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SPECIAL ARTICLE
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THE RISK OF PHYSICAL ENVIRONMENT TOWARD INCIDENT OF MALARIA IN LAKE AREA, JAYAPURA REGENCY, PAPUA PROVINCE

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ABSTRACT

The incidence of malaria represented serious health problem in Indonesia. In Papua province, especially in the area of Sentani Lake, the prevalence of malaria was still high. It was influenced by various physical environmental factors. The study aimed at identifying and analyzing the correlation between physical environment and the incidence of malaria in the region of Sentani Lake. It was an observational and analytic study conducted in four villages in the area of Sentani district, Jayapura, which were Yoboi/Kehiran, Hobong, Ifar Besar and Ifale. Its population was all of the residents of Sentani district and there were 200 individuals randomly drawn as samples. Data were collected using questionnaires, observation, documentation, and interviews. The data were analyzed using bivariate analysis, Chi-Square statistic test, and logistic regression. The results showed that the physical environmental factors and the incidence of malaria were significantly correlated with the Chi-Square value of 7.531 ($p = 0.006 < 0.05$) and the regression ratio OR of 4.132 ($p = 0.009 > 0.05$).

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The physical environmental factors, including temperature, humidity, rainfall, water condition, elevation, and living condition, had significant influence on the incidence of malaria in Sentani Lake region.

INTRODUCTION

Incident of Malaria in Jayapura Regency were not spread evenly. From 16 clinics, there were found the highest malaria incident in 3 clinics, East Sentani, Sentani, and West Sentani Clinics, that stated as endemic area of malaria. Sentani Lake included into area of Sentani Clinic, with the data as follow: in 2013 the malaria incident was increasing with Annual Parasite Incidence (API) 232 per 1000 population, whereas the malaria incident was decreasing became 13,824 cases (AMI 122 per 1000 population) (Health Department of Jayapura Regency, 2013).

According to the reality of malaria incident in Sentani Lake area, there were some prior researches such as Ayomi et.al. 2012 about the temperature in Sentani Lake area which was stated normal as same as the temperature in other areas in Indonesia because it was temperature of tropical area that emphasized on the difference of lowest to highest temperature at the day and night that influenced the mosquitoes' propagation.

Else, the other similar research was conducted by Arsin and Karim, 2008 about the correlation of temperature with malaria incident in Central Halmahera which measured the temperature in that area was around between 26,8 ^{0}C to 27 ^{0}C influenced the malaria incident.

Marrai (2006) did the research with the title "Factors which was related to the dynamic of malaria *falciparum* spread in Nabire City Sub District". The research used *Cross Sectional* method. Based on the research result, it could be known that there was relation between environment condition, population condition, and vector existence with malaria incident (*falciparum*) in Nabire City Sub District.

The change of weather elements was influenced to the disease's vector. The increasing of temperature, humidity, and rainfall, were proven to be followed by the increasing of malaria cases happened in Srilangka and Punjab. The difference of area characteristic was influenced to weather difference so that the vector population in certain area which has different characteristic would also have different density (Raharjo, 2003; Kumar, et.all., 2014).

In Sentani Lake area, the malaria incident was high. This research was aimed to know the influence of physical environment factor toward the malaria incident in Sentani Lake area.

METHODS

Time and Location

This research was done during 6 months (April-November 2013). The research locations were four villages in Sentani District area of Jayapura Regency, that were Yoboi/Kehiran, Hobong, Ifar Besar, and Ifale villages with research method of cross sectional approach with observation analytic research, with theb sample were all population in Sentani District in the number of 200 people. The sampling was done in random.
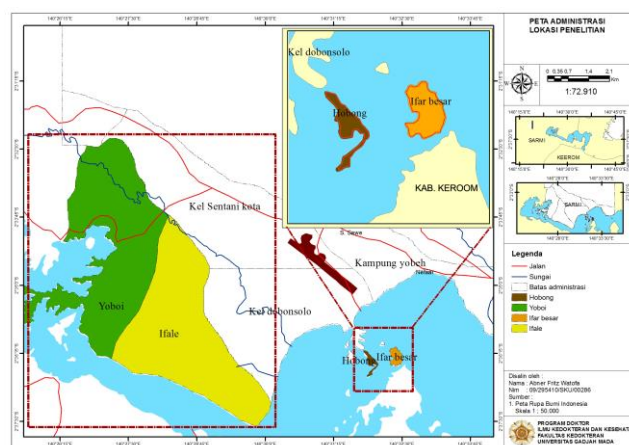

Figure 1. Administration Map of Research Location in Sentani Lake

Procedure

Data sampling method of physical environment which consisted of temperature, rainfall, water pH, land and air humidity, height and using of area, was done by using questionnaire, observation, documentation, and interview. Those data, then, were analyzed by using *bivariate* analysis, statistic test of *Chi-Square*, and logistic regression test. The data presentation to know the distribution of frequency of each independent variable toward malaria spread was analyzed by using *bivariate* analysis and statistic test of *Chi-Square* toward respondents' answers of each questionnaire.

Statistic test which used to analysis the data was *Chi Square* test with cross tabulation 2 x 2 to find *odds ratio* (OR) (Thompson, 1994). This statistic test was used to get p value with meaning level p < 0,05 in order to observe the correlation between the explanation *(exposure)* with malaria incident *(outcome)* was used prevalence ratio value (RP) with 95% *confidence interval* (Ci).

Logistic regression was commonly called logistic model or logit model, in statistic was used to predict the probability of certain incidents by checking the data at the logit function of logistic curve (Ghozali, 2012). This method was general linier model commonly used for binominal regression. As same as general regression analysis, this method used some predictor variables, both numeric and category. Logistic regression test was an approach of mathematic model that was used to analyze the correlation between one or some independent variables with a dependent variable of category, such as healthy and sick.

RESULTS

Characteristics of respondents in Sentani Lake

The respondents of this research were commonly men in the productive ages with low level of education background. The main profession was farmer. The distribution of respondents' characteristic could be seen at Table 1.

Table 1. Respondents' Characteristics

Parameter	Group	Quantity (person)	Percentage (%)
Gender	Man	116	58
	Woman	84	42
	Total	200	100
Group of Age (year)	≤ 20	14	7
	21 – 30	91	45,5
	31 – 40	70	35
	41– 50	21	10,5
	> 50 years old	4	2
	Total	200	100
Education level	SD	17	8,5
	SMP	53	26,5
	SMA	117	58,5
	D-3	3	1,5
	S-1	10	5
	Total	200	100
Profession	Farmer	127	63,5
	PNS	11	5,5
	Laborer	57	28,8
	Businessman	5	0,5
	Total	200	100

Univariat Analysis of Research Variable

The variable of this research were factors of physical environment risks included temperature, humidity, rainfall, water condition or water pH, height, using of area, and people's houses condition. The average of air temperature in the research location was 27,3 ^{o}C. While, the lowest air temperature was 23 ^{o}C and the highest air temperature was 32 ^{o}C. This data of temperature was supported by the report about the temperature issued by Meteorology and Geophysical Board of Papua, the maximum temperature in the research location at the day was 32,2 ^{o}C, the temperature at the night was 23,6 ^{o}C, while the temperature average at the day was about 27,6 ^{o}C commonly occurred in November and December.

The humidity average in the research location was 81,2%. The air humidity in the research location was also supported by the measuring result of air humidity reported by BMG Papua that the humidity in Yoboi/Kehiran Village was 82%, in Hobong village was 81%, while in the other two villages Ifar Besar and Ifale were 80%. The highest humidity was occurred in Yoboi/Kehiran Village of 84%. While, the humidity average in the four of research locations were 80,7% almost similar with the temperature humidity acquired by doing direct measurement, that was about 81,2%.

Based on the data reported by BMG Papua, the highest air humidity in the research location was started in January until December 2012, for about 81 – 84%. The highest air humidity was occurred in January and June 2012. While, the lowest air humidity were occurred in Ifar Besar and Ifale Villages because both locations were in an island.

The data of rainfall in the research location taken from BMG of Sentani District in 2013 was 135 mm/month with the number of rainy days were 13 days/month or almost a half of each month were rainy day. The wet months were in Mei-February, while the dry months were in March-April. The highest rainfall per month in 2010-2012 was in March of 471,7 mm, while the lowest was occurred in June of 92,4 mm.

The water condition or water pH in this research was taken from Healthy Department of Jayapura in 2012 around 6,8 – 7,70. The highest water pH was occurred in Yoboi/Kehiran Village for 7,70, while the lowest water pH was occurred in Ifale Village for 6,8. The measurement result of water pH done in the research location showed the result which was more or less similar for around 6,68-7,68. The highest water pH was occurred in Yoboi/Kehiran Village for 7,68, while the lowest was occurred in Ifale Village for 6,68. The whole

water pH in the research location was run around 6,68-7,70.

Commonl, the research location was in the low height. The height of dry land was only 60$^{'}$, while for the marshland was only 10°. Regarded from the slope of Sentani Lake from the north side only had the slope of 0 - 10°, while from the south side was only 0 - 4°.

In the research location, especially in the people's settlements, there was wide enough of underbrush, dry agriculture land, and mixed dry land. There were 200 people had profession as farmers, 127 person (63,5%) of them breaked the lands around the research location as plantation or farm.

Some houses in the research location were build above the river or lake. The observation result showed that the people houses in Sentani Lake consisted two types: stage houses above the water and semi-permanent houses on the land.

Bivariat Test

Bivariat Test of the research variable used Chi-Square test in order to know whether the physical environment factors had meaning or did not toward the malaria incident in Sentani Lake area. In order to know whether the physical environment factors (temperature, humidity, rainfall, water pH, height, land using, and physical condition of the houses) had meaning or did not toward the malaria incident, it was done *Cross tab* testing.

The result of *cross tab* testing was done in order to know whether the physical environment factors (temperature, humidity, rainfall, water pH, height, land using, and physical condition of the houses) had meaning or did not toward the malaria incident. The result showed that *Chi-Square* value was 7,531 with p = 0,006 < 0.05.

Based on the counting result, it could be known that the correlation strength between physical environment factors and malaria incident was 89%. Therefore, it could be explained that physical environment factors were very meaningful for the malaria incident in Sentani Lake area (for 89%). Meant that malaria incident in Sentani Lake area had correlation with physical environments (temperature, humidity, rainfall, water pH, height, land using, and physical condition of the houses) in that area. Physical environment factors (temperature, humidity, rainfall, water pH, height, land using, and physical condition of the houses) could decrease or increase the malaria incident in Sentani Lake area.

Logistic Regression Test

Logistic regression test was done in order to know how independent variables, that were physical environment factors, could predict the dependent variable, that was malaria incident. Based on the logistic regression test result, it showed that the testing of model I had p < 0,05 so model I could be used. Based on the explanation, it showed that physical environment factors were influenced to malaria incident in Sentani Lake area. The correlation strength could be seen from OR (EXP (B). The strength of correlation between physical environment factors included: temperature, humidity, rainfall, water pH, height, land using, and physical condition of the houses (OR=4,132).

DISCUSSION

Temperature

The research result showed that air temperature had correlation with malaria incident in Sentani Lake area. The measurement of air temperature done during the research and also reported by the BMG Papua showed that the average of temperature level, maximum temperature, and minimum temperature were still in the limit of appropriate temperature for the viability of malaria mosquitoes. The suitability of air temperature as similar as in the research location made malaria mosquitoes survived and had propagation optimally.

Air temperature was the transmission of malaria diseases (McCuthan et.all., 2004; Blanford et.all., 2013; Weiss et.all., 2014). Malaria disease would grow up in line with the mosquitoes' growth. If the air temperature in certain area was still enable for *Anopheles* to survive, the malaria disease would be also grow in that area. The temperature in Sentani lake was around 23 ^{o}C to 32 ^{o}C with the average of 27,3 ^{o}C, was the temperature range where malaria mosquitoes could adapt with it because the temperature which could be adapted by malaria mosquitoes was between 15 ^{o}C to 40 °C (Bhattacharya, dkk., 2006).

Temperature had vital role for the mosquitoes' growth. *Sporogonic* cycle needed 9 to 10 days at the temperature of 28 ^{o}C and would be negative in it's growth at the temperature under 16 ^{o}C or up 30 ^{o}C (Craig dkk., 1999). The temperature increase was also impacted to the short of parasite incubation phase so that speed up the propagation of malaria disease (Kumar dkk., 2014).the mosquitoes would stop growing at the temperature up of 35 ^{o}C, for example occurred in Delhi in the summer with the temperature above 40 ^{o}C or in Bhutan 35 ^{o}C (Wangdi dkk., 2010).

The wide of spreading area of the mosquitoes was also very depended on the temperature, moreover for the lowland which had hilly near it. The temperature increase of 1°C was identically with the increasing of land 154 m (Wandiga dkk, 2010). Therefore, in Sentani Lake area, the mosquitoes' breeding place was not only found in around the lake but also in the slopes of Cycloops Mountains.

Humidity

Humidity, as one of physical environment factors, was also related with malaria incident in Sentani Lake area. The measurement of air humidity which was done directly in the research location and the data reported by BMG Papua showed the result that was more or less similar that could be seen from the average of humidity, the highest and lowest humidity. The research result showed that the humidity in four research locations were, in fact, different each others. Yoboi/Kehiran Village which located in the flood pain of Sentani Lake had higher air humidity than Hobong Village, Ifale Village, and Ifar Besar Village that were located in the island. The high humidity was influenced by the evaporation and the existence of vegetations such as sago, nipa, eceng gondok, and others. The humidity was also related with rainfall (Huang dkk., 2011).

The result of this research showed that the average of air humidity in Sentani Lake area was around 80.7% - 81,2 (the average of measurement result and BMG). The air humidity which could be adapted by *Plasmodium falciparum* and *Plasmodium vivax* was 55% until 80% (Bhattacharya dkk., 2006). The humidity under 60% would shorten the mosquitoes' live phase so that there was decreasing of malaria risk, while in the humidity above 60%, the infection level was increasing significantly, moreover malaria risk was at the turn of 80% that was twice higher than the humidity of 60% (Ye dkk., 2007; Tian et.all., 2008). While, the research done by Suwito and Singgih (2010) stated that the humidity with highest average was in December of 84,30% and the lowest was in August for 76%, had meaningful correlation with *Anopheles* density per person per night (MBR).

Rain fall

Rainfall was part of physical environment factors which very influenced to the mosquitoes cycle in Sentani lake area. The research result showed that rainfall in the research location was high. The high rainfall was caused by the existence of Cycloop mountain. The aqueous vapor brought from Pacific Ocean was changed into rain around the mountains. High rainfall caused the water in the river and lake were overabundance, and caused the slick around people's settlements. Moreover, every rainy season, this area always got flood. The problem of flood was related with the forest area which was narrow caused by the land breaking, traditionally temporary farm, and vegetation fired at dry season (Walukow, 2011).

Sago's marshes which always full of water also became the place of mosquitoes' propagation (*breeding place*) permanently. The impact of this high rainfall, anything which could receive water would full of water, for example ex of fallen trees, ex of animals' sole, ex of vehicles' wheel, ex of drinking bottles, and others. The water slick in those places finally became the breeding place of mosquitoes.

The rainfall occurred in Sentani lake area was related with the malaria incident, when it was rainy season, the number of malaria sufferers were increasing. The higher of rainfall in the research location, the number of malaria sufferers were also increasing. This research result was in line with the research done by Suwito and Singgih (2010) in South Lampung and Pesawaran that stated that the result of statistic counting of correlation between rainfall and *Anopheles* density had meaningful correlation. Determination coefficient showed value of 0,569, meant that the density of *Anopheles* mosquitoes 56,9% caused by rainfall (Suwito and Singgih 2010). Subbarao (1998) also stated that rainfall was dominant factor of malaria disease in India.

Water Condition (pH)

Research finding showed water pH was one of factor that supported malaria incident in Sentani Lake area. The result showed that water pH around 6,70-7,70, was normal degree for the mosquitoes larva's live. Effendi (2008) stated that water pH of 6,68-7,68 was normal degree which supported the propagation of larva's live. Research done by Soleimani-Ahmadi et. all. (2014) in south east Iran, stated that there were found overabundance of *Anopheles* larva in the water with pH 7,1 until 8,6. Abdullah and Merdan (1995) stated that larve liked normal water or little bit alkali. The research result in Ghana, Ethiopia, Sri Lanka, China and India were also showed similarity that *Anopheles* larva optimally growth in normal pH or little bit alkali (Saxena et.all., 1992; Piyaratne et.all., 2005; Kenea et.all., 2011; Kudom et.all., 2012; Liu et.all., 2012;).

Height

Height was one part of physical environment factor that influenced toward the malaria incident in

Sentani lake area. The research result showed that research location was tended to be in the lowland. In the lowland, mosquitoes had wide flying scope. Else, the height of certain area was close related with temperature, so that in the lowland, the average temperature was higher than plateau that was enable the mosquitoes easily adapted and had propagation and also had high aggressiveness.

Research finding that relevant with this research was research in Tanzania which stated that in the plateau, the mosquitoes' density was decreasing. However, in this research, the decrease of the mosquitoes was presumed because of the water slick or river were also decreased (Drakeley dkk., 2005). In the plateau, the water resorption occurred quickly and the water flow was tended to be rapid so that could be difficult for the larva to live.

Land Using

The using of land was one of factor that supported malaria incident in Sentani Lake area. Beside being used to build a house, land in the research location also used as plantation, farm field, fish pool, and cotes. The using of land as plantation, farm field, fish pool or cotes commonly did not pay attention to a good layout. The plantation/farm was commonly leaved for long time after the harvest. The cleanness and comfort of fish pools and cotes were not kept.

The utilization of land which did not pay attention to the good layout would influence micro climate such as the change of local temperature, humidity, evaporation, and local weather which all of them close related with malaria disease (Foley, dkk., 2005). Larva in the farm field was quicker to be the mosquitoes (Munga, dkk., 2006).

Physical of the Houses

Physical condition of the houses was generally simple because it made of the materials such as ex board or bamboo, so that there were many holes at the houses' wall. There were not any gauze put on the holes so that the mosquitoes were freely entered the houses and attacked the people inside. The houses' cleanness, inside and outside, was sleazy. There were many tools scattered around, untidy, dirty, and it was musty inside the house caused the mosquitoes liked those places. There were stack of second tools and rubbish around the houses. There were also water slicks, underbrush, and wild plants. As a whole, the physical condition of the houses, inside and outside, became the causes of malaria disease in Sentani lake area.

This research result was in line with the research in Trenggalek that found the strong correlation between houses' construction and malaria incident because all of respondents' houses did not have gauze and canopy to prevent the mosquitoes entered the houses (Yudhastuti, 2008). The uncovered holes would cause the increasing of mosquitoes' population inside the houses (Sintasath et. all., 2005; Ye dkk., 2006).

CONCLUSION

The statistic testing result of physical environment (temperature, humidity, rainfall, water pH, land using, and physical condition of the houses) in Sentani Lake area had meaningful relation with malaria incident. Temperature, humidity, rainfall, water pH, land using, and physical condition of the houses were related each others in influencing propagation of malaria mosquitoes which was impacted into malaria incident in Sentani Lake area.

The government, especially Health Department, hoped able to think of the risk factors of physical environment in controlling the *Anopheles*' propagation so that there was appropriate action for each environment's change. Controlling and good environment's layout should be managed immediately and done by the related parties, in this case was Government of Jayapura Regency to manage the lands used for the settlements, fields, farms, or kept the existence of the forest. Critical land should also be repaired because it would influence the locale climate in Sentani Lake area that affected to the higher mosquitoes' propagation. .

Government immediately did the reconstruction of drainage and water resorption in the slopes of Cycloop mountains. Drainage system and water resorption were important to decrease the water slick in the land surface which became the media of larva's live. Drainage and water resorption were also useful as fresh water source and prevent the flood in the rainy season.

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