Original Article

Althea Medical Journal
ISSN Online: 2337-4330
https://doi.org/10.15850/amj.v11n2.3190

Spatial Autocorrelation of Dengue and Its Relationship with Population Density in South Kalimantan, Indonesia

Norjanah Norjanah,[1] Muhammad Rasyid Ridha[2]
[1]Urban and Regional Planning Study Program, Faculty of Science and Technology, Universitas Terbuka, Indonesia, [2]Organization Research for Health, The National Research and Innovation Agency (BRIN-Indonesia), Cibinong, West Java, Indonesia

Abstract

Background: Dengue is a viral infection transmitted to humans through the bite of *Aedes aegypti* and *Ae. Albopictus* mosquitoes. Demographic factors that may influence the development and prevalence of dengue cases include variations in population density, community characteristics, and economic and social demographics. This study aimed to determine the distribution, spatial autocorrelation, and relationship between population density and dengue.

Methods: Secondary data analysis was conducted in South Hulu Sungai Regency, South Kalimantan, Indonesia. Data on dengue cases, population density for each district, and base maps were collected to and then be used as analysis material. Spatial autocorrelation was analyzed using the Moran's index and Local Spatial Autocorrelation Index (LISA), then the correlation of population density with dengue was carried out using linear regression.

Results: Spatial Autocorrelation had positive autocorrelation and clustered spatial patterns in 2017 and 2018; whereas in 2019-2021 was negative and the spatial pattern was spread. There was a decrease in cases from high to low (HL) in Kandangan District in 2021, which was previously high to high (HH) in 2017–2019. There was a correlation between population density and dengue (R-value=0.448) with a moderate category.

Conclusions: Dengue cases are more widespread in Kandangan. The spatial autocorrelation of dengue that occurs between sub-districts in South Hulu Sungai Regency is due to sub-districts location in the city center. There is a correlation between dengue and population density. Therefore, controlling dengue should be prioritized in the city center area first to break the chain of dengue transmission between sub-districts in South Hulu Sungai Regency.

Keywords: Dengue, spatial autocorrelation, spatial pattern, population density

Althea Med Journal. 2024;11(2):113–119

Received: March 17, 2023
Accepted: April 15, 2024
Published: June 30, 2024

Correspondence:
Norjanah, S.PWK
Urban and Regional Planning Study Program, Faculty of Science and Technology, Universitas Terbuka, Indonesia.
Balanti Village, Kalumpang Sub-district, Kandangan., South Kalimantan, Indonesia

E-mail:
norjanah1414@gmail.com

Introduction

An infected mosquito transmits dengue virus (DENV) to humans through its bite, and *Aedes aegypti* is the main vector of this disease.[1,2] The fastest-growing mosquito in the world infects 390 million people every year.[3] The distribution of dengue cases is found in tropical and subtropical areas.[4] Although this mosquito can thrive in natural containers such as the hollows of bromeliad trees, the mosquito is now well adapted to urban habitats, especially in man-made containers such as old clay pots that are dry and weather-worn. Dengue fever has become a dangerous disease in densely populated urban centers.[5] *Aedes albopictus* is a secondary vector of the dengue virus and prefers breeding sites near dense vegetation, including plantations associated with a high risk of rural workers such as rubber and oil palm plantations, but is also common in urban areas.[6]

According to the World Health Organization (WHO), dengue fever cases doubled from 24 million in 2010 to 52 million in 2019. The global incidence of dengue fever has increased dramatically, affecting about half of the world's population. Between 100 million and 400 million people are infected each year, more than 80% of whom are usually mild and asymptomatic.[7] Dengue fever cases in Indonesia, with a cumulative number of confirmed cases from January 2022, were reported as many as 87,501 cases (Incidence Rate (IR) 31.38/100,000 population) and 816 deaths (case fatality rate (CFR) 0.93%). South Kalimantan is a dengue-endemic area with cases reaching 764, a far increase compared to 2021, which was only 201 cases. One of the districts in South Kalimantan that has a high case rate of dengue is South Hulu Sungai Regency which ranks 3rd in cases of dengue. [8,9]

Factors that can influence the increasing and spreading of dengue cases include environmental factors such as geographical (weather and climate) and demographic (dynamics of population density, social, economic demographic), and pathogenic factors as well as the host factor.[10] Population density affects the number of houses and indirectly, if it is accompanied by the behavior of littering and not closing water reservoirs, it will become a habitat for mosquitoes.[11] The high number of mosquitoes provides a high potential for dengue transmission as well.

The population density affects the incidence of dengue every year with a strong value of a moderate relationship, this is because people tend to group and gather in one location.[12] The risk of infection in the community also depends on the knowledge about dengue and the implementation of daily vector control activities.[13] Therefore, this study aimed to determine the distribution, spatial autocorrelation, and relationship between population density and dengue. This study is expected to provide an overview of the pattern of distribution of cases and mitigation measures for controlling dengue fever.

Methods

This quantitative analytical study used a time trend ecological research design to examine the correlation of population density with dengue cases. The population of this study was the population in the South Hulu Sungai region and dengue cases were all confirmed dengue cases from the Public Health Center reported to the South Hulu Sungai Regency Health Office.

The secondary survey data were employed. Data on dengue cases per district per month in the period 2017–2021 were obtained

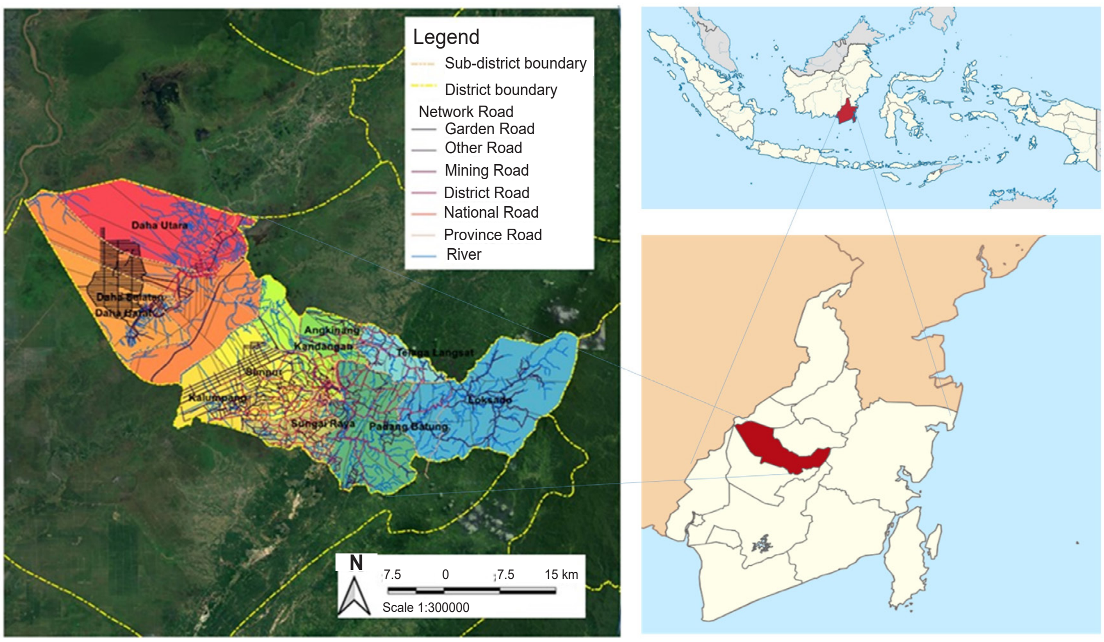

Figure 1 Map of South Hulu Sungai Regency, South Kalimantan Province, Indonesia

from the South Hulu Sungai Regency Health Office. Meanwhile, data on population density per district were obtained from the *Badan Pusat Statistik (*BPS-Statistic Indonesia). This research has received approval from the National Unity and Politics Agency of South Hulu Sungai Regency with Number 070/145/B-Kesbangpol.

In brief, about the location of South Hulu Sungai Regency; this area consisted of 15 districts and 144 villages. Astronomically, South Hulu Sungai Regency was located between 02^{0}29'58" to 02^{0}56'10" South Latitude and 144^{0}51'19" to 115^{0}36'19" East Longitude. The administrative boundaries of South Hulu Sungai Regency were as follows: to the north it bordered North Hulu Sungai Regency and Central Hulu Sungai Regency, to the south it bordered Tapin Regency, to the east it bordered Central Hulu Sungai Regency and Kota Baru Regency, and to the west it bordered North Hulu Sungai Regency and Tapin Regency (Figure 1).

The collected data were analysed with Geographic Information System (GIS) using QGIS 3.22.10 and GeoDA version 1.6 to determine the distribution of dengue cases and population size. Spatial autocorrelation analysis in this study used two methods, namely the global Moran's index and the Local Indicator of Spatial Autocorrelation (LISA). Global spatial autocorrelation or Global Moran's Index was a measuring tool for calculating global spatial autocorrelation, showing grouped or random relationships.[14] The relationship between population density and dengue was analysed by simple linear regression, using statistical data processing software.

Results

The results of the study showed that the most dengue cases were in the Kandangan and Simpur district which were also district with high population density, whereas the lowest cases were in the Loksado. The highest case data in 2018 were 396 cases, while the lowest cases were in 2021 with 4 cases (Table 1).

The distribution of dengue cases was known to be close to neighboring districts such as Kandangan, Simpur, Sungai Raya, and Padang Batung. In 2018, there were 35–70 cases in Simpur, Sungai Raya, and Padang Batung districts, while Kandangan districts had 70–105 cases. The density category in Kandangan district was at very high density, Sungai Raya district has high density, Simpur district had medium density, and Padang Batung district had low density (Figure 2).

The results of the global Moran's Index test showed a positive and negative correlation between sub-regions in the number of annual dengue cases over the last five years (2017–2021), indicating similarities in the characteristics of dengue cases in adjacent sub-regions or a relationship between dengue cases that occurred in spatial clusters (Table 2).

The relationship between the number of dengue cases for the high-high (HH) indicator was the highest in 2 districts in 2017 and 2018, and 1 district in 2019. Meanwhile, for the low-high (LH) indicator, the highest was in

Table 1 Annual Dengue Fever Cases and Population Density by District in South Hulu Sungai Regency for the Period 2017–2021

District	2017		2018		2019		2020		2021	
	D	P	D	P	D	P	D	P	D	P
Padang Batung	4	105	40	106	29	107	9	105	-	106
Loksado	-	27	2	27	-	28	-	25	-	25
Telaga Langsat	-	170	26	172	26	175	-	176	-	178
Angkinang	2	310	35	313	17	316	31	318	-	322
Kandangan	13	476	86	481	68	486	6	458	2	461
Sungai Raya	5	219	41	221	15	223	3	223	-	226
Simpur	5	180	102	181	66	182	32	185	-	187
Kalumpang	1	47	10	48	9	48	-	48	-	49
South Daha	6	133	33	135	24	137	6	126	-	127
West Daha	-	54	19	54	1	55	11	53	-	54
North Daha	2	124	2	126	15	128	6	119	2	120
Total	38	129	396*	130	270	132	104	126	4**	127

Note: D=dengue case, P=population density (people/km^2), * The highest data cases in 2018 (n=396 cases) ** The lowest data cases in 2021 (n= 4 cases) (Source: BPS-Statistic Indonesia, 2022)

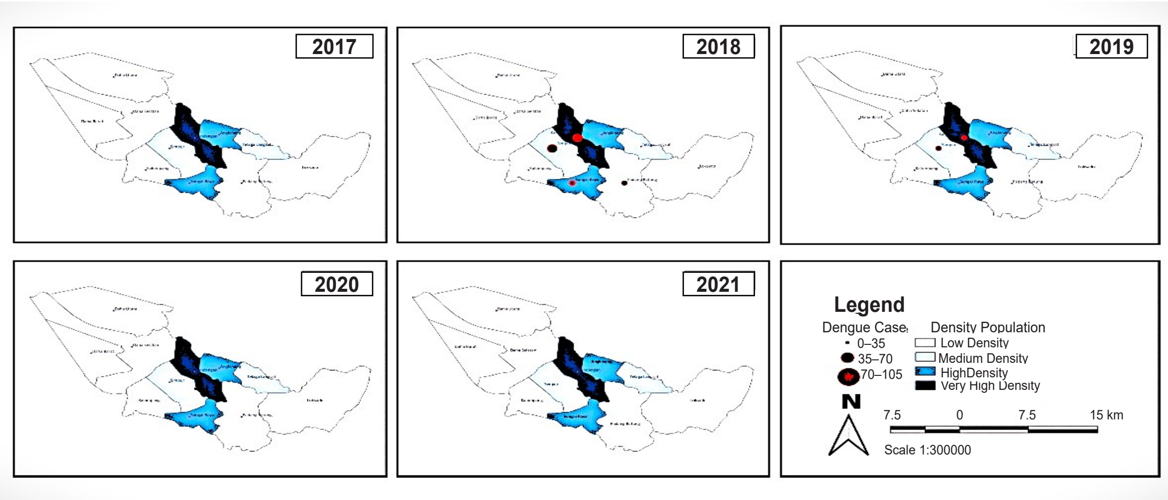

Figure 2 Overlays of Population Density with Dengue Cases in South Hulu Sungai Regency in 2017–2021

Table 2 Spatial Autocorrelation (Moran's Index) of Dengue Fever

Years	Moran's Index	Spatial Pattern
2017	0.059	Positive autocorrelation, clustered spatial patterns
2018	0.097	Positive autocorrelation, clustered spatial patterns
2019	-0.019	Negative autocorrelation, spatial pattern spread
2020	-0.220	Negative autocorrelation, spatial pattern spread
2021	-0.159	Negative autocorrelation, spatial pattern spread

Table 3 Relationship between Population Density and Dengue Cases

R	R Square	Adjusted R Square	F	Sig.	Unstandardized Coefficients
0.448[a]	0.201	0.182	10.539	0.002[b]	4.245[b]

Note: a= Dependent Variable: dengue case, b= Predictors: (Constant), Population Density

3 districts in 2021 (Figure 3).

There was a correlation between dengue and population density (p=0.02) with a correlation coefficient of 0.448 (moderate category). The resulting coefficient of determination (R Square) was 20.1%, indicating that 79.09% was influenced by factors other than population density (Table 3).

Discussion

South Hulu Sungai Regency is one of the endemic areas for dengue in South Kalimantan Province, Indonesia, considering that dengue cases occur every year and are spread across all sub-regions. Based on the results of the study, the incidence of dengue fever in South Hulu Sungai Regency has decreased in the last five years (2017–2021). The highest spike in dengue morbidity rates occurred in 2019. In general, the decline is thought to be due to the absence of case surveillance and full hospitals due to COVID-19 cases, as reported in Thailand[15] and Guangzhou, China.[16] The national dengue report noted that dengue cases started to decline in 2020–2021. However, Kandangan and Simpur districts showed high cases in the 2- and 3-year periods.

The study's findings prove that there is an influence between population density and dengue incidence. Overall, these findings show that increasing population density has contributed to the increase in the incidence of dengue fever as reported in several densely populated districts in other parts of Indonesia,[17] Sri Lanka,[18] and Bangladesh.[19]

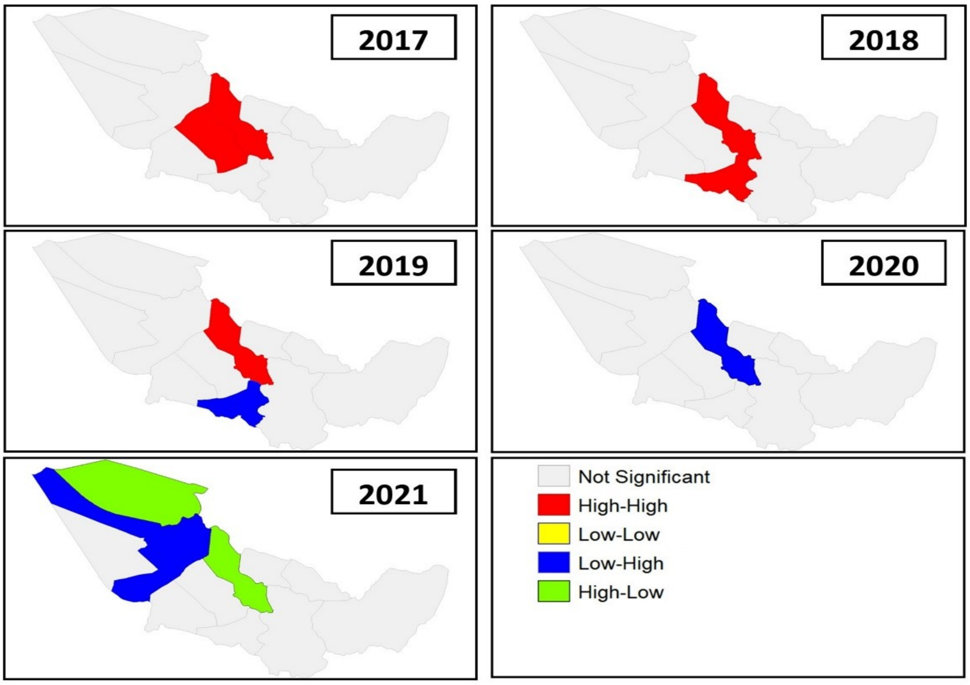

Figure 3 Cluster Map (a) LISA of Dengue case in South Hulu Sungai Regency (2017–2021)

This research data was analyzed using the Global Moran Index as a spatial autocorrelation indicator to assess the distribution pattern of dengue cases in South Hulu Sungai Regency over the past 5 years. The results of the analysis showed that the global Moran index value in 2017 and 2018 is greater than zero, indicating positive autocorrelation between sub-districts for the number of annual dengue cases over the last 5 years and cumulatively. In addition, dengue transmission between districts occurred in groups. Risk factors for dengue transmission in surrounding sub-districts also influence the increase in cases and distribution patterns of dengue transmission in all districts in South Hulu Sungai Regency. This is consistent with previous research in South Hulu Sungai Regency also for the 2011–2015 period,[20] as well as in various other places in Indonesia such as Bali[21] and Jakarta.[22] However, in 2019, 2020, and 2021 show negative autocorrelation, which indicates that adjacent locations have different values and tend to spread.[23]

Since spatial autocorrelation with the Morans global index method only analyzes the correlation between dengue incidents in urban administrative areas, not between neighborhoods or streets, therefore, an analysis was also conducted using the local spatial autocorrelation index (LISA) method to determine the spatial correlation between dengue incidents in a location or region.[24] Based on the analysis results, the highest population type (HH) segmentation is found in Kandangan, Simpur, and Sungai Raya districts. The HH indicator shows that these three areas are dengue outbreak areas and can affect the surrounding areas. Therefore, these three areas are considered very vulnerable to dengue cases and need higher level case management interventions.

More interestingly, the sub-district with HH index borders the Central Hulu Sungai district which is densely populated and very spread out, while the sub-district with the LL index is on the outskirts. The results showed that dengue cases have increased in the last five years, especially in the central region, while cases are fewer in sub-counties located on the southern border, similar to the study in Guangdong–China where the cluster with the highest relative risk (RR) for dengue is located in downtown of Guangzhou.[16] This explains that the rate of movement of the population in urban areas is very high, in favor of the phenomenon of the transmission of dengue fever between regions. In addition, since the South Hulu Sungai region borders other neighboring regions, rapid communication is require between sub-districts in other regions in the form of clinical notifications and vectors for local risk management mapping and disease detection can be controlled earlier.[25]

The main factor influencing the transmission of dengue is the large number of habitats for dengue vector mosquitoes (*Ae. aegypti,* and *Ae. albopictus*) around residential areas. If the dengue vector is found around the house, the risk of contracting dengue fever is 4–8 times greater compared to in a mosquito-free house.[26] This is because *Ae. aegypti* prefers man-made clean water reservoirs around residential areas to grow and reproduce. This explanation indicates that *Ae. aegypti* is not a species of mosquito that likes to fly far to find its host's blood and lay eggs. Usually, *Ae. aegypti* only moves between rooms where the mosquitoes grow to maturity, such as bedrooms, living rooms, or bathrooms. However, when *Ae. aegypti* does not find host blood or a place to reproduce in the house, the mosquitoes have the ability to fly as far as 50 m to 50 km with an average of 25 m to 6 km to find these two things.[27]

The proximity of mosquito flight abilities is also influenced by physiological factors, landscape (vegetation), and climate (rainfall, temperature, and humidity). However, in general, *Aedes spp.* mosquitoes can flight far at temperatures above 15 °C and humidity levels of around 80%.[27] Climate variability in South Hulu Sungai Regency strongly supports the bionomics of *Aedes spp.* mosquitoes to reproduce, grow, and fly for blood, namely the temperature in the range of 19.5–31.7 °C and humidity in the range of 51–87%.[28] This increases the risk factors for dengue transmission.

The distance between one sub-district center and the surrounding sub-district centers in South Hulu Sungai Regency ranges from 0.5–7.1 km. This distance is within the flying radius of *Ae. aegypti's* flying range. In addition, in several sub-districts in South Hulu Sungai Regency, it was reported that the larval-free index (LFI) value was still below 95%. If the LFI value is below the national standard, then the area still has the potential for dengue transmission to occur.[29] Therefore, the existence of Ae. aegypti in one sub-district can carry the dengue virus to other sub-districts, so that dengue can spread sporadically among sub-districts in South Hulu Sungai Regency.

The limitation of this study is that the analysis is only at the subdistrict level. Analysis at the village level would provide more in-depth information on the relationship with population density, hence, requiring more detailed data recording in the reporting system. In the future, analysis of the relationship with climate patterns can also be carried out for seasonal intervention.

In conclusion, dengue cases are generally distributed in densely populated areas. Spatial autocorrelation of dengue fever that occurs between sub-districts in South Hulu Sungai Regency is caused by the group of sub-districts in the city center. Therefore, dengue control efforts should be prioritized in the city center area first. If dengue cases in this area decrease, it is very likely that it will break the chain of transmission between regions in South Hulu Sungai Regency. In addition, a Campaign on the Prevention and Control of Dengue are encouraged at schools and community.

References

1. Weeraratne TC, Perera MDB, Mansoor MACM, Karunaratne SHPP. Prevalence and breeding habitats of the dengue vectors *Aedes aegypti* and *Aedes albopictus* (Diptera: Culicidae) in the semi-urban areas of two different climatic zones in Sri Lanka. Int J Trop Insect Sci. 2013;33(4):216–26.
2. Yang CF, Hou JN, Chen TH, Chen WJ. Discriminable roles of Aedes aegypti and Aedes albopictus in establishment of dengue outbreaks in Taiwan. Acta Trop. 2014;130:17–23.
3. Fredericks AC, Fernandez-Sesma A. The burden of dengue and chikungunya worldwide: implications for the southern United States and California. Ann Glob Health. 2014;80(6):466–75.
4. Fatima SH, Atif S, Rasheed SB, Zaidi F, Hussain E. Species distribution modelling of *Aedes aegypti* in two dengue-endemic regions of Pakistan. Trop Med Int Health. 2016;21(3):427–36.
5. Ridha M, Sulasmi S. Larval survey of the dengue-endemic area in Samarinda: guide to determine risk containers. Int J Public Health Sci. 2022;11(4):1176–83.
6. Champion SR, Vitek CJ. Aedes aegypti and Aedes albopictus habitat preferences in South Texas, USA. Environ Health Insights. 2014;8:EHI--S16004.
7. Tsheten T, Gray DJ, Clements ACA, Wangdi K. Epidemiology and challenges of dengue surveillance in the WHO South-East Asia Region. Trans R Soc Trop Med Hyg. 2021;115(6):583–99.
8. Harapan H, Michie A, Yohan B, Shu PY, Mudatsir M, Sasmono RT, et al. Dengue viruses circulating in Indonesia: a systematic review and phylogenetic

analysis of data from five decades. Rev Med Virol. 2019;29(4):e2037.
9. Gani H, Maharja R, Salcha MA, Gani H, Wardhani N, Nurani N, et al. Dengue hemorrhagic fever incidence in Indonesia using trend analysis test and spatial visualization. Int J Public Health. 2022;11(4):1190–201.
10. Rahman MS, Ekalaksananan T, Zafar S, Poolphol P, Shipin O, Haque U, et al. Ecological, social, and other environmental determinants of dengue vector abundance in urban and rural areas of northeastern Thailand. Int J Environ Res Public Health. 2021;18(11):5971.
11. Khalid B, Bueh C, Ghaffar A. Assessing the Factors of Dengue Transmission in Urban Environments of Pakistan. Atmosphere (Basel). 2021;12(6):773.
12. Muhammad RNYBM, Isfandiari A. Correlation of free larvae index and population density with dengue fever incidence rate. Indones J Public Health. 2022;17(3):477–87.
13. Sulistyawati S, Dwi Astuti F, Rahmah Umniyati S, Tunggul Satoto TB, Lazuardi L, Nilsson M, et al. Dengue vector control through community empowerment: lessons learned from a community-based study in Yogyakarta, Indonesia. Int J Environ Res Public Health. 2019;16(6):1013.
14. Anselin L. GeoDa (Spatial Statistical Program). Encycl Res Methods Criminol Crim Justice. 2021;2:839–41.
15. Prasertbun R, Mori H, Mahittikorn A, Siri S, Naito T. Pneumonia, influenza, and dengue cases decreased after the COVID-19 pandemic in Thailand. Trop Med Health. 2022;50(1):1–4.
16. Jiang L, Liu Y, Su W, Liu W, Yang Z. Decreased dengue cases attributable to the effect of COVID-19 in Guangzhou in 2020. PLoS Negl Trop Dis. 2021;15(5):e0009441.
17. Istiqamah SNA, Arsin AA, Salmah AU, Mallongi A. Correlation study between elevation, population density, and dengue hemorrhagic fever in Kendari City in 2014–2018. Open Access Maced J Med Sci. 2020;8(T2):63–6.
18. Sirisena P, Noordeen F, Kurukulasuriya H, Romesh TA, Fernando L. Effect of climatic factors and population density on the distribution of dengue in Sri Lanka: a GIS based evaluation for prediction of outbreaks. PLoS One. 2017;12(1):e0166806.
19. Sharmin S, Glass K, Viennet E, Harley D. Interaction of mean temperature and daily fluctuation influences dengue incidence in Dhaka, Bangladesh. PLoS Negl Trop Dis. 2015;9(7):e0003901.
20. Kusairi A, Yulia R. Mapping of dengue fever distribution based on Indonesian National Standard Cartography Rules as an Prevention Indicator of Outbreaks. J Pendidikan IPA Indonesia. 2020;9(1):91–6.
21. Dhewantara PW, Marina R, Puspita T, Ariati Y, Purwanto E, Hananto M, et al. Spatial and temporal variation of dengue incidence in the island of Bali, Indonesia: an ecological study. Travel Med Infect Dis. 2019;32:101437.
22. Prasetyowati H, Dhewantara PW, Hendri J, Astuti EP, Gelaw YA, Harapan H, et al. Geographical heterogeneity and socio-ecological risk profiles of dengue in Jakarta, Indonesia. Geospat Health. 2021;16(1).
23. Hafeez S, Amin M, Munir BA. Spatial mapping of temporal risk to improve prevention measures: a case study of dengue epidemic in Lahore. Spat Spatiotemporal Epidemiol. 2017;21:77–85.
24. Anselin L, Li X, Koschinsky J. GeoDa, from the desktop to an ecosystem for exploring spatial data. Geogr Anal. 2022;54(3):439–66.
25. Guo P, Liu T, Zhang Q, Wang L, Xiao J, Zhang Q, et al. Developing a dengue forecast model using machine learning: A case study in China. PLoS Negl Trop Dis. 2017;11(10):e0005973.
26. Ong J, Aik J, Ng LC. Adult Aedes abundance and risk of dengue transmission. PLoS Negl Trop Dis. 2021;15(6):e0009475.
27. Bargielowski I, Kaufmann C, Alphey L, Reiter P, Koella J. Flight performance and teneral energy reserves of two genetically-modified and one wild-type strain of the yellow fever mosquito Aedes aegypti. Vector-Borne Zoonotic Dis. 2012;12(12):1053–8.
28. Kaufmann C, Collins LF, Brown MR. Influence of age and nutritional status on flight performance of the Asian tiger mosquito Aedes albopictus (Diptera: Culicidae). Insects. 2013;4(3):404–12.
29. Muhammad Rasyid Ridha, Liestiana Indriyati, Juhairiyah, Budi Hairani, Jusniar Ariati HK. Implementasi model juru pemantau jentik (Jumantik) dalam pengendalian vektor demam dengue pada masyarakat heterogen. Jakarta: BRIN; 2022.