KNOWLEDGE AND PRACTICES REGARDING MALARIA AND ITS PREVENTION AND THEIR ASSOCIATED SOCIO-DEMOGRAPHIC FACTORS AMONG THOSE LIVING ALONG THE THAILAND-MYANMAR BORDER

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Abstract. There are malaria case clusters in Thailand along the Thailand-Myanmar border. In this study, we aimed to compare the knowledge and practices regarding malaria and its prevention and their associated socio-demographic factors between those who entered the forest (forest goers) and those who did not (non-forest goers) among those living in Thailand along the Thailand-Myanmar border in order to inform efforts to reduce malaria clusters in this study population. The study consisted of 2 parts: a questionnaire survey and in-depth interviews. The inclusion criteria for questionnaire survey study subjects were: living in a study village during the study period, being able and willing to participate in the study and being aged >13 years. Inclusion criteria for in-depth interview subjects were: the same criteria as the questionnaire survey but subjects must be aged ≥18 years. Exclusion criteria for both the questionnaire survey and the in-depth interview subjects were being unable or unwilling to communicate with the researchers. Study subjects for the questionnaire survey were randomly selected from those living in two study villages in Tak Province, Thailand. Study subjects for the in-depth interviews were purposively selectively chosen based on their representation of groups in villages. The 2 parts

of the study were conducted during March-April 2019. The minimum number of study subjects calculated to be needed for the questionnaire survey was 369. The minimum number of subjects chosen for in-depth interviews was 30 in order to represent 6 groups of people in the study population: housewives, leaders, the elderly, the youth, forest goers and non-forest goers. A total of 385 subjects were included in the questionnaire survey, 40.8% male, and 30 subjects were included in the in-depth interviews, 56.6% male. The mean (±standard deviation) age of questionnaire study subjects was 36.2 (±16.7) (range: 13-95) years and of in-depth interview subjects was 43 (±18) (range: 18-78) years. Among questionnaire subjects, 50.3% were forest-goers and among interview subjects 60.0% were forest-goers. About three-fourth (76.8%) of questionnaire forest-goers knew malaria mosquito biting times versus 90.6% of non-forest-goers (p=0.001). Almost all (97.4%) of forest-goers believed malaria is curable versus 78.5% of non-forest-goers (p=0.001). Almost half (45.4%) of forest-goers believed malaria was transmitted by drinking mosquito larvae contaminated drinking water versus 31.4% of non-forest-goers (p=0.003). Of the forest-goers, 22.8% believed malaria mosquitoes bite all day long versus 9.4% of non-forest goers (p<0.001). Forest-goers stated they did not take any mosquito bite preventive measures 53.7% of the time versus 16.2% of the time among non-forest goers (p<0.001). Bed nets were used by forest-goers 30.1% of the time and by non-forest-goers 78.5% of the time (p<0.001). About half (50.5%) of forest-goers had a good knowledge about malaria versus 38.2% of non-forest-goers (p=0.272). The only socio-demographic factor significantly positively associated with better preventive practices was being ethnic Karen (p=0.046). Malaria knowledge level was not significantly associated with preventive practices. Among interview subjects, the reason given for not using bed- or hammock-nets among forest-goers was the inconvenience of carrying them into the forest. Most forest goers used other methods to prevent mosquito bites, such as wearing long sleeve shirts and planting mosquito repellant plants. In summary, we found forest-goers had a greater knowledge about malaria but poor practices regarding malaria prevention. We conclude there are other factors besides knowledge that cause forest-goers to have poorer practices. These need to be determined in order to develop interventions to improve preventive practices in the study population. Further studies are needed to determine the cause of the disconnect between knowledge and practices in the study population.

Keywords: malaria, socio-demography, knowledge, malaria prevention, forest-goers, Karen, ethnic minority, Thai Myanmar border, border population

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INTRODUCTION

The incidence of malaria in Thailand and much of the Greater Mekong Sub-region is declining (WHO, 2018). Thailand's National Malaria Elimination Strategy (NMES) 2017-2026 outlines a vision for reaching zero indigenous cases in Thailand by 2024 and aims to eliminate malaria in Thailand by 2026 (Ministry of Public Health, 2016). The prevalence of malaria in Thailand varies and can be divided into "forest acquired malaria" and "border area acquired malaria," with the borders referring to the borders between Thailand and the following countries: Myanmar, Cambodia, Laos and Malaysia (Bhumiratana *et al*, 2013; Sattabongkot *et al*, 2018). Thirteen million people in Thailand (19% of the total population) are at risk for contracting malaria, especially those living in the forested and border areas (WHO, 2018; Ministry of Public Health, 2016; Nofal *et al*, 2019; Imwong *et al*, 2015; Ngernna *et al*, 2019; Sriwichai *et al*, 2017). The people who live or work in these higher risk areas are often impoverished, uneducated have little or no access to hospital hospitals, public health intervention programs or malaria surveillance programs, making it more difficult to eliminate malaria (Parker *et al*, 2015; Munajat *et al*, 2021). It is necessary to understand malaria prevention practices among those who go into the forests (forest-goers) in this population to develop programs to eliminate malaria (Guyant *et al*, 2015; Parker *et al*, 2015; Nofal *et al*, 2019).

Previous knowledge, attitudes, and practice studies regarding malaria have been conducted to inform program efforts to eliminate malaria (Macheso *et al*, 1994; Thanabouasy *et al*, 2009). Several studies have discovered misconceptions about malaria and the use of mosquito nets in the forest in this high-risk population (Kyawt-Kyawt-Swe and Pearson, 2004; Malaria Consortium, 2013; Aung *et al*, 2019). Studies have suggested new approaches are needed to change behavior in this high-risk population since current approaches have not resulted in meeting the goal of malaria elimination in this population (Bhumiratana *et al*, 2013; Saita *et al*, 2019; Singh *et al*, 2013).

In this study, we aimed to determine and compare the knowledge regarding malaria and its preventive measures between forest goers and non-forest goers living along the Thai-Myanmar border and assess the effect of selected associated sociodemographic factors on knowledge and practices in order to inform programs to improve the control of malaria in the study area.

MATERIALS AND METHODS

Study area

This study was conducted in Suan Oi Village, Tha Song Yang Sub-district and Nong Bua Village, Mae Usu Sub-district, both in Tha Song Yang District of Tak Province, Thailand (Fig 1) during March-April 2019. Tha Song Yang District is located

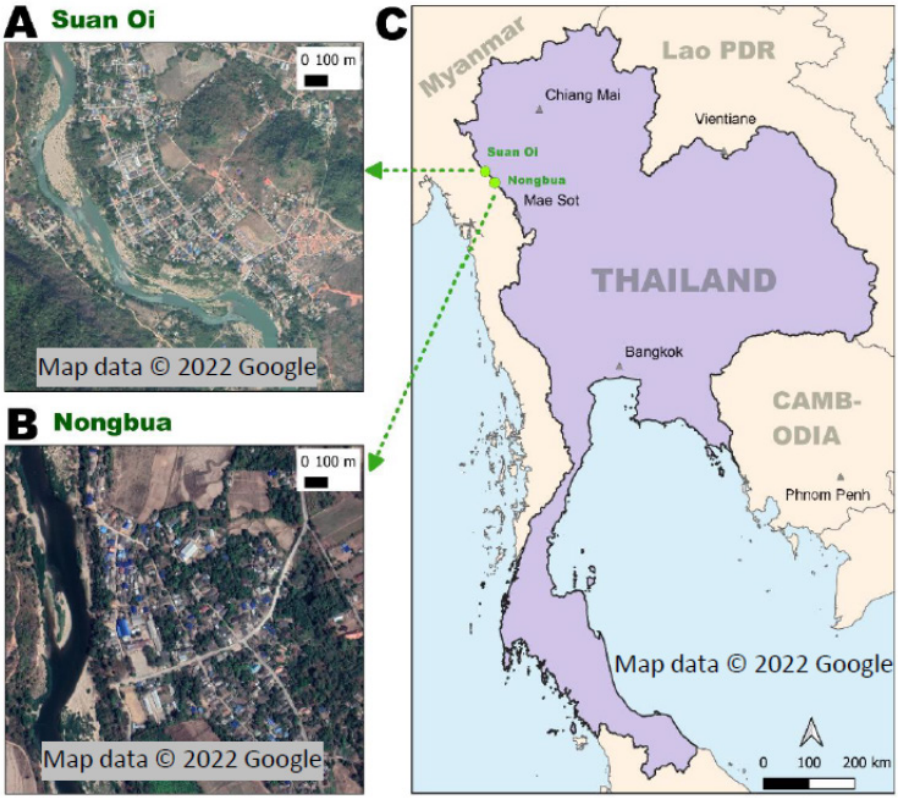

Fig 1 - Study village location

A and B: satellite images of the study villages; C: location of the study villages along the Thailand-Myanmar border

along the Moei River, which marks the international boundary between Thailand and Myanmar (across the border from Kayin State, Myanmar). Seventy percent of the people in the study area are ethnic minorities, mostly Karen (Parker *et al*, 2015). People in the study area often go into the forest to hunt and collect forest products (US President's Malaria Initiative, 2018; Kwansomboon *et al*, 2017; Parker *et al*, 2014). The reason for choosing these study villages is the presence of continuing malaria transmission in them over years, with 1643 cases of malaria (31.8% Thai; 68.2% non-Thai) in Tha Song Yang District during 2019, the largest number of malaria cases of any district in Thailand and the presence of regular migration in this area (Division of Vector-Borne Diseases, 2019; Corbel *et al*, 2013). Ninety-two percent of the malaria cases in this district are due to *Plasmodium vivax* and 5% are due to *P. falciparum* (Division of Vector-Borne Diseases, 2019). Malaria in this region is seasonal with 2 peaks: the larger during May-July and the smaller during October-November (Division of Vector-Borne Diseases, 2019; Zhou *et al*, 2005).

Design

We conducted a cross-sectional comparison study between forest goers and non-forest goers living in the study area. We divided the study into 2 parts. The first part used a questionnaire and was conducted among a large, randomly selected group and the second part used in-depth interviews conducted among individuals specifically selected to represent different components of the study population.

Questionnaire part

Inclusion criteria for study subjects included in the questionnaire part of the study were: living in the study village during the study period, being able and willing to participate in the study and being aged >13 years. The exclusion criterion for study subjects was being unable to communicate with the research team.

The questionnaire study sample size was calculated using the formula: $n = (z^2pq)/d^2$, where z = the z-score corresponding to the degree of confidence, p = the prevalence of malaria knowledge among the population living along in the study area based on a previous study (60.4%) (Aung *et al*, 2016), q = (1-p) and d = the desired precision (Daniel and Cross, 2013).

The minimal sample size determined to be needed for the study was 369. A total of 400 participants were determined to be needed to compensate for questionnaire non-responses. Subjects were selected by systematic random sampling based on the total population in the study area obtained from the 2017 International Centers of Excellence for Malaria Research (ICEMR)

census data (ICEMR, 2017). Each subject was randomly chosen from a list of the census data in the study villages.

Each participant was to complete a questionnaire. The questionnaire consisted of questions about socio-demographic characteristics; knowledge about malaria, such as its cause, prevention and control; the participant's preventive practices; and practices regarding going into the forest. Malaria knowledge levels were classified based on the percentages of correct answers (>80% of answers correct: good; 60-80% correct: average; <60%: poor).

Each questionnaire subject was asked to complete a mobility calendar asking if they crossed the border, went into the forest, stay outside overnight and if they used any mosquito bite preventive measures (Fig 2). This calendar was completed weekly for 3 consecutive weeks.

Interview part

Thirty subjects were purposely selected for the interview part of the study, which asked in-depth questions about the reasons for entering the forest and the reasons for using or not using malaria prevention methods. The interview subjects were selected

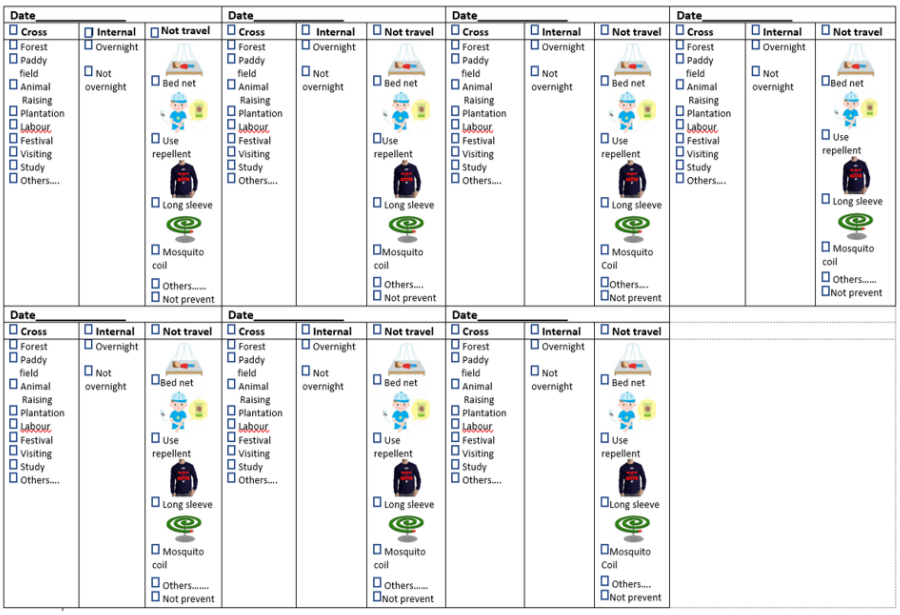

Fig 2 - Mobility calendar

to represent the different groups of people in the village: the village head, housewives, the elderly, the youth, forest goers, and non-forest goers. The inclusion criteria and exclusion criterion for the subjects in the interview part of the study were the same as those for the questionnaire except the minimum age of interview subjects was 18 years.

Data analysis

The data from the quantitative survey were entered into the Statistical Package for the Social Sciences (SPSS) for Windows, version 23.0 (IBM, Armonk, NY).

We used descriptive and inferential statistical analysis to evaluate the questionnaire data. We used frequencies and percentages to classify categorical variables. We used means ± standard deviations (SD) to summarize continuous variables. We used Chi-squared or Fisher's exact tests and univariate logistic regression and multivariate logistic regression analyses to evaluate variable associations. A p-value < 0.05 was considered statistically significant.

We evaluated the interview data using thematic analyses. Subject responses were first transcribed and then translated into English. After translation, the thematic content was analyzed using NVivo 12 software (https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home) (Walsh, 2003).

RESULTS

Questionnaire results

Sociodemographic characteristics:

A total of 385 subjects were included in the questionnaire study, 40.8% male. The mean (±SD) age of subjects was 36.2 (±16.7) (range 13-95) years.

About half (50.4%) of subjects (n = 194) were forest-goers. Subjects who were significantly more likely to be forest-goers were those who owned land in Myanmar (crude odds ratio (cOR) = 5.28; 95% confidence interval (CI): 2.77-10.06, p<0.001). Subjects who were significantly less likely to be forest-goers were those with a secondary or higher education level (cOR = 0.24; 95% CI: 0.14-0.43, p<0.001), being literate in the Thai language (cOR = 0.36; 95%CI: 0.24-0.56, p<0.001) and being born in Thailand (cOR = 0.36; 95%CI: 0.24-0.56, p<0.001) (Table 1).

Knowledge about malaria:

Approximately three-fourth (76.8%) of the forest-goers and 90.6% of non-forest-goers (p=0.001) knew the biting time for Anopheles mosquitoes. Up to 97.4% of forest-goers and 78.5% of non-forest goers knew malaria is curable (p=0.001) (Table 2).

About half (50.5%) of forest-goers and 38.2% of non-forest-goers (p=0.272) had a good overall knowledge level about malaria, 32.5% of forest-goers

Table 1

Univariate logistic regression analysis of factors potentially associated with being a forest-goer

Variables	Total (N=385) *n* (%)	Forest goers (N=194) *n* (%)	Univariate logistic regression	
			cOR (95% CI)	*p*-value
Gender				
Female	228 (59.2)	109 (56.2)	1	
Male	157 (40.8)	85 (43.8)	1.29 (0.86-1.94)	0.222
Age (years)				
60 and over	37 (9.6)	22 (11.3)	1	
18 to 59	283 (73.5)	154 (79.4)	0.81 (0.40-1.63)	0.563
13 to <18	65 (16.9)	18 (9.3)	0.26 (0.11-0.61)	0.002
Mean age ±SD 36.2±16.7 years; Range 13-95 years for 385 participants				
Ethnicity				
Thai	44 (11.4)	24 (12.4)	1	
Karen	341 (88.6)	170 (87.6)	0.83 (0.44-1.56)	0.558
Education level				
None	211 (54.8)	131 (67.5)	1	
Primary	97 (25.2)	41 (21.1)	0.45 (0.27-0.73)	0.001
Secondary or higher	77 (20.0)	22 (11.3)	0.24 (0.14-0.43)	<0.001
Thai literacy				
No	184 (47.8)	113 (58.2)	1	
Yes	201 (52.2)	81 (41.8)	0.42 (0.28-0.63)	<0.001
Place of origin				
Myanmar	150 (39.0)	98 (50.5)	1	
Thailand	235 (61.0)	96 (49.5)	0.36 (0.24-0.56)	<0.001
Owner land at Myanmar site				
No	318 (82.6)	140 (72.2)	1	
Yes	67 (17.4)	54 (27.8)	5.28 (2.77-10.06)	<0.001

CI: confidence intervals; cOR: crude odds ratio; SD: standard deviation

Table 2

Knowledge about malaria among forest-goers and non-forest-goers

Knowledge areas	Total (N = 385) *n* (%)	Forest-goers (N = 194) *n* (%)	Non-forest goers (N = 191) *n* (%)	*p*-value
Knew malaria is transmitted by mosquito bite	333 (86.5)	165 (85.1)	168 (87.9)	0.247
Knew correct *Anopheles* biting times	322 (83.6)	149 (76.8)	173 (90.6)	<0.001
Knew symptoms of malaria (fever and shaking chills)	374 (97.1)	188 (96.9)	186 (97.4)	0.511
Knew malaria can cause death	365 (94.8)	189 (97.4)	176 (92.1)	0.022
Knew importance of seeking health care early for malaria	338 (87.8)	168 (86.6)	170 (89.0)	0.286
Knew malaria is curable	339 (88.1)	189 (97.4)	150 (78.5)	<0.001
Knew malaria transmission can continue if incompletely treated	326 (84.7)	165 (85.1)	161 (84.3)	0.474
Knew bed nets can prevent contracting malaria	366 (95.1)	187 (96.4)	179 (93.7)	0.165

and 44.5% of non-forest-goers (p=0.016) had a moderate overall knowledge level about malaria and 17.0% of forest-goers and 17.3% of non-forest-goers (p=0.591) had a poor overall knowledge level about malaria (Table 3).

Almost half (45.4%) of forest-goers and 38.4% of non-forest-goers (p=0.003) believed malaria was transmitted by drinking water containing mosquito larvae. About 22.8% of forest-goers and 9.4% of non-forest-goers (p<0.001) believed Anopheles mosquitoes bite primarily during the daytime (Table 4).

Malaria preventive practices among forest-goers and non-forest goers:

The results of the mobility calendar revealed, forest goers used at least one preventive measure 85.1% of the time and non-forest goers 80.6% of the time (p<0.001). Forest goers used bite protection measures 92.2% of the time at home, 13.1% of the time during day trips into the forest and 66.7% of the time when staying overnight in the forest (Table 5).

Up to 78.2% of forest goers used bed nets while 73.1% of non-forest goers used bed nets (p<0.001).

Table 3

Comparison of malaria knowledge levels between forest-goers and non-forest goers

Population group	Knowledge level		
	Good (score >80%)	Average (score 60-80%)	Poor (score <60%)
Forest-goers (N = 194), *n* (%)	98 (50.5)	63 (32.5)	33 (17.0)
Non-forest-goers (N = 191), *n* (%)	73 (38.2)	85 (44.5)	33 (17.3)
Total	171 (44.4)	148 (38.4)	66 (17.1)
p-value	0.272	0.016	0.591

Table 4

Incorrect beliefs about malaria among forest-goers and non-forest-goers

Beliefs	Total (N = 385) *n* (%)	Forest-goers (N = 194) *n* (%)	Non-forest goers (N = 191) *n* (%)	*p*-value
Malaria causes joint pain and diarrhea.	226 (58.7)	109 (56.2)	117 (61.3)	0.182
Malaria is transmitted by drinking water containing mosquito larvae	148 (38.4)	88 (45.4)	60 (31.4)	0.003
Anopheles mosquitoes bite during the daytime.	62 (16.1)	44 (22.8)	18 (9.4)	<0.001
Malaria relapse cannot be prevented	59 (15.3)	29 (14.9)	30 (15.7)	0.474
Physical contact or sharing belongings can transmit malaria	34 (8.8)	22 (11.3)	12 (6.3)	0.058

Table 5

Malaria preventive practices among forest and non-forest goers

Malaria preventive practice and the location it was used	Forest goers (N =194)		Non-forest goers (N =191)		*p*-value
	Total nights observed	Preventive practices *n* (%)	Total nights observed	Preventive practices *n* (%)	
Any bite protection					
Overall	5,736	4,879 (85.1)	5,739	4,623 (80.6)	<0.001
At home	5,060	4,663 (92.2)	5,623	4,553 (81.9)	
Day trip in the forest	464	61 (13.1)	0	0 (0.0)	
Overnight in the forest	135	90 (66.7)	0	0 (0.0)	
Overnight elsewhere	77	65 (84.4)	85	70 (82.4)	
Bed nets					
Overall	5,736	4,486 (78.2)	5,739	4,197 (73.1)	<0.001
At home	5,524	4,403 (79.7)	5,623	4,137 (73.6)	
Overnight in the forest	135	43 (31.9)	0	0 (0.0)	
Overnight elsewhere	77	40 (51.9)	85	60 (70.6)	

Table 5 (cont)

Malaria preventive practice and the location it was used	Forest goers (N =194)		Non-forest goers (N =191)		*p*-value
	Total nights observed	Preventive practices *n* (%)	Total nights observed	Preventive practices *n* (%)	
Repellent					
Overall	5,736	22 (0.4)	5,739	15 (0.3)	<0.001
At home	5,060	1 (0.02)	5,623	15 (0.3)	
Day trip in the forest	464	16 (3.4)	0	0 (0.0)	
Overnight in the forest	135	4 (3.0)	0	0 (0.0)	
Overnight elsewhere	77	1 (1.3)	85	0 (0.0)	
Other methods*					
Overall	5,736	397 (6.9)	5,739	411 (7.2)	0.615
At home	5,060	285 (5.6)	5,623	401 (7.1)	
Day trip in the forest	464	45 (9.7)	0	0 (0.0)	
Overnight in the forest	135	43 (31.9)	0	0 (0.0)	
Overnight elsewhere	77	24 (31.2)	85	10 (11.8)	

*Other methods used were: wearing long sleeved clothes and pants, using biofuels to make smoke and using cigarette smoke.

However, forest goers used bed nets only 31.9% of the time when staying overnight in the forest versus 79.7% when at home (p<0.001). Overall, 0.4% of forest goers used mosquito repellent and 0.3% of non-forest goers used mosquito repellant (p=0.248). Forest goer used mosquito repellant 3.7% of the time when going on a day trip in the forest and 3.0% when staying overnight in the forest.

Selected factors associated with malaria knowledge levels and preventive practices:

The only factor significantly positively associated with better preventive practices was Karen ethnicity (adjusted odds ratio (aOR) = 0.11; 95% CI: 0.01-0.99, p=0.046) (Table 6). However, in our study, subject malaria knowledge was not significantly positively associated with malaria prevention among forest-goers with average malaria knowledge levels (aOR = 0.66; 95% CI: 0.20-2.12, p=0.487) or among forest-goers with good malaria knowledge levels (aOR = 0.40; 95% CI: 0.13-1.19, p=0.099).

Interview results

Thirty subjects were included in the interview part of the study. The mean (±SD) age of in-depth interview subjects was 43 (±18) (range: 18-80) years old. Ninety percent of interview subjects were familiar with malaria from their own personal experiences.

The following are examples of statements among interview subjects about their knowledge about malaria.

> *"I know that mosquitoes can transmit malaria. In the early days, I worked in the forest and got bitten by mosquitoes a lot. Many times I had fever with chills and that was malaria"* (Male, aged 68 years).
>
> *"While in the forest, mosquitoes bite all the time, I cannot tell biting time of malaria mosquito as I cannot tell which one is malaria mosquitoes."* (Male, aged 46 years)
>
> *"I think the cause of malaria is due to a combination of mosquito bites and drinking dirty water, water where mosquito larvae are present. Malaria germs are passed from mosquitoes to eggs to larvae."* (Male, aged 66 years)
>
> *"I always miss out when malaria staff come to distribute bed nets. They tell villagers about malaria and how to prevent malaria. I am normally out in the forest or on the farm."* (Female, 40 years)

Many subjects reported having previously had malaria. They felt malaria nowadays was not as severe as malaria in the past, due to early

Table 6

Associations between selected factors and being a forest-goer

Factors	Number	Prevention* *n* (%)	cOR (95% CI)	*p*-value	aOR (95% CI)	*p*-value
Ethnicity						
Thai	24	23 (15.8)	Ref		Ref	
Karen	170	123 (84.2)	0.11 (0.01-0.87)	0.036	0.11 (0.01-0.99)	0.046
Age group in years						
≥60	22	16 (11.0)	Ref		Ref	
18-59	154	115 (78.7)	1.10 (0.40-3.02)	0.845	0.99 (0.34-2.88)	0.991
13-17	18	15 (10.3)	1.87 (0.39-8.87)	0.428	1.24 (0.21-7.35)	0.813
Gender						
Female	109	83 (56.8)	Ref		Ref	
Male	85	63 (43.2)	0.89 (0.46-1.72)	0.921	0.96 (0.48-1.94)	0.921
Education level						
Never attended	131	96 (65.8)	Ref		Ref	
Primary school	41	32 (21.9)	1.29 (0.56-2.98)	0.542	1.03 (0.32-3.30)	0.960
Secondary school and above	22	18 (12.3)	1.64 (0.51-5.18)	0.399	1.26 (0.29-5.56)	0.756

Table 6 (cont)

Factors	Number	Prevention* *n* (%)	cOR (95% CI)	*p*-value	aOR (95% CI)	*p*-value
Thai literacy						
No	113	84 (57.5)	Ref		Ref	
Yes	81	62 (42.5)	1.12 (0.58-2.19)	0.725	0.66 (0.25-1.73)	0.406
Place of origin						
Myanmar	96	77 (52.7)	Ref		Ref	
Thailand	98	69 (43.7)	0.58 (0.30-1.14)	0.116	1.29 (0.53-3.09)	0.568
Own land in Myanmar						
No	140	105 (71.9)	Ref		Ref	
Yes	54	41 (28.1)	1.05 (0.50-2.18)	0.893	1.43(0.65-3.15)	0.379
Malaria knowledge level						
Poor	33	28 (19.2)	Ref		Ref	
Average	63	50 (34.2)	0.68 (0.22-2.12)	0.487	0.66 (0.20-2.12)	0.487
Good	98	68 (46.6)	0.40 (0.14-1.15)	0.090	0.40 (0.13-1.19)	0.099

*Using any preventive method against mosquito biting in 15 days or more in the previous month

aOR: adjusted odds ratio; CI: confidence intervals; cOR: crude odds ratio; Ref: Reference

Poor knowledge: score <60%; Average knowledge: 60-80%; Good knowledge: >80%

diagnosis and treatment.

> *"Malaria now is easy to treat with medicine. But if someone gets malaria and does not seek treatment or receive treatment promptly, they will get really sick and may die. I have seen people from Myanmar with malaria trying to cross the border into Thailand for treatment, but they could not make it soon enough and they died."* (Female, 35 years)

Some forest-goers pointed out the inconvenience of carrying bed nets or hammock nets when traveling in the forest. They sometimes sought other practical ways to prevent mosquito bites.

> *"I am working in the forest. It's difficult to hang the net because the net is not designed to be used in the forest. I think smoking or wearing long sleeves or trousers is the most practical way to prevent the mosquito bites even though they may be less effective."* (Male, 56 years)

> *"I saw only one or two hammock nets in our village, we do not bring them into the forest. We stay overnight in the forest when we hunt. If we sleep in the forest, we sleep on the ground under the trees and cover ourselves with thin blankets. This way, it is easier to move quickly if a big animal, like an elephant, approaches us."* (Male, 35 years)

> *"Using repellent when going into the forest is effective. We apply repellent first, then wear long-sleeve shirts and long plants. The repellent is effective for up to 3 hours, so it is enough for half a day in the forest. It is too expensive for us to buy, I only use it when it is distributed free from the malaria clinic, but it has not been distributed for the past few years."* (Female, 25 years)

DISCUSSION

This study investigated knowledge, attitudes and practices about malaria and its prevention and evaluated potentially associated factors comparing forest goers and non-forest goers living in Tak Province, Thailand along the Thai-Myanmar border, in order to guide efforts to prevent malaria in this area.

The results of our study showed the majority of the forest goers were ethnic Karen, and owned agricultural land in Thailand. In the Greater Mekong Sub-region, farmland along international borders is often located near forests with easy access to hunting and gathering forest products. Many Karen in these areas are subsistence farmers, regularly going into the forest to collect food for household consumption (Bhumiratana *et al*, 2013; Panvisavas, 2001; Prothero, 1999; Jongdeepaisal *et al*, 2022; Charoenniyomphrai *et al*, 2003). This forest-collected food is needed due to inadequate income

among those who are forest goers but it increases their risk for contracting malaria (Nofal *et al*, 2019; Thet *et al*, 2022).

In our study, most forest goers were aware malaria is caused by mosquito bites, similar to the findings of another study of the Greater Mekong Sub-region (Nofal *et al*, 2019). In our study, 85.1% of forest goers knew mosquito bites could transmit malaria, slightly lower than the 97% reported from a study of forest goers in Mukdahan Province, Northeastern Thailand (Rahim *et al*, 2022).

In our study, significantly more non-forest-goers knew about malaria mosquito biting times than forest-goers. Although *Anopheles* mosquitoes commonly known as nocturnal biters, it has been reported that they can bite in the early morning when it is still dark (Soe *et al*, 2017). A previous study from the forest in Cambodia found 20% of the mosquitoes collected during the daytime were female *Anopheles* mosquitoes (Vantaux *et al*, 2021) showing malaria risk is not just nocturnal. This is why our finding is so concerning that only 13.1% of forest goers used bite protection when going into the forest during the daytime.

In our study, forest goers were significantly more likely to know malaria is curable than non-forest goers. This is most likely due to previous experiences with malaria or being more likely to know forest goers with previous experiences with malaria (Keang *et al*, 2019; Jongdeepaisal *et al*, 2022).

In our study, many subjects had the misconception that a person could get malaria by drinking water polluted with mosquito larvae, similar to the findings of previous studies from Bangladesh, India and the Greater Mekong Sub-region (Singh *et al*, 2013; Saha *et al*, 2019; Nofal *et al*, 2019).

In our study, malaria knowledge levels were greater among non-forest-goers than forest-goers. This could be because many of the forest goers in our study had lower education levels, as seen in similar studies from Myanmar, India, Tanzania and Mukdahan, Thailand (Thet *et al*, 2022; Hla-Shein *et al*, 1998; Singh *et al*, 2013; Mazigo *et al*, 2010; Sumari *et al*, 2016; Tipmontree *et al*, 2009).

Our study revealed that having a better knowledge about malaria and its prevention did not correlate with better mosquito bite preventive practices, similar to a study from Myanmar that reported a significant negative association between malaria knowledge levels and both attitudes and practices (Aung *et al*, 2019). Only one study, from Myanmar, reported a significant positive association between malaria knowledge and good preventive practices (Hein, 2017).

In our study, forest goers reported using mosquito nets in the forest was

not practical, similar to studies from the borders between Thailand and Myanmar, Cambodia and Lao PDR (Pooseesod *et al*, 2021; Jongdeepaisal *et al*, 2022).

In our study, an interview subject reported not having bed nets since they were distributed during working hours, similar to the findings of previous studies along the Thai-Myanmar border (Maung *et al*, 2018; Linn *et al*, 2019).

In our study, very few subjects used mosquito repellant, stating it was too expensive, similar to the findings of a previous studies that reported low repellant use to due cost and the chemical smell (Wharton-Smith and Shafique, 2014; Gryseels *et al*, 2015; Crawshaw *et al*, 2017).

In our study, among those who used other methods to prevent mosquito bites, smoking and wearing long sleeves were mentioned as the most common methods used, similar to previous studies that mentioned the use of blankets, wearing long sleave clothes and using cigarette smoke (Nofal *et al*, 2019; Malaria Consortium, 2013; Pooseesod *et al*, 2021; Jongdeepaisal *et al*, 2022). In our study, Karen subjects used prevention methods more frequently than Thai subjects, similar to the findings of a previous study from Thailand (Malaria Consortium, 2015).

There were several limitations in our study. This study was confined to a selected population as may not be generalizable to other populations. The questionnaire subjects were selected randomly but interview subjects were not and study subject selection bias may result in answers that do not reflect those of the overally study population. Our questionnaire was not pilot-tested so the results may be influenced by misunderstanding the meaning of the questions. This was evident in some questions which were elimited from the study after the results were obtained since it was evident the subjects did not understand what was being asked. Another limitation of our study was that it was conducted in the dry season when the mosquito bite preventive practices are different from those in the rainy season; however, the questions in our study instrument were not specific to the dry season.

In summary, we found that although forest-goers had higher greater knowledge about malaria, they had poor practices regarding malaria prevention. We conclude, other factors besides knowledge may be a cause for the forest-goers to have poorer practices. Further studies are needed to determine the cause of the disconnect between knowledge and practices and develop interventions to improve preventive practices in this high-risk population.

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