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Research

Malaria Surveillance Mapping in Yogyakarta Special Region, Indonesia

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ABSTRACT

Background: Kulon Progo is one of contributing malaria cases in Indonesia and eliminating incidence malaria still unsolved problem in Indonesia. This study aims to analyze the relationship between mosquito breeding sites, the distribution of malaria cases through Arc-GIS specifically for buffering and spatial analysis in Kulon Progo Regency from 2015 to 2021.
Subjects dan Method: This descriptive research retrospective approach was conducted from secondary data on malaria cases in Kulon Progo between 2015 and 2021. The variable research in this study are positive malaria cases diagnosed using the traditional method of thick blood and thin smear. The sampling technique in this study used total sampling, in totally 265 cases were included. The Data on malaria cases in Kulon Progo Health Office were used as instruments to develop the spatial map and questionnaires served as a confirmation sheet for demographic characteristic. GPS (Global Positioning System) 10.3 used to determine the coordinates of malaria cases. Data on malaria cases are presented in a six-year time series. Area classification using Arc-GIS 10.1 software with buffer analysis and visualization data was utilized to determine the distribution pattern of malaria.
Results: Incidence declined sharply 23.9 to 0.4 cases per 100,000 in 2015 to 2021. The purely cluster of malaria cases trend were in the watershed area at a distance of <250 meters in Kokap Sub-district. Malaria cases were mostly found in rice fields with a distance of <250 meters in Samigaluh Sub-district. All malaria cases were in the garden areas of <250meters in Nanggulang and the forest area of >250 meters in the Kalibawang Sub-district.
Conclusion: Probability of malaria transmission are rivers, rice fields and gardens. It is necessary to hold training on the use of the Arc-GIS application for surveillance officers.

Keywords: Gis, malaria, mapping, surveillance.

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BACKGROUND

Malaria is caused by a parasite called plasmodium, which enters the human body through the bite of the Anopheles sp. Mosquito (Samson et al., 2016; MMV, 2018; WHO, 2021). Globally, the number of malaria cases is increased from 227 million in 2019 to 241 million in 2020. Africa has the highest number of malaria cases (92%) and followed by Southeast Asia (5%) and the

Mediterranean (2%). It is estimated that 15 African countries and India account for 80% of malaria deaths. Globally, of malaria cases accounted the burden in Nigeria (27%), the Democratic Republic of the Congo (12%), Mozambique (5%), Uganda (4%), India (4%), and South-East Asia Region (2%) in 2020 (WHO, 2020; WHO, 2021).

In Indonesia there was a decrease of malaria cases in high endemic areas in 2014, from 16% in 2012 to 11% in 2014. Furthermore, the proportion of low-endemic areas went down from 68 % to 67 % in 2014. As a result, precautionary control must always be implemented because a low endemic area can become a high endemic area. The prevalence of malaria cases has decreased from 1.3% in 2013 to 0.6% in 2017 (Ministry of Public Health Indonesia, 2018). Kulon Progo are located in Yogyakarta Indonesia that consistently contributes high malaria cases. The total malaria cases in Kulon Progo was fluktuative which is 87 cases in 2014, 122 cases in 2015, 96 cases in 2016, 84 cases in 2017, 30 cases in 2018, 16 cases in 2019, 7 cases in 2020, and 2 cases in 2021 (Public Health Bantul District Departement, 2018; Public Health Kulon Progo District Departement, 2020). But many surveillance activities in Kulon Progo do not include an incident risk map (Public Health Kulon Progo District Departement, 2020). As a consequence, many policies and procedures focus on the administrative scope and leaving the risk area out of the spotlight.

Epidemiological studies should be concerning the actual location and must reflect where the risks factor of disease, so the prevention policies will be giving the accurate response and solution of the study's findings. The Arc-GIS can be used to create a picture of the incidence or prevalence of health problems in a population (Hanifati et al., 2018; Khashoggi and Abdulkader, 2020). Noticing the distribution pattern of infectious diseases can be a key health policy if the surveillance activities are active down to buffer analysis (Shirayama et al., 2009; Zayeri et al., 2011; Hasyim et al., 2018; Rezaianzadeh et al., 2020) This study aims to analyze the relationship between mosquito breeding sites, the distribution of malaria cases through Arc-GIS specifically for buffering and spatial analysis in Kulon Progo Regency from 2015 to 2021.

SUBJECTS AND METHOD

1. Study Design

The objective of this study was to assess a pattern of malaria case distribution using surveillance data, with an indication of the results of malaria diagnosis in Kulon Progo District from 2015 to 2021 and the implementation of Arc-GIS as a medium for strengthening the surveillance system and mapping of malaria case clusters in Kulon Progo District. This is descriptive study applied in a retrospective approach.

2. Population and Sample

Secondary data on malaria cases in Kulon Progo Health Office from 2015 to 2021 were used. The sampling technique of this study used total sampling that confirmed stratified to API (Lwanga and Lemeshow, 1991). Therefore, 265 cases were included.

3. Study Variables

The main variable research in this study is positive malaria cases in Kulon Progo District between 2015 and 2021.

4. Operational Definition of Variables

Malaria: cases diagnosed using traditional method of thick blood and thin smear in Kulon Progo District between 2015 and 2021 based on secondary data from the Kulon Progo Health Office.

5. Study Instruments

Data on malaria cases in Kulon Progo Health Office from 2015 to 2021 were used as instruments to develop the spatial map of the Kulon Progo Regency and the questionnaires served as a confirmation sheet for demographic characteristic. GPS (Global Positioning System) 10.3 used to determine the coordinates of malaria cases.

6. Data Analysis

The results of descriptive and analytic data are presented in incidence rate, frequencies, percentages, and maps. Maps present the endemicity of malaria cases by sub-district. Data on malaria cases are presented in a six-year time series. Area classification using Arc-GIS 10.1 software with buffer analysis and visualization data was utilized to determine the distribution pattern of malaria in rivers, gardens, rice fields, and forest areas that have the potential as breeding places for malaria mosquitoes.

7. Research Ethics

This secondary data analysis research protocol was approved by the ethics committee of Universitas Ahmad Dahlan No. 011906057.

RESULTS

1. Incidence rate and Spatial Trends

A total of 265 case are included in this research. Meanwhile, the distribution pattern based on incidence rate shows that the highest was in 2015 with 98 cases (41%), as mentioned in (Table 1).

Table 1. Incidence of malaria spatial in Kulon Progo (Case/100,000)

Time	Frequency	Incidence rate
2015	98	23.9
2016	78	18.9
2017	56	13.4
2018	30	7.3
2019	16	3.7
2020	7	1.5
2021	2	0.4
Total	**265**	**100**

Table 2. Demographic of malaria cases in Kolon Progo, 2015-2021

Variable	Category	Frequency	Percentage
Gender	Man	165	58.3%
	Woman	100	41.7%
Age (Year old)	0-5	12	5%
	6-11	19	7.9%
	12-25	50	20.8%
	26-45	66	27.5%
	46-65	70	28.7%
	≥65	24	10%
Occupation (Not labor force)	Housewife	28	11.7%
	Student/unemployed	45	18.8%
	Children	18	7.5%
Occupation (Labor force)	Farmer	114	47.5%
	Labor	13	5.4%
	Entrepreneur	18	7.5%
	Civil servant/teacher	4	1.7%

In terms of distribution characteristics, most malaria cases were experienced by men (58.3%), aged 46-65 years (28.7%), and working as farmers (47.5%) wich is presented in (Table 2).

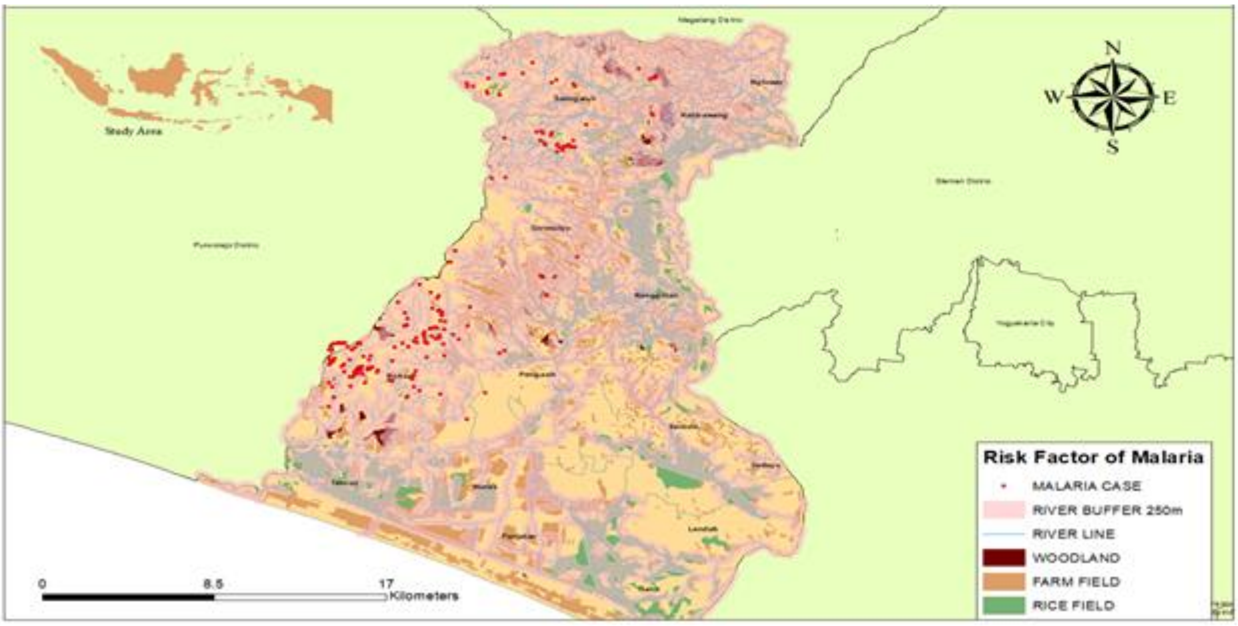

Figure 1. The Location river of the detected spatial clusters of woodland malaria cases in Kulon Progo Regency from 2015 to 2021

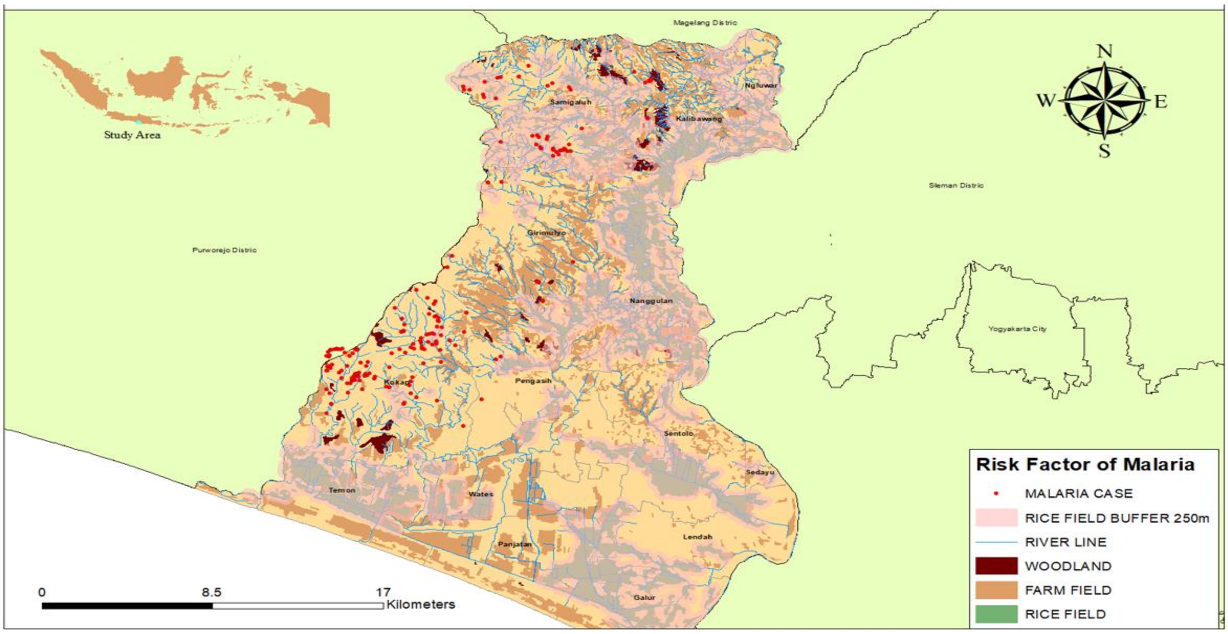

Figure 2. The Location rice field of the detected spatial clusters of woodland malaria cases in Kulon Progo Regency from 2015 to 2021

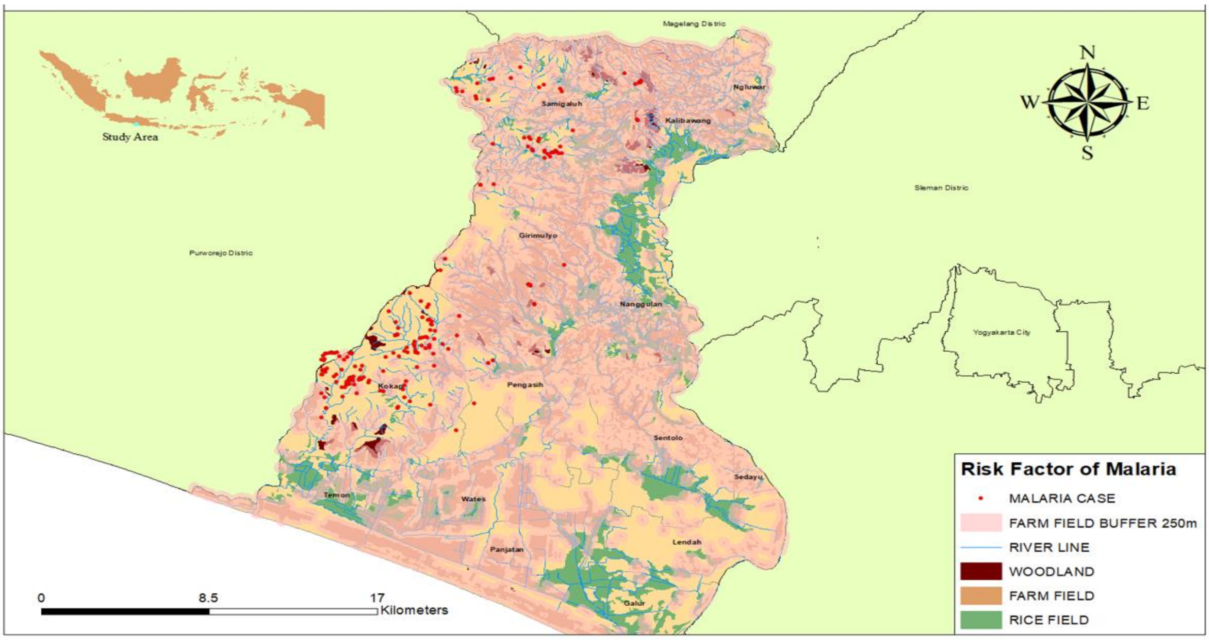

Figure 3. The Location farm field of the detected spatial clusters of woodland malaria cases in Kulon Progo Regency from 2015 to 2021

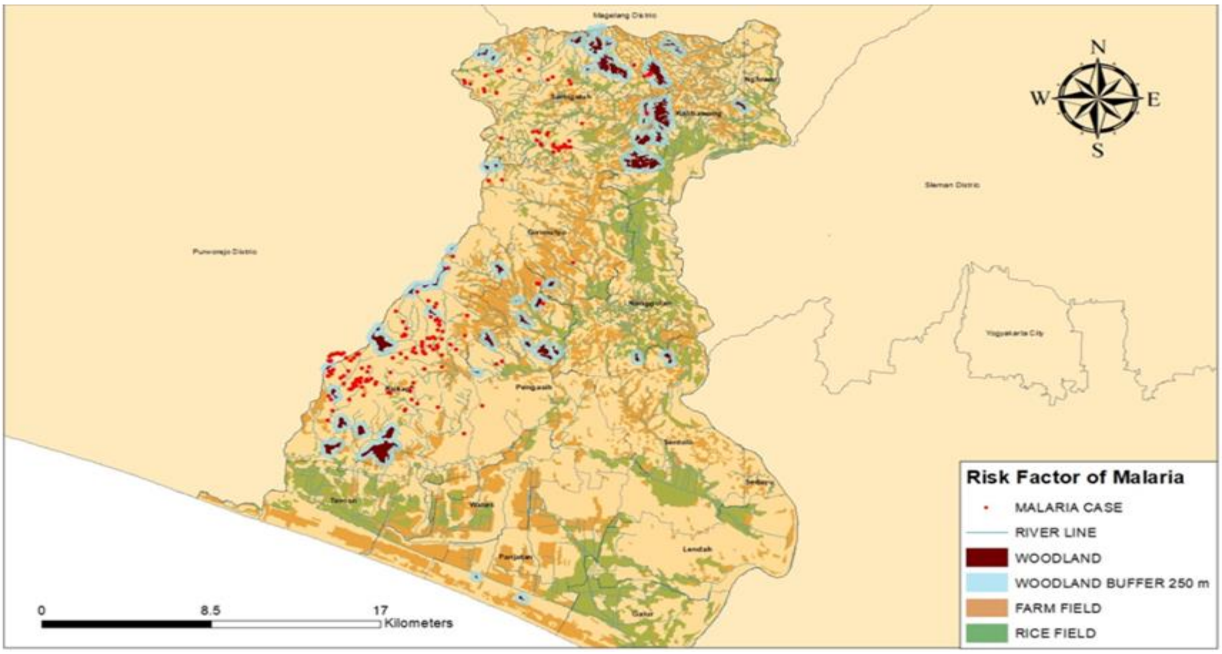

Figure 4. The Location forest of the detected spatial clusters of woodland malaria cases in Kulon Progo Regency from 2015 to 2021

1. Spatial Analysis

The implementation of the use of Arc-GIS is useful as evidenced by the clustering of the distribution of malaria cases in Kulon Progo. The results of spatial analysis on the distribution pattern of malaria cases illustrate the trends of malaria cases in the rice filed area of <250 meters of river in the Kokap Sub-district (Figure 1). Meanwhile, cases were discovered far from high-risk areas such as rivers and gardens.

More cases, however, were noticed at <250 of rice field in Kulon Progo, as demonstrated in (Figure 2). Those cases were also discovered in the farm field areas at a distance of <250 meters after buffering was completed in Kulon Progo (Figure 3). Furthermore, exhibits that malaria cases were identified far from river areas, gardens, and rice fields, but close to forest areas at a distance of <250 meters in Kulon Progo (Figure 4).

DISCUSSION

Malaria cases in Kulon Progo has been viewed through three different perspectives: the spatial, incidence rate, and demographic. Analysis confirmed of the incidence of malaria cases based on time shows that overall trend has decreased between 2015 to 2021 from 23.9 per 100.000 to 0.4 per 100.000 (Table 1), with the most cases found in Kokap Sub-district (Figure 1). In this surveied, almost malaria cases age highest than 46-64 years old because activities daily close to river, rice field and forest. it was observed through the demographic survey that the major was engaged in activities like farmer (Chaiphongpachara et al., 2018).

As (figure 1) demonstrates that the results of the cluster spatial analysis have revealed that the zone with the highest cases of malaria is the Kokap Sub-district area. Based on geographic, Kokap sub-district is close to river as of spatial analysis and buffering show that the radius of distribution of case location to the place potential as risk factors (Rohani et al., 2011; Ndiath et al., 2014). In this study, the buffering was performed with a radius <250 meters to determine the approximate size limit or radius of the nearest or farthest location from the case with a potential breeding place for Anopheles sp mosquitoes (Ndiath et al., 2014; Rezaianzadeh et al., 2020). Moreover, breeding place different species occupy disparate habitats trend to be associated with river and forest habitats (Sriwichai et al., 2015; Chaiphongpachara et al., 2018) (Figure 1) depicts the results of this research, which show that the spatial pattern of the highest malaria case cluster in Kulon Progo from 2015 to 2021 is adjacent to the river basin area.

The results of this study indicate that the spatial trend pattern of malaria cases is in the river flow area <250 meters. Based on river buffers, rivers can be seen to be a risk factor for malaria transmission. It has been discovered that mosquitoes can lay their eggs in rivers, puddles, and dammed water bodies. Because water is required for the oviposition and breeding stages of mosquito larvae, mosquito density is higher during the rainy season than during the dry season, resulting in seasonal malaria epidemiology (Olalubi et al., 2020). Anopheles larvae breed in rivers, ditches, and habitat within a radius of 0.5–2 km of the homes of malaria-positive sufferers (Gómez-Barroso et al., 2017; Kifle et al., 2019). The reproductive habitat of Anopheles sp is in seepage or flow from the river to the surrounding environment and forms puddles (Gómez-Barroso et al., 2017; Hasyim et al., 2018; Ihantamalala et al., 2018; Kifle et al., 2019). In other mountainous and hilly areas, springs and streams with water-filled rock basins can be breeding grounds for anopheles (Sullivan et al., 2011; Ndiath et al., 2014; Hanifati et al., 2018). Furthermore, rice field buffer shows that malaria cases are mostly concentrated in the radius of the buffer <250 meters from the rice fields in Kokap Sub-district, as displayed in (Figure 2). This is compliant with the breeding habitats for Anopheles sp larvae, which include rivers, ponds, and rice fields (Rakotomanana et al., 2007; Gouagna et al., 2011). Rice field is a potential habitat area at high risk of malaria transmission with a buffer zone of 500 meters (Dambach et al., 2009; Pergantas et al., 2017).

Almost malaria cases were found <250 meters from the garden area. Based on the flight distance of mosquitoes, which is 0.5 km, this means that the presence of the garden maybe a risk factor for malaria transmission (Chaiphongpachara et al., 2018). During the day, the garden serves an important role as a resting place for Anopheles sp mosquitoes (Booman et al., 2003; Sullivan et al., 2011). This means that the presence of shrubs/gardens near the house increases the risk of malaria (Balicer et al., 2018; Argaw et al., 2021). Anopheles is a species of mosquito that is a vector of malaria and lives in habitats such as garden areas (Shirayama et al., 2009; Djamouko-Djonkam et al., 2019). Gardens are a high-risk area for malaria transmission, with less than 10% of the area within 1 km (Brock et al., 2019).

The results of this study also show that majority of the malaria cases occurred >250 meters from the forest. This signifies that based on the mosquito flight distance of 0.5 km, the presence of forests is not a risk factor for alaria transmission. Which reported that forest does not have a significant effect on the incidence of malaria, with a distance of 900 to 1,250 meters (Adeola et al., 2016). However, several cases of malaria were discovered <0.5 km away from the forest area because the forest is a breeding site for Anopheles sp. Because of Indonesia's geographical location on the equator, it has a tropical climate, and the living environment in the forest will increase the incidence of malaria because it is classified as an endemic area. Activities such as leaving the house at night without long-sleeve clothes and repellents in mosquito breeding sites such as forests will increase the risk of transmission. Living near a mosquito breeding site increases the risk of transmission by 2.37 times and living in a forest area with active transmission increases the risk of transmission by 7.19 times

Some methods of prevention and control of Anopheles sp vectors are spatial monitoring, analysis of time trends (Ndiath et al., 2014; Ndiath et al., 2015; Lavoie et al., 2019) and environmental management such as cleaning the environment that has the breeding potential, for example clearing shrubs in the garden area near the house and closing standing water which has the potential to become a breeding ground for mosquitoes (Ndiath et al., 2014). Wearing long-sleeve clothes when going out at night, using insecticide-treated mosquito nets, using repellants, putting on mosquito repellant gauze, and giving prophylactic treatment when entering or working in endemic areas are also the ways that can prevent and control the vector (Brownson et al., 2009; WHO, 2009; Hou, 2011). Thus, Arc-GIS is significantly for detect spread malaria cases, and breeding place (Chaiphongpachara et al., 2018). Meanwhile, in this study surveillance officer can’t implementation useful Arc-GIS (Public Health Kulon Progo District Departement, 2020).

The strength of this study lies in its focuses on the incidence rate and analysis of the cluster of the distribution pattern and area coverage of a geosphere phenomenon based on breeding places for malaria mosquitoes in rivers (Wangdi et al., 2016) garden,(Wangdi et al., 2018) rice fields (Diuk-Wasser et al., 2007; Dambach et al., 2009; Adlaoui et al., 2011; Argaw et al., 2021) and forests (Obsomer et al., 2007; Wangdi et al., 2016; Shi et al., 2017) by buffering (Lin et al., 2009; Zayeri et al., 2011; Sluydts et al., 2014; Simangaliso and Eutasius, 2016; Parker et al., 2017) which has not been implemented investigation thoroughly in the vulnerable areas in Kulon Progo District in 2015-2021. The findings of this study are projected to support stakeholders in making policy and providing representative management of malaria case elimination. However, this study has some limitations does not perform risk factor analysis and space-time permutation or space-time temporal analysis. The malaria case distribution can be seen from the buffering of malaria locations, that rivers, rice fields, and gardens are places risky for malaria transmission, while forests are not. The Arc-GIS is significantly in the implementation of surveillance and helps provide an overview for determining targets and policy-making strategies. It is suggested that buffering prioritize malaria areas because Arc-GIS has not been implemented for health surveillance officers.

AUTHOR CONTRIBUTION

All the authors have contributed significantly for the analysing data as well as preparing the final manuscript.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare for this study.

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