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Original Article

Risk Factors Analysis of Malaria Transmission at Cross-Boundaries Area in Menoreh Hills, Java, Indonesia

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Abstract

Background: Risk factors of Malaria transmission at cross-boundaries area is important to be identified. This study aimed to identify the risk factors of Malaria transmission at cross-boundaries area in Menoreh Hills, Java, Indonesia.

Methods: The design of the study was an observational study with a case-control design. Data on malaria cases and controls were obtained from the Primary Health Care in Menoreh. All malaria positive patients with clinical and laboratory examinations recorded in health services during 1 Jan 2015-31 Dec 2015. Overall, 138 cases and 138 controls were included. Several variables were collected such as altitude, night out behavior, the use of mosquito nets, nighttime bed, travel history, mosquito bite prevention activities, cattle ownership, distance to mosquito breeding site, etc. Data were obtained by structured questionnaires and observation. Data were analyzed by univariate, bivariate and multivariate

Results: The altitude of house >500 m above sea level proved to be influential as a risk factor for Malaria (OR 3.62, 95% CI 1.61-8.16, P=0.002). Several variables were identified as a risk factor of Malaria such as the wall of the house from bamboo/wood, no insecticide and distance of house <100 m from mosquito breeding site.

Conclusion: An awareness for the local health sector particularly to provide a recommendation for house construction to protect a community from Malaria transmission.

Keywords: Altitude; Malaria; Menoreh; Risk factors; Indonesia

Introduction

Malaria is a vector-borne disease that has a major impact on global public health with around 3.4 billion people at risk. This disease is caused by five species of *Plasmodium* parasites, with *P. falciparum* and *P. vivax* are considered as the greatest threat. *Plasmodium* is transmitted by the bites of female *Anopheles* mosquitoes (1). In 2018, an estimated 228 million cases of malaria occurred worldwide compared to 2010 with 251 million cases and 231 million cases in 2017. Most of the malaria cases in 2018 were in the African Region (213 million or 93%), followed by Asia Southeast with 3.4% and Eastern Mediterranean Region with 2.1%. The incidence of malaria has decreased globally between 2010 and 2018, from 71 to 57 cases per 1000 population at risk (2). In Indonesia, Malaria has become the target of elimination gradually by 2030. Based on Indonesia Regular Health Research (3), the incidence of Malaria in Indonesia in 2013 was 1.9%, with 10 provinces have Annual Parasitic Incidence (API) values between 1-5 per 1000 inhabitants, 6 provinces have API values> 5 per 1000 inhabitants, and there is area who have an API value of > 50 per 1000 inhabitants (Badan Penelitian dan Pengembangan Kesehatan Kemenkes RI, 2013). About 70.3% of the area in Indonesia categorized as unstable transmission and most of the population lives in this unstable transmission area (4).

Malaria transmission is determined by various factors such as the environment and behavior of people. Environmental factors which related to Malaria include temperature, rainfall, humidity, altitude, a composition of the vegetation index, conditions of the house (conditions of walls, roofs, floors, ventilation, the existence of livestock, density of the rooms, near breeding sites/rivers etc.) (5-7). The behavioral determinants that correlated with malaria such as the use of personal protection, the use of mosquito nets and insecticide spraying (8,9). Each country and areas have their own determinant risk depend on environmental, ecology and local socioeconomic factors (8). Integrated understanding about the patterns of malaria transmission, risk factors, the environment, socioeconomic conditions of each region needs to be understood in the context of developing a malaria control program (10).

In addition to environmental and behavior factor, altitude is considered one of the factors that determine the geographical coverage of malaria transmission. This is related to the decrease in average temperature since Malaria decreases at increasing altitude. Malaria transmission rarely occurs at altitudes above 2000m above sea level (masl). However, currently, there are a higher density of *Anopheles* mosquito and Malaria incidence in altitude more than 1500 masl (10). The incidence of malaria is also higher at altitudes >100 m asl in hilly areas in Bangladesh and statistically significant (11). In Irian Jaya Mountains, Indonesia, which was previously rare in malaria, currently Malaria is more commonly found (12). Indeed, it is interesting to examine whether high-altitude is a factor that plays a role in malaria incidence in Indonesia. The results of the study in Kenya showed that differences in altitude of place reflected the differences of Malaria prevalence (13). In general, at higher altitudes associated with malaria, this is related to lower temperatures which slows the development of *Anopheles* vectors and malaria transmission. In Kenya, the elevation is not significant for malaria prevalence on the district scale (13).

This study would explore the correlation of several environmental factors including altitude with Malaria incidence in the Menoreh region, Central Java Indonesia. In this region, the determinant of malaria is strongly influenced by ecosystems, vegetation and policies to eradicate malaria vector. Menoreh is an area that is administratively located in the border of Magelang Regency and Purworejo Regency, Central Java Province. Menoreh area is an area that forms a unique ecosystem that is the source of life for living things. This area is a karst and breccia area, as a buffer for cultural heritage objects, one of which is Borobudur Temple. Menoreh hills are a malaria-endemic area. In addition, the Menoreh region borders two surrounding endemic areas, namely in Purworejo and Magelang Districts. Vector eradication in this area facing difficulties since geographically this area covered by different local government. There were more than 3500 cases of malaria occurring in Menoreh (cross-border area of Central Java Province and Yogyakarta Special Region) for 11 yr from 2005-2015. Menoreh Hills were the highest contributor of malaria cases in the two regencies (39%-47% during 2011–2015) (14). Rainfall, humidity and migration affected the incidence of malaria (15). However, the information about the risk factors of Malaria transmission in cross-boundaries area is still limited.

We aimed to find out the risk factors which correlated with the Malaria transmission at cross-boundaries area in Menoreh Hills, Java, Indonesia. Results of this study would provide valuable information and input for Malaria prevention and control.

Materials and Methods

Study design and the area of study

The design of the study was an observational study with a case-control design. Data on malaria cases and controls were obtained from the Primary Health Care in Menoreh, while interviews and observations were carried out at each case and control's houses. The area of this study is the Menoreh ecosystem which located in an altitude of around 100-900 m above sea level, and there are Moderate Case Incidence/High Case Incidence villages for 5 consecutive years (2010-2014) and bordering each other. This region is suspected as a source of transmission every year on Java. There are two provinces bordering each other which are this region, namely the Province of Central Java, and the Special Region of Yogyakarta. Purworejo Regency and Kulonprogo Regency are regencies in the 2 Provinces bordered, which consist of 3 malaria-endemic sub-districts which include Kaligesing District, Bagelen District, and Kokap District. Population of cases is all malaria positive patients with clinical and laboratory examinations recorded in health services during 1 Jan 2015-31 Dec 2015. The control population, i.e. non-malaria sufferers, was recorded in the Primary Health Care and health services during the period of 1 Jan 2015-31 Dec 2015. Samples were 138 cases and 138 controls.

Most cases were distributed in Kaligesing Community Health Center (81 cases), Dadirejo Community Health Center (30 cases), Bagelen Community Health Center (15 cases), Kokap I Community Health Center (9 cases) and Kokap II Community Health Center (3 cases). The 5 villages with the most cases were Somongari, Kaligono, Semono, Sokoagung, and Kalirejo. Location of study could be seen in Fig. 1.

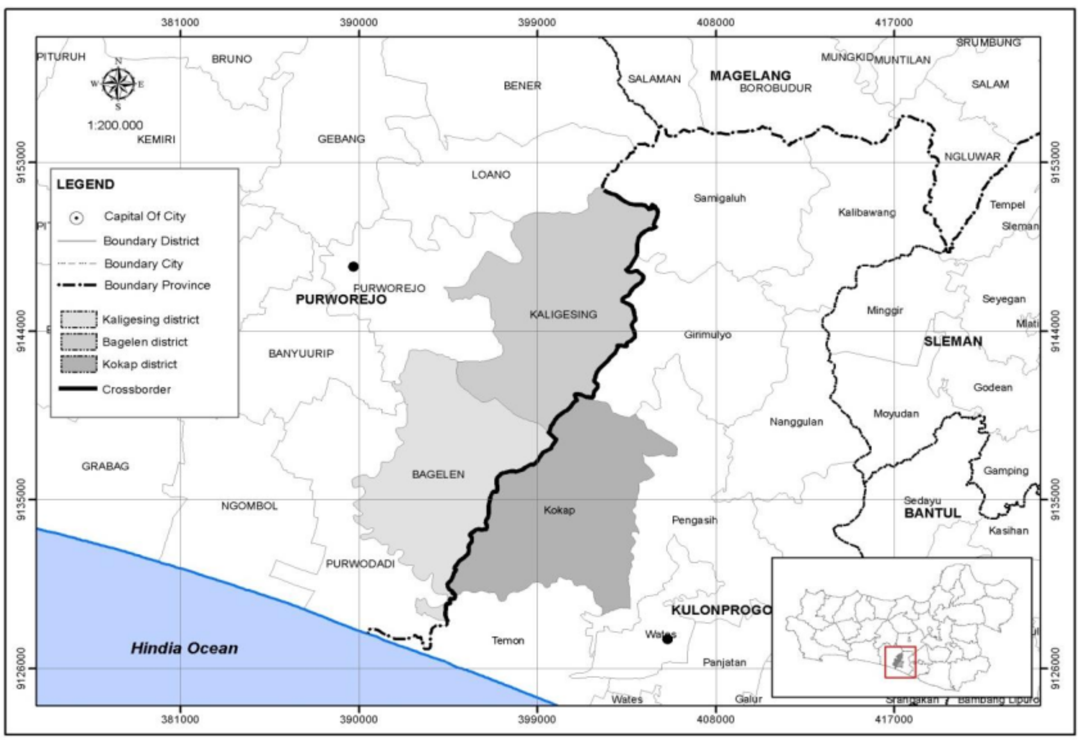

Fig. 1: Location of cross-boundary area in Menoreh hills Indonesia

Collecting data & analysis

Several variables were collected in this study such as altitude, night out behavior, the use of mosquito nets, nighttime bed, travel history, mosquito bite prevention activities, cattle ownership, distance to mosquito breeding site etc. Data were obtained by structured questionnaires and observation. Data were analyzed by univariate, bivariate and multivariate. Bivariate analysis to identify strong independent variables related to malaria. Multivariable analysis with logistic regression to determine the variables that most influence the incidence of malaria by first doing analysis in stages to ensure the existence of confounding or not. All data were analyzed with SPSS 19.0 for Windows.

Ethical approval

The protocol was approved by the ethical committee of the Faculty of Medicine Universitas Gadjah Mada number: KE/ FK/222/EC/2016.

Results

The results of the univariate analysis showed that among the respondents, the gender variables between cases and controls were almost the same. The average age of control was 35.2 yr, slightly more than the case of 32.1 years. The univariate analysis of behavior and socioeconomic characteristic could be seen in Table 1. The education level of the control group was better than the case group. About 20% of the control group had a high school education and above and only 11% in the case group. The employment variables between the case group and control characteristics are almost the same, most as farmers and housewives/school children. In the physical condition of the house, the condition of the control group is better than that in the case group, there are about 62% of the controls that have permanent walls of brick/brick/brick, and in the case group around 40%. In the condition of the house ceiling and ventilation, both the case house and the control of most ceilings are open and there is no gauze ventilation, which allows the mosquito to enter the house. Most cases and control groups have livestock and are at risk because livestock is placed close to settlements which are <10 meters away. Goats and chickens are livestock mostly maintained by respondents. The physical condition of the house and environmental of the case and control groups are shown in Table 2.

Mosquito breeding sites that are found in both cases and controls are almost the same, such as rivers, springs, water, inundation, ponds, basins/stalls. The average breeding distance to the house in the case group was closer (83.9 m) than the control group (167 m). As for the distance of the house to the Primary Health Care, in the case group (4646 m) was almost the same compared to the control group (4743.5 m). In the variable altitude of residence, the average house height of the case group (311 m asl) was lower in the control group (349 m asl). The physical.

Bivariate analysis showed that there were 7 variables with a value of $P<0.25$ which were spraying, preventing mosquito bites, education, walls of the house, roof/ceiling, a distance of the house to mosquito breeding and the height of the house. The next step is to enter the 7 variables into multivariate analysis with logistic regression analysis. The following are the best model results for factors that influence the incidence of malaria.

The best model results showed that the altitude of the house> 500 meters asl is a greater risk of occupants suffering from malaria compared to houses which located in altitude ≤ 500 meters asl with OR=3.625 (P=0.002). Details of the analysis presented in Table 3.

Table 1: Behavior and socioeconomic characteristics

Variables	***Group: n(%)***	
	Cases	Controls
Night out behavior		
1. Yes, Night out	64 (46.4)	62 (44.9)
2. No	74 (53.6)	76 (55.1)
Ownership of mosquito nets		
1. 0 (do not have)	49 (35.5)	42 (30.4)
2. 1 - 2 pieces	76 (55.1)	84 (60.9)
3. 3 - 4 pieces	13 (26.1)	11 (8.0)
4. More than 4 pieces	0 (0.0)	1 (0.7)
Use of mosquito nets		
1. Do not use	83 (60.1)	86 (62.3)
2. Use	55 (39.9)	52 (38.7)
Insecticide Spraying in last 1 year		
1. No	118 (85.5)	100 (72.5)
2. Yes	20 (14.5)	38 (27.5)
Prevent to mosquito bites		
1. Did not do prevention	53 (38.4)	36 (26.1)
2. Do prevention	85 (61.6)	102 (73.9)
Mosquito bites prevention activities		
1. Using repellent	30 (21.7)	31 (22.5)
2. Using anti-mosquito drug	39 (28.3)	53 (38.4)
3. Wear long clothes	43 (31.2)	65 (47.1)
4. Plant mosquito repellent plants	0 (0.0)	1 (0.7)
Nighttime bed		
1. Outside the room	15 (10.9)	17 (12.3)
2. In the room	123 (89.1)	121 (87.7)
Travel history		
1. Yes, traveling	61 (44.2)	55 (39.9)
2. No	77 (55.8)	83(60.1)
Education		
1. Uneducated	19 (13.8)	13 (9.4)
2. Has not finished elementary	35 (25.4)	28 (20.3)
school	38 (27.5)	37 (26.8)
3. Graduated from elementary	30 (21.7)	34 (24.6)
school	15 (10.9)	20 (14.5)
4. Graduated from junior high	1 (0.7)	0 (0.0)
school	0 (0.0)	5 (3.6)
5. Graduated from senior high	0 (0.0)	1 (0.7)
school		
Occupation		
1. Farmer	67 (48.6)	53 (38.49)
2. Plantation	0 (0.0)	1 (0.7)
3. Labor	10 (7.2)	14 (10.1)
4. Private work	4 (2.9)	9 (6.5)
5. Traders	3 (2.2)	7 (5.1)
6. Retired	0 (0.0)	1 (0.7)
7. Civil servant	0 (0.0)	4 (2.9)
8. unemployed	54 (39.1)	49 (3.5)

Table 2: Behavior, socioeconomic and environmental characteristics

Variables	***Group: n(%)***	
	Cases	Controls
House wall		
1. Bamboo	27 (19.6)	10 (7.2)
2. Wood	58 (42.0)	42 (30.4)
3. Brick	13 (9.4)	27 (19.6)
4. Brick plaster	37 (26.8)	59 (42.8)
5. Others, such as brick making	3 (2.2)	0 (0.0)
Roof/ Ceiling		
1. Open, there is no roof of the ceiling	127 (92.0)	119 (86.2)
2. Bamboo covered	1 (0.7)	2 (1.4)
3. Wood covered	1 (0.7)	0 (0.0)
4. Plasterboard covered	9 (6.5)	17 (12.3)
Gauze ventilation		
1. Not available	135 (97.8)	134 (97.1)
2. Available	3 (2.2)	4 (2.9)
Cattle ownership		
1. Yes, at-risk (large cattle, such as cows, goats and enclosure <10 meters)	40(29.0)	43(31.2)
2. No cattle	98(71.0)	95(68.8)
Type of cattle		
1. Cow	3 (2.2)	2 (1.4)
2. Goats	59 (42.8)	70 (50.7)
3. Chicken/duck	74 (53.6)	65 (47.1)
Type of mosquito breeding place near the house		
1. River	61 (29.3)	72 (36.6)
2. Wellspring	57 (27.4)	63 (32.0)
3. Small river	52 (25.0)	28(14.2)
4. Basin/ Inundation	29 (13.9)	16(8.1)
5. Pond	9 (4.3)	10(5.1)
6. Rice fields	-	6(3.0)
7. Lake	-	2(1.0)
Average distance	83.9 m	167.0 m
The distance of the house to mosquito breeding place		
1. ≤ 100 meters	114 (62.8)	96 (69.6)
2. > 100 meters	24 (17.4)	42 (30.4)
The average distance to mosquito breeding place	83.9 m	167.0 m
Distance of the house to the Primary Health Care	73 (52.9)	55 (39.9)
1. < 4000 meters	65 (47.1)	83 (60.1)
2. ≥ 4000 meters	4646.4 m	4743.5 m
Average distance to Primary Health Care		
Altitude (above sea level)		
1. ≤ 500 meters asl	9(6.5)	37(26.8)
2. > 500 meters asl	129(93.5)	101(73.2)
Average altitude	311 m	349 m

Table 3: The best analysis results of factors that influence the incidence of malaria

No.	*Variables*	*B*	**P**	*OR*	*95% CI*
1.	Altitude (> 500 meters)	1.288	0.002	3.625	1,610-8,160
2.	House's wall (bamboo/wood)	0.790	0.003	2.203	1,307-3,713
3.	Spraying (not sprayed in the last 1 year)	0.730	0.026	2.075	1,090-3,951
4.	Distance of house with mosquito breeding place (≤ 100 meters)	0.662	0.040	1.939	1,032-3,643

Discussion

This study highlighted that altitude of house location influences the malaria incidence in the area of study. Menoreh ecosystem is a hilly area with the highest altitude of 1017 m above sea level. In this study, most of cases were found with an average height of 311 meters with Standard Deviation (SD) 127.78 and controls 349 m with SD=198.97. The results of this study are in accordance with the results of a study in Bangladesh, where forest and highland areas were at risk of malaria, related to the presence of *Anopheles* vectors found in forests and forest margins (11). Altitude >100 meters is a risk factor for malaria in Bangladesh with OR=3.44. While, in Uganda, higher altitudes of 1,500 m were associated with lower malaria risk (16). This fact is in accordance in Indonesia, which stated that the incidence of malaria at an altitude of >1200 m is less than the incidence in 200 m (17). In the tropical area, altitude has a role in the spread of malaria in relation to the *Anopheles* mosquito. The higher a place will lower the average temperature. This temperature will affect the sporogony cycle and age of mosquitoes (12). The conducive area for *Anopheles* mosquito breeding site is at an altitude of 500-1000 m, because in that region has a warm temperature, which will shorten the duration of the extrinsic cycle (sporogony cycle). The study in Ethiopia which divides altitude into 6 categories, namely <1000 m, 1000-1500 m, 1500-2000 m, 2000-2500 m, 2500-3000 m and> 3000 m, showed that the increasing prevalence of malaria prevalence diminishes. Malaria incidence is more common in areas with a height of <1000 m (5). *An. aconitus* malaria vector was found in rice field ecosystems at an altitude of 400-1000 meters (16). We found that the incidence of malaria was more prevalent in areas with an altitude between 500-800 m. The results also similar to a study in Tanzania (18) and Malawi (19) which stated that the prevalence of malaria parasites decreased with increasing the altitude of residence. The most prevalence of malaria is found in residents with a height of 500 m in Tanzania and 650 m in Malawi, and decreasing to a height of 2000 m.

The rivers in the area of study flow during the rainy season and the dry season, and in those places where mosquitoes breed. There are many rivers and rivers (small rivers) at the research location and the distance of the river/river to the houses of people close enough (<200 meters) is still within the range of flying *Anopheles* mosquitoes are at risk of increasing malaria cases. *An. Balabacencis* larvae breeding place usually is a pool of water covered by shrubs in the form of a water basin/basin in the river, in a pond, open puddles like a puddle. While *An. maculatus* breeds in mountainous areas, such as small rivers, springs, ponds, puddles on the banks of rivers and seepage of fields whose water flows slowly (12). A natural resting place for malaria vectors in Kokap Subdistrict, Kulonprogo Regency, which are shaded holes and used as household waste disposal sites (7).

The advantage of this research is that this study used a comprehensive analysis of malaria risk factors which included environmental, behavioral and socioeconomic factors. In the multivariate analysis, the confound control is carried out, so that internal validity is better. Meanwhile, the limitation of this study is that this study used a case-control study design, namely with reverse inference methodology starting from new diseases traced to exposure, so the possibility of the emergence of recall bias is greater, such as mosquito bite prevention behavior, night out behavior and use of mosquito nets. The malaria case used was only malaria cases recorded in health services based on micro-examination, where there may still be asymptomatic cases not reported in health services.

Finally, we concluded the main determinant of malaria in Menoreh's hilly ecosystem is altitude. In this study, several variables were identified as a risk factor of Malaria such as the wall of the house from bamboo/wood, no insecticide and distance of house <100 m from mosquito breeding site. This result should be an awareness for local health sector particularly to provide a recommendation for house construction for a new house to protect a community from malaria. It is also important to increase the prevention effort of Malaria to minimize them from *Anopheles* mosquito bites.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

All authors declare that there is no conflict of interest.

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