ENVIRONMENTAL FACTORS FOR MALARIA INFECTION IN TANINTHARYI REGION, MYANMAR: A CASE-CONTROL STUDY

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ABSTRACT:

Background: The risk of malaria infection can be influenced by the environment factors including house characteristic and house environment. The range of these risks can be more diverse in rural areas, which can include a mix of different housing styles and environments. This study aimed to identify environmental risk factors related to malaria infection in Tanintharyi Region, Myanmar.

Methodology: A case-control study was conducted among 153 malaria cases and 406 controls in Thanintharyi region, Myanmar during May and June 2016. WHO Rapid Diagnosis Test was used to diagnose malaria infection at mobile clinic. All participants completed questionnaires and participated in face-to-face interviews for the project to obtain socioeconomic, house characteristics, and house environments. Multiple logistic regression was performed to quantify environmental risk factors to malaria infection.

Results: Most of participants (54.5%) were male with the average age (±SD) 35 (±12.3) years old. Participants with a lower annual income have increased risk of malaria infection. Houses with bamboo wall [OR=3.63, 95%CI: 2.13,6.20], houses without ceiling [OR=1.95, 95% CI: 1.25,3.03], houses close to stream [OR=1.66, 95%CI :1.12, 2.45], and houses with compound less than one acres [AOR= 13.96, 95%CI :3.16, 61.6] were significant risk factors of malaria infection. Moreover, participants having a poor knowledge regarding malaria [AOR=5.58, 95%CI:2.61,11.9] have increased risk of malaria infection.

Conclusion: The findings of this study suggest that improving the house and household environment, together with promoting the knowledge about malaria infection could be a feasible way to reduce the risk of malaria.

Keywords: Environmental factors, Malaria, Myanmar

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INTRODUCTION

Malaria become one of the most severe public health problems worldwide [1]. In Myanmar, malaria became a major public health problem because of changes in climate and ecology, migration in population, emergence of multidrug resistant *P. falciparum* malaria and vectors resistant to insecticides, and changes of behavior in malaria vectors [2].

Since malaria cases were distributed unevenly not only between villages, but also within villages, environmental factors may play its importance role. This heterogeneity has been observed to attribute to a variety of environmental factors. These are the characteristics of the house where people live, the usage of protective measures for the mosquito vector, the presence of a vector-breeding site close to house, working patterns which may also result in human contact with the vector, population

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movements or socioeconomic, culture and demographic characteristics of the population [3]. Design of a house is an important factor in minimizing the access by insects, particularly those that are vectors of disease [4]. Few studies have been conducted about an influence of environment factors on malaria infection in Myanmar especially in Tanintharyi Region, where there is a mix of different housing styles and housing environments, and also a mixture environments [5]. Malaria main vectors in Tanintharyi Region are *Anopheles minimus* and *Anopheles dirus*. Seasonal prevalence of *Anopheles minimus* mosquitoes is from March to June and that for *Anopheles dirus* is from May to December. An epidemic period of malaria in Tanintharyi region is in May, June and July [6]. Therefore, this study aimed to identify environmental risk factors related to malaria infection in Tanintharyi Region, Myanmar.

MATERIALS AND METHODS

Study site

Tanintharyi region is located at the southern end of Myanmar. According to data from 2011 related to malaria epidemic, reported malaria morbidity rates in Tanintharyi Region were much higher than other regions. Four out of ten townships - Boke-pyin, Kyun-su, Palaw and Tha-yet-chaung, were selected as a study area because they were illustrated as malaria high endemic area in this region. Majority occupations are rubber farm workers, oil palms workers, farmers and fishermen [7].

Study design and participants

An unmatched 1:2 case-control study was conducted during summer season of 2016. The sample size was calculated by the formula for case-control study which was described in Kelsey et al. [8] with 80% of power. The estimated proportion exposed in the control group was 30%, and the suggested odd ratio from previous study on housing environment and malaria was 2.13. Therefore, 153 cases and 306 controls were participated. It is regarded as a malaria case when a person living currently in the study area who had malaria symptoms and whose WHO Rapid Diagnosis Test (RDT) was positive at the time of examination by mobile clinics. It is regarded as a malaria control when a person living currently in the study area who had neither history of malaria infection nor positive WHO Rapid Diagnosis Test result. WHO Rapid Diagnosis Test is able to quantify malaria infections as *P. faciparum* infection, *P. vivax* infection, mix infection and no infection.

Data collection

Socio-demographic, housing conditions, housing environment characteristics, knowledge of malaria and behavior related to protective and control were assessed via questionnaires administered to the participants at the mobile Clinics through face-to-face interview. The questionnaire was accessed at the same day as RDT test.

Data analysis

To analyze the collected data, SPSS version 16 was used. Descriptive statistics was utilized to find out mean, percentage and standard deviation. Bivariate analysis, [crude odds ratio (OR), 95% confidence interval and corresponding *p*-value < 0.05] was employed. Multivariate analysis was utilized. Variables were first assessed using bivariate analysis. Those significant at the P < 0.25 level were then grouped into the four main categories: socio-demographic, housing characteristics, housing environment and knowledge and these groups were analyzed by multiple logistic regression. Those individual variables analyzed within categories that were significant at the 0.05 level were included in the final model, which was also adjusted for reported bed net use.

Ethical consideration

Ethical approval to conduct this study was sought from Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University. Ethical approval number is COA No.098/2016 and date of approval was May 3, 2016.

RESULTS

The total number of subjects in this study was 459 (153 cases and 306 controls). Most of the respondents of cases and controls were Burma, female, aged between 26 to 45 years, married, and attained primary school education, total yearly family income between 1,200,001 to 2,600,000 Kyats and staying at the house for 5 to 27 years. Majority of occupation for cases was housewife and that for controls was working multiple occupations. Most of them did not work at rice field.

Univariate analyses

In Table 1, there was association between wood (Crude OR = 0.37, *p*-value = 0.001) used as material for first floor of house with malaria cases and

Table 1 Association between housing conditions and malaria infection (n=459)

House or housing condition	Malaria		Crude OR	95% C.I		*p*-value
	Cases (n=153)	Controls (n=306)		Lower	Upper	
Age of house in years						
1 - 6	39	48	1			
7 - 33	91	221	1.536	0.6	3.936	0.371
34 - 80	23	37	2.44	0.9	6.616	0.08
House tenure						
Own	127	263	1			
Rent	26	43	1.252	0.736	2.129	0.407
Number of floor						
2 floor	49	84	1			
1 floor	104	222	0.803	0.526	1.225	0.309
Materials used for first floor of house						
Cement	37	31	1			
Brick	28	36	0.652	0.328	1.295	0.222
Wood	57	131	0.365	0.206	0.644	0.001*
Bamboo	11	34	0.271	0.118	0.622	0.002*
None	13	53	0.206	0.095	0.445	<0.001*
Others	7	21	0.279	0.105	0.744	0.011*
Compositions of house walls for first floor of house						
Brick or adobe	32	83	1			
Wood or branches not covered with mud or branches covered with mud	44	168	0.679	0.402	1.149	0.15
Bamboo	77	55	3.631	2.127	6.199	<0.001*
Materials used for roof of house						
Zinc sheet	87	277	1			
Straw or palm	65	25	8.278	4.92	13.929	<0.001*
Other (Brick or wood)	1	4	0.796	0.088	7.216	0.839
Ceiling						
Yes	35	112	1			
No	118	194	1.946	1.25	3.032	0.003*
Number of hole in the mosquito bed net						
None	113	227	1			
1 - 6	22	20	2.21	1.158	4.217	0.016*

* Statistically significant at p<0.05

controls. Wood contributed as the protective factor for malaria and it decreased the risk of malaria 0.37 times than the reference group (cement). Bamboo (Crude OR = 0.27, *p*-value = 0.002) used as material for first floor of house was also associated with malaria cases and controls. Bamboo contributed as the protective factor for malaria and it decreased the risk of malaria 0.27 times than the reference group (cement). For compositions of house walls, bamboo was significantly associated with malaria cases and controls (Crude OR = 3.63, *p*-value = <0.001) and it was the risk factor. It increased the risk of malaria 3.63 times higher than the reference group (brick and adobe). Age of house, house tenure, number of floors, whether animals sleep in the house, presence or absence of mosquito bed net, number of openings in the subject's room and number of windows that were closed in the subject's room were not statistically significant for house and housing conditions.

Straw or palm (Crude OR = 8.28, *p*-value = <0.001) used as roof of house is significantly associated with malaria cases and controls, and they are regarded as risk factor. It increased the risk of malaria 8.28 times higher than the reference group (zinc sheet). Absence of ceiling increased the risk of malaria 1.95 times significantly comparing with present ceiling of house (Crude OR = 1.95, *p*-value = 0.003). Number of one to six holes in the bed net was also significantly associated with malaria cases and controls (Crude OR = 2.21, *p*-value = 0.02) and it was risk factor for malaria infection. It increased the risk of malaria 2.21 times higher than the reference group (no holes in the bed net).

Table 2 Association between housing environmental factors and malaria infection (n=459)

Characteristics of the housing environmental factors	Malaria		Crude OR	95% C.I		*p*-value
	Cases	Controls		Lower	Upper	
Canal						
No	136	289	1			
Yes	17	17	2.125	1.053	4.29	0.035*
Stream						
No	75	188	1			
Yes	78	118	1.657	1.12	2.452	0.012*
River						
No	124	286	1			
Yes	29	20	3.344	1.822	6.139	<0.001*
Well						
No	32	53	1			
Yes	121	253	0.792	0.486	1.292	0.351
Nearest forest						
No	51	190	1			
Yes	102	116	3.276	2.179	4.925	<0.001*
Living on the flat ground						
Yes	125	218	1			
No	28	87	0.561	0.348	0.906	0.018*
Number of any kinds of breeding sites (rubber plantations, slow running water, swamps) (<200m around the house)						
None	57	170	1			
1	38	83	1.365	0.839	2.223	0.21
2	42	50	2.505	1.507	4.165	<0.001*
3 or > 3	16	3	7.953	2.04	30.999	0.003*
Livestock in the compound						
Yes	45	153	1			
No	108	153	2.4	1.587	3.63	<0.001*
Number of nearby houses (<50m around the house; house(s))						
0 - 1	46	45	1			
2- 6	90	213	0.413	0.256	0.667	<0.001*
7 - 15	17	48	0.346	0.174	0.69	0.003*

* Statistically significant at p<0.05

Table 2 described the association between characteristics of the housing environmental factors. Canals around houses had significant association with malaria cases and malaria controls (Crude OR = 2.13, *p*-value = 0.04) and it was risk factor for malaria. It increased the risk of malaria 2.13 higher than the reference group (no canal). Streams and rivers around houses also has significant association with malaria cases and malaria controls at (Crude OR = 1.66, *p*-value = 0.01) and (Crude OR = 3.34, *p*-value = <0.001) respectively and they were the risk factors for malaria infection. Streams around houses increased the risk of malaria 1.66 times higher than the reference group (no streams) and river around houses increased the risk of malaria 3.34 times higher than the reference group (no rivers). Well was not statistically significant to cases and controls of malaria for house and housing environmental factors.

Having more than one nearby house decreased the risk of malaria infection. Forests locaed near respondents' houses was risk factor for malaria and it was statistically significant (Crude OR = 3.28, *p*-value = <0.001). It increased the risk of malaria 3.28 times higher than the reference group (no forest). There was also significant association between not living on the flat ground with malaria cases and controls at (Crude OR = 0.56, *p*-value = 0.02). Not living on the flat ground decreased the risk of malaria infection 0.56 times than the reference group (living on the flat ground). It was the protective factor for malaria infection. Number of two and three or more than three breeding sites within less than 200 m around the houses were also

Table 3 Effect of socio demographic, housing characteristics, housing environmental and knowledge on malaria infection in multivariate analyses

Variables	Adjusted OR	95% C.I		*p*-value
		Lower	Upper	
Age (years)				0.595
46 - 60	1			
26 - 45	0.677	0.289	1.587	
18 - 25	0.93	0.438	1.971	
Income (Kyats)				<0.001*
2600001 - 4500000	1			
1200001 - 2600000	15.461	5.138	46.527	
110000 - 1200000	5.848	2.181	15.677	
Materials used for first floor of house				0.007*
Cement	1			
Brick	2.016	0.684	5.939	
Wood	1.016	0.395	2.613	
Bamboo	0.227	0.061	0.846	
None	0.257	0.073	0.905	
Others (tiles or straw or palm)	1.188	0.267	5.287	
Compositions of house walls for first floor of house				<0.001*
Brick or adobe	1			
Wood or branches	1.594	0.719	3.531	
Bamboo	10.017	4.079	24.602	
Bushes but not trees (<200m from the house)				0.049*
No	1			
Yes	1.782	1.003	3.168	
Acres of owned house land				0.001*
One to Two acres	1			
Less than one	13.961	3.164	61.609	
Livestock in the compound				0.057
Yes	1			
No	1.81	0.982	3.337	
Number of nearby houses (<50m around the house, house(s))				0.065
0 - 1	1			
2 - 6	0.474	0.229	0.98	
7 -15	0.331	0.12	0.914	
Mosquito bed net				0.112
Present	1			
Absent	0.236	0.04	1.404	
Knowledge				<0.001*
Good knowledge	1			
Moderate knowledge	19.053	9.107	39.861	
Poor knowledge	5.577	2.612	11.907	

* Statistically significant at p<0.05

risk factors for malaria and they are statistically significant at (Crude OR = 2.5, *p*-value = <0.001) and (Crude OR = 7.95, *p*-value = 0.003) respectively. Having two breeding sites within less than 200m around the houses increased the risk of malaria 2.5 times higher than the reference group (no breeding sites). Having three or more than three breeding sites around the houses increased the risk of malaria 7.95 times higher than the reference group (no breeding sites). There were significant associations between having no livestock in the compound with malaria cases and controls (Crude OR = 2.4, *p*-value = <0.001) and it was risk factors for malaria. Having no livestock in the compound increased the risk of malaria infection 2.4 times higher than the reference group (having livestock in the compound).

Multivariate analyses

Table 3 described association between measured variables and malaria risk. The variables included in the final model were shown in this table. Socio demographic factors associated with an increased risk of malaria included total family yearly income at groups between 1,200,001 to 2,600,000 kyats and 110,000 to 1,200,000 kyats (*p*-value = <0.001). Housing characteristics that were found to lower the risk of malaria included floor constructed with bamboo and no materials used for first floor of house (*p*-value = 0.007). Bamboo used for compositions of house walls for first floor of house contributed increased malaria risk (*p*-value = <0.001). Housing environmental characteristic associated with an increased risk of malaria included presence of bushes but not trees within 200m around the house (*p*-value = 0.05) and the fact that the area of the land on which the house was located was less than one acres (*p*-value = 0.001). Moderate knowledge and poor knowledge were also increased the risk of malaria (*p*-value = <0.001). Age, livestock in the compound and number of nearby houses within less than 50m from the house were not associated with malaria risk.

DISCUSSION

The current study was conducted to document specific factors for malaria in relation to characteristic of household and household environment in Tanintharyi Region, Myanmar. Age was not associated with malaria infection. Housing environments with many potential breeding sites such as bushes is associated with malaria infection. This finding aligned with other study in which the risk factors of malaria is much more confined to limited areas and among certain occupations [9]. Total family yearly income from 1200001 to 2600000 Kyats and 110000 to 2600000 Kyats were risk factors for malaria infection and strongly associated with malaria at *p*-value of 0.003 and <0.001 respectively This finding was similar with other study from Thailand [10]. Mostly, lower income family have poor housing conditions because of not being able to afford to repair or maintain their houses.

This study did not observe any associations between age of houses and house tenure, in line with the findings of other study [11]. The use of bamboo for first floor of houses and the use of straw or palms for the roof of houses increased the risk of malaria. This finding was similar with other study [11]. Poorly constructed houses have been linked to an increased risk of malaria in several studies [12, 13]. The finding which stated the fact that no ceiling in the house was the risk factor for malaria was different from other study [3]. Houses without ceiling provide more chance for the entry of mosquitoes. Compositions of first floor house with walls made of bamboo or no materials are likely to be a protective factor for malaria infection. This may be because there is same chance for entry of mosquitoes with or without floors for first floor of houses. Additionally, building first floor with brick was possible to be a risk factor because it may contribute to darkness area and reduce air ventilation in house.

Presence of canals, streams, river within less than 200m from the houses and presence of nearby forests were the risk factors for malaria infection. Closer proximity to forest border was associated with increased malaria risk and is consistent with other findings [14-16]. The result of our study that had the association between malaria and the distance from the house to the nearest canal was congruent with the findings of other study [3]. Other studies also have observed that houses located close to streams and canals had a higher risk of malaria because of proximity to mosquito breeding sites [17-19]. Presence of two and three or more than three breeding sites within less than 200m around the house increased the risk of malaria and agreed with other study [3]. In the final multiple regression, having bushes but not trees within less than 200m around the house was also associated with malaria risk and increased the risk of malaria. Studies have shown that the closer the proximity of the living place to a potential breeding site of the vector, the higher the risk. As shown by some authors in Dakar [20], this is probably due to a high vector density in the area close to the breeding site, which decreases in areas located farthest away. Not living on the flat ground decreased the risk of malaria and statistically significant at *p*-value of 0.018. Living on flat ground, where water is most likely to accumulate, was associated with increased risk corroborating results found by Cohen [21]. Absence of livestock in the compound was risk factor for malaria and was different from other study which was done in Pakistan [22]. This may because the animals can be deployed to form a barrier between that vector and man. Presence of nearby houses within less than 50m was associated with risk of malaria. However, in the final model of multiple regression, the association was not statistically significant at p value of 0.06.

In the final model of multiple regression, the respondent who does not have good knowledge malaria were at high risk of malaria infection. As a result, the programs of health education needs to be enhanced to provide the knowledge on malaria vector and transmission as well as symptoms which are very important and essential information in terms of malaria infection. The moderate practice decreased the risk of malaria and this finding was similar with other study at Botswana [23].

Limitation of this study was a recalled bias from participants. Home observation and inspection from malaria case and control are suggested for further study. Since this study was done at only four townships from Thanintharyi Region, it is not the full representation of the whole population of this region. Furthermore, encouraging people to build their houses far from water reservoirs could be one of the messages published by an educational and information campaign, and could have some impact on the prevalence of the disease.

CONCLUSION

Regarding to differences and mixture of housing style and house environment characteristics in Thanintharyi Region, several characteristics were found to be associated with malaria in this study. The findings of this study suggest that repairing and maintaining existing housings, reducing breeding sites such as bushes and providing intervention to promote knowledge related to malaria infection could be a feasible way to reduce the risk of malaria.

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