study showed a moderate correlation between mobility and DHF incidence. The distribution pattern of DHF incidence was mostly in areas with a high level of mobility. This result is in line with Arsin et al., 2021 (23), who examined the correlation of climate factors, including average temperatures, relative humidity, wind speed, and mobility on the incidence of Dengue Hemorrhagic Fever (DHF) in Kendari, Indonesia. They showed a positive correlation between average, relative humidity, and mobility with the incidence of DHF in Kendari in 2014-2018; meanwhile, the wind speed did not show a significant correlation with the incidence of DHF. They concluded that the climate pattern, especially the average temperature, relative humidity, and mobility, should be monitored to control the DHF disease.

CONCLUSIONS

The results of this study showed that there was no correlation between the incidence of DHF and poverty or the coverage of healthy houses. Meanwhile, population density, health facilities, altitude, and mobility were correlated with DHF incidence. The distribution pattern of DHF increased in line with population density; DHF was found in areas close to community health centers, areas close to sea level had a high incidence of DHF, and areas with high altitude had a high incidence of DHF.

REFERENCES

1. Wang WH, Urbina AN, Chang MR, Assavalapsakul W, Lu PL, Chen YH, et al. Dengue hemorrhagic fever - A systemic literature review of current perspectives on pathogenesis, prevention and control. J Microbiol Immunol Infect. 2020;53(6):963-978.
2. WHO. Dengue and Severe Dengue. Geneva; 2023.
3. The Indonesian Ministry of Health. Infodatin: The Situation of Dengue Hemorrhagic Fever in Indonesia. Jakarta; 2023.
4. Natsir N, Arsin A.A, Ishak H, Alimuddin I, Masni M, Alimuddin I, et al. Transmission of Four Serotypes ofDengue Virus in Several Asian Countries Literature Review. Pharmacogn J. 2023;15(6):1-6.
5. South Sulawesi Provincial Health Office. Health Profile of South Sulawesi Province in 2022. Makassar; 2022.
6. Achmadi U. F. Area-based Disease Management. Jakarta: UI Press; 2012.
7. Hasirun. Spatial Model of Risk Factors of Dengue Haemorrhagic Fever in East Java Province in 2014. Thesis. Universitas Airlangga; 2016.
8. Suwandono A. Dangue Update: A Lookat the Journey of Dangue in West Java. I. Aprianita TD, Suhendra F, editors. Jakarta: LIPI Press; 2019.
9. Qinglin L, Ming LZ, Yong TC, Shunmugarajoo AAP, Azmel AB, Yiing YS. Association of Dengue Serotypes and its Complications: A Retrospective Cohort Study. Med J Malaysia. 2023;78(3):372-378.
10. Abualamah WA, Banni HS, Almasmoum HA, Allohibi YA, Samarin HM, Bafail MA. Determining risk factors for dengue fever severity in Jeddah City, a case- control study (2017). Polish JMicrobiology. 2020;69(3):331-7.
11. Mia S, Er AC, Begum RA, Pereira JJ, Ahmed F. Assessing Demographic Distribution of Dengue Infections in Seremban District, Malaysia. Indian J Public Health Research & Development. 2020;11(05):692-698.
12. The Indonesia Ministry of Health. DHF Cases Increase, Ministry of Health Promotes 1 House 1 Jumantik Movement (G1R1J). Kementerian Kesehatan; Jakarta. 2023.
13. Arsin AA. Epidemiology of Dengue Fever (DHF) in Indonesia. Makassar: Masagena Press; 2013.
14. Istiqamah SNA, Arsin AA, Salmah AU, Mallongi A. Correlation Study between Elevation, Population Density, and Dengue Hemorrhagic Fever in Kendari City in 2014 - 2018. J Medical Sci. 2020;8:63-66.
15. The Indonesian Ministry of Health. Healthy Homes Clean Environment. Directorate General of Health. Jakarta. Kementerian Kesehatan. 2023.

16. Indonesia Republic. Government Regulation of the Republic of Indonesia Number 12 of 2021 concerning the Implementation of Housing and Settlement Areas. Jakarta. 2021.
17. Nguyen-Tien T, Do DC, Le XL, Dinh TH, Lindeborg M, Nguyen-Viet H. Risk factorsof dengue fever in an urban area in Vietnam: A case-control study. BMC Public Health. 2021;21:664.
18. Magalhães AR, Codeço CT, Svenning JC, Escobar LE. Neglected tropical diseases risk correlates with poverty and early ecosystem destruction. Infect Dis Poverty. 2023;1:1-15.
19. Mulligan K, Dixon J, Sinn CLJ, Elliot SJ. Is dengue a disease of poverty? A systematic review. Pathogens and Global Health. 2015;109(1):10-18.
20. Susianti NA, Riyanto IA, Ismayuni N, Rizki RLP, Cahyadi A. Geographic Accessibility to Healthcare : Study Case Dengue Fever in Purwosari Sub-District, Gunungkidul Regency, Yogyakarta, Indonesia. Indon J Geogr. 2023;55(2):309-319.
21. Kim Y, Byon Y, Yeo H. Enhancing healthcare accessibility measurements using GIS: A case study in Seoul, Korea. 2018:1-19.
22. Gyawali N, Johnson BJ, Dixit SM, Devine GJ. Patterns of dengue in Nepal from 2010-2019 in relation to elevation and climate Patterns of dengue in Nepal from 2010 - 2019 in relation to elevation and climate. Transactions of the Royal Society of Tropical Medicine & Hygiene. 2021;115(7):741-749.
23. Arsin A.A, Nurul S, Istiqamah A, Elisafitri R, Akbar M, Sirajuddin S, et al. Correlational Study of Climate factor, Mobility and the Incidence of Dengue Hemorrhagic Fever in Kendari, Indonesia. Enfermería Clínica. 2020;30(56):280-284.