Advances in Health Sciences Research, volume 25
2nd Sriwijaya International Conference of Public Health (SICPH 2019)

Spatial Modeling of Environmental Sanitation as the Distribution Determinant of Malaria Cases in Lahat Regency

1st Elvi Sunarsih
Public Health Faculty
Universitas Sriwijaya
Indralaya, Indonesia
elvisunarsih@fkm.unsri.ac.id

2nd Imelda Gernauli Purba
Public Health Faculty
Universitas Sriwijaya
Indralaya, Indonesia
purba7@gmail.com

3rd Suheryanto
Public Health Faculty
Universitas Sriwijaya
Indralaya, Indonesia
Suheryanto_mhg254@yahoo.com

4st Amrina Rosyada
Public Health Faculty
Universitas Sriwijaya
Indralaya, Indonesia
arosyadaeffendy@gmail.com

5st Rahmatillah Razak
Public Health Faculty
Universitas Sriwijaya
Indralaya, Indonesia
tillahrazak@gmail.com

6thDwi Septiawati
Public Health Faculty
Universitas Sriwijaya
Indralaya, Indonesia
dwiseptiawati@unsri.ac.id

Abstract— *Malaria is a disease and a world health problem, due to the fact that its potential vector has the capacity to transmit and spread, leading to wide-ranging concerns and international impacts. This study, therefore, aims to create a spatial model of environmental sanitation as a determinant of the spread of malaria cases in Lahat district. This involved a survey method, designed based on geographic information systems, using (1) secondary data, encompassing malaria cases between 2015-2018 and information on climate, including temperature, humidity, pressure, rainfall and solar radiation, and also (2) primary data, characterized by sanitation of the residential or physical environment around the house, the presence of wire mesh, the existence of the sky, wall density and the economic ability of the people. Therefore, the data obtained were evaluated using spatial analysis. Also, selections were made from the entire population of the Lahat district using the cluster random sampling technique from 24 districts, 5 were selected as clusters, encompassing Lahat, Gumai, West, South, and East Merapi. The results showed the endemic occurrence of malaria cases in 2015 and 2016 in the same place, which includes the district of Lahat, West Merapi and East Kikim by up to 51-100 cases and above per year. In 2017, there was endemic only in the Kikim Timur sub-district, which reached 51-100 cases or more, while 2-51 were recorded in the districts of Lahat, West Merapi, East Merapi, East Kikim, West Kikim, Central Kikim, South Kikim, Tebing Tinggi, Pseksu and Pajar Bulan, in 2018. Based on the primary data, the incidence of malaria was 61%, and 39% for non-malaria cases. Environmental sanitation was characterized majorly by ventilation (95%), 72% have no gauze, 54% were devoid of ceiling, 78% had no wall holes, 66% bushes, there was about 49% trenches and gutters, and the presence of livestock drums (45%). Meanwhile the climate frequency distribution was as follows: (1) The wind speed recorded in 2015, 2016, 2017, and 2018 were 3.52, 0.74, 0.7, and 3.73 knots, respectively. (2) summed up to 70.9%, 76.7%, 78.4%, 84.8%, respectively, (3) Rainfall was about 328.50, 389.67, 298.50, and 204.68 mm, respectively. (4) the duration of solar radiation recorded was 51.13%, 47.25%, 51.96%, and 47.23%, (5) the temperature was 26.7, 27.2, 26.5, and 26.5 ° C, while (6) the air pressure was 1010.98, 1010.07, 1009.90, and 934.48 mb, respectively. Therefore, it is concluded that the malaria endemic cases for 4 years in a row occurred in Lahat, as well as West and East Merapi districts, while climate frequency varied through the years, and environmental sanitation played no significant role.*

Keywords: spatial, environmental sanitation, malaria, Lahat Regency

I. INTRODUCTION

Malaria is a world health problem, due to the fact that its potential vector possesses the capacity to transmit and spread, subsequently leading to global impacts. This disease is caused by the presence of plasmodium parasites living and multiplying in human erythrocytes, and is transmitted by female Anopheles mosquitoes. Generally, there are 4 types of malaria, which include tropical, tertiana, ovale, and quartana, and the World Health Organization (WHO) estimates the probability for about 41% of the world's population to be infected. Furthermore, a yearly estimate of approximately 300-500 million sufferers experience serious illnesses, and at least 1-2.7 million die as a result (1).

Global Health Observation (GHO) show the occurrence in 194,126 Indonesians, of which 45 died (2), hence, the Minister of Health is highly concerned about the elimination of malaria in regulation number 293/menkes/sk/iv/2009. Based on the decision issued, there is a recognized level of seriousness through the adoption of concrete actions, with a goal of being totally free in 2030 (3).

South Sumatra Province is an area known to possess malaria endemic, with about 36,201 recorded clinical cases, of which 28,491 were laboratory confirmed and 2,055 were positive sufferers with an API of 0.3 per 1000 population. This value is included in the low category (low incidence). Furthermore, Lahat Regency is the first endemic area in South Sumatra where the source of livelihood for most of the population were in the aspect of agriculture/plantations and mining, facilitating the potential for exposure (4).

Due to the high tendency of transmission through mosquito vectors commonly identified in the surrounding, there is need to avert spreading this disease from sick to healthy individuals, subsequently attenuating the occurrence of a widespread outbreak. This practice requires proper targeting to foster preventive approaches, and geographic information system (GIS) is, therefore, needed for the effective execution of malaria programs.

II. METHOD

The method used is a survey designed using a geographic information system approach. The secondary data acquired include information on malaria cases at Lahat Regency and Climate, encompassing Temperature, Humidity, Pressure, Rainfall, as well as the Duration of Sun Radiation in 2015-2018. Meanwhile, the primary data obtained were based on the form of sanitation adopted in the housing environment, both physically and within the surrounding, evaluating the presence of screen wire and ceilings, wall density and the economic capacity of the community. Therefore, samples were obtained from the population, which is the entire community of the Lahat district, through the cluster random sampling method, where 5 districts were selected from 24, consisting of Pagar Gunung, and a sum of 100 respondents. Furthermore, GIS database compilation to data analysis involved the use of spatial analysis with weighting and scoring.

III.RESULTS

The results of analyzing the variables status of malaria cases are shown in Table 1.

Table 1. Distribution of Respondents Based on The Status of Malaria

Malaria Status	Frequency	Percentage (%)
Yes	61	61.0
No	39	39.0
Total	100	100

Table 1 shows that the majority of respondents in this study experienced malaria status (61.0%), while 39.0% were free.

Table 2. Distribution of Environmental Sanitation Variables

Environmental Sanitation	Frequency	Percentage
Ventilation		
No	5	5.0
Yes	95	95.0
Gauze		
No	72	72.0
Yes	28	28.0
Ceiling		
No	54	54.0
Yes	46	46.0
Wall Holes		
No	78	78.0
Yes	22	22.0
Bushes		
No	34	34.0
Yes	66	66.0
Trenches and gutters		
No	51	51.0
Yes	49	49.0
The presence of livestock drums		
Yes	55	55.0
No	45	45.0

Environmental Sanitation

Based on the table, it is seen that most respondents, approximately 95.0% have ventilation, while 5.0% were deficient. In addition, a majority, about 72.0%, did not have gauze, while the remaining 28.0% had, and those devoid of a ceiling were 54.0%, as it was identified in 46.0% of respondents.

A bulk of participants (78.0%) had no holes in the wall, in contrast with the remaining 22.0, and about 66.0% live in shrubs, while 32.0% settled in areas where there are no bushes. About 51.0% of respondent had no ditch or gutter, as against the remaining 49.0%, and it is also established that 55.0%, of residence had no animal pens, as against the 45.0% with a habitat for livestock.

Spatial Analysis of Climate Conditions

In 2015, the average wind speed recorded in the 29 districts of Lahat Regency was 3.52 knots, which declined by a value of 0.74 knots to 2.78 knots, in 2016. Furthermore, 3.48 knots was recorded in 2017, indicating a simultaneous increase by 0.7 knots and 3.73 knots in 2018, characterized by a 0.25 knots elevation, in contrast with the previous year.

The average air humidity percentage of the 29 Subdistricts in Lahat Regency within 2015 was 70.9%, followed by a 5.8% increase to 76.7%, observed in 2016, and a simultaneous elevation by 1.7% based on the 78.4% recorded in 2017, in contrast with the previous year.

The average rainfall recorded in Lahat Regency was 389.67 mm in 2016, estimated to have increased by 61.17 mm, in contrast with the value recorded in 2015. This consequently decreased by 91.17 mm in 2017, as 298.50 mm was reported, and the average rainfall of 204.68 mm in 2018 marked a drastic decline of 93.82 mm, when compared with the previous year.

The duration of solar radiation in Lahat Regency showed an average exposure time of 51.13% in 2015, which declined to 47.25% in 2016, by 3.88% in contrast with the previous year. Also, a increase by 4.71% was recorded in 2017, compared with the value reported in 2016 a 47.23% duration of solar radiation was observed in 2018, depicting a decline by 4.73%, in contrast with the previous year.

The average temperature in 2016 was 27.2 °C, which was 0.5 °C higher, in contrast with the value reported in 2015. In addition, 26.5° C was observed in 2017, depicting a 0.7° C decrease, and no change was reported in 2018.

The average air pressure recorded in 2015 and 2016 was about 1010.98 and 1010.07 mb, respectively, indicating a 0.91 mb decline. The value reported in 2017 was 1009.90 mb, which is 0.17 mb lower than the previous year, and 934.48 mb reported in 2018 shows a significant decrease in value by 75.42 mb, in contrast with the air pressure in 2017.

Modeling Analysis of Environmental Sanitation

Based on the analysis, 3 respondents without ventilation had the malaria status (60.0%), which was also experienced by 58 of the respondents with proper ventilation (61.1%). Based on PR 0.98 (CI 0.47-2.04) and the p-value (1,000), the statistical test show the absence of any relationship between the presence of ventilation and malaria status.

It was also established that 46 respondents without a gauze (63.9%), and 15 with a wire (53.6%) exhibited the status of malaria. Based on the PR 1.19 (95% CI 0.81-1.75) and the p-value (0.471), the statistical test results show the absence of a relationship between both parameters.

The results show that 36 respondents without a ceiling (66.7%), and 25 with a ceiling (54.3%), exhibited the status of malaria. This indicates the absence of a statistically significant relationship between both parameters, with PR 1.22 (95% 0.88-1.69) and the p-value (0.292).

A total of 50 respondents without a hole in the wall (64.1%), and 11 with holes (50.0%) had the status of malaria. This denotes the absence of a statistically significant relationship between both parameters, as the test results show PR 1.28 (95% CI 0.81-2.01) and the p-value (0.342).

Based on the analysis it was established that about 23 respondents (67.6%) living in areas with no bushes, and 38 of those with homes covered in bushes (57.6%) had the malaria status. This indicates the absence of a statistically significant relationship between both parameters, as the test results show PR 1.17 (95% CI 0.86-1.60) and the p-value (0.446).

A total of 32 respondents (62.7%) living in an area with no trenches and gutters, and 29 respondents (59.2%) with these facilities had the malaria status. This indicates the absence of a statistically significant relationship between both parameters, as the results show a PR 1.06 (95% CI 0.77-1.45) and p-value (0.873).

Based on the analysis, it was established that 35 respondents (63.6%) devoid of livestock pens and 26 (57.8%) with this facility in their homes had the malaria status. This indicates the absence of a statistically significant relationship between both parameters, as seen in the results showing PR 1.10 (95% CI 0.80-1.51) with p-value (0.695).

IV. DISCUSSION

The malaria epidemiology capitalizes on the interactions between three factors, encompassing the Host, agent (plasmodium), and environment . Furthermore, the host is divided into two parts, including the definitive, which is the female Anopheles mosquito as a vector, and the intermediate, being humans. In addition, the factors that influence the intermediated host include age, sex, race, social status, previous medical history, the individuals' way of life, heredity, nutritional status, and level of immunity. These are important because they influence the risk of exposure to a disease source, while environmental factors include sanitation and climate (5).

The result shows that about 95.0% of the respondents have ventilation, as against the remaining 5.0%, and the analysis show the absence of a relationship with malaria status. A similar correlation was established with the entry of mosquitoes into the house through windows doors and ventilation holes (6). In addition, the risk factor of Malaria was explained through six variables, encompassing occupation, ventilation net, the adoption of bed net, presence of livestock cage, use of repellent s, and the practice of outdoor activities at night. Moreover, the ventilation net variable show the absence of a statistically significant relationship in bivariate analysis (7).

The percentage of respondents with and without gauze was 28.0 and 72.0%, respectively. Furthermore, the statistical test indicate the absence of a significant relationship between the presence of wire mesh and the status of malaria. This was not in line with other studies associated areas with high potential for malaria transmission with the presence of physical environmental factors, consisting of residential houses without gauze in air vents and ceiling-free houses, as well as the biological environment characteristics (8).

Respondents with and without a ceiling was 46.0% and 54.0%, respectively, while statistical test show the absence of a relationship with malaria status. This is not in agreement with the study conducted in Kenya, which demonstrated the enhanced tendency for house design modification, through the inclusion of a ceiling, to reduce mosquito densities (9). However, other studies in Gambia and Ethiopia reported a decrease in indoor resting mosquitoes (10) . In addition, the presence of ceiling prevents the entry of malaria vector for rest, especially at night (11).

Most respondents did not have holes in the wall (78.0%), indicating no significant correlation with malaria. However, other studies show the enhanced propensity for the formation of breeding habitat, resulting from the condition of the house walls and the habit of late night outings, which subsequently leads to the incidence of malaria. Furthermore, a good condition of the dense wall causes a 71% lower risk of malaria (12), thus, relating the incidence of malaria with the construction of a house. Therefore, those made of wood and bamboo are more prone to infection than houses made of bricks (13).

The result show that respondents live in areas with (66.0%) and without (34.0%) shrubs, characterized by the presence of swamp that allows the rapid growth of plants. However, statistical test show the absence of a correlation between its presence and the incidence of malaria. Therefore, areas with shrubs and mosaic cover vegetation were classified to have moderate risk, while the existence of forests, bare, and urban settlements were classified as lowest risk (14).

The total amount of respondents with and without ditchwere 49.0% and 51.0%, respectively , and malaria as a contagious and deadly disease is very dominant in the tropical and sub-tropics areas, making the presence of ditches a risk factor (15). Based on the table, residence without animal pens was 55.0%, while

45.0% had livestock pens, indicating the absence of a statistically significant relationship against malaria status. Therefore, it is assumed that livestock possess the capacity to prevent transmission, indicating the ability to contribute towards prophylaxis in Indonesia (16).

V. CONCLUSION

Based on the result of this study, it is concluded that the cases of malaria endemic for 4 years in a row occurred in Lahat, and West and East Merapi districts. In addition, it was recognized that climate frequency in lahat varies through the years, and no correlation was established between environmental sanitation and malaria cases.

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