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Attitudes Toward *Plasmodium knowlesi* Malaria Prevention Behaviours Among at-risk Communities and Health District Officers' Efforts and Challenges in Promoting These Behaviours: An Elicitation Study in Peninsular Malaysia

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ABSTRACT

This study explores at-risk communities' attitudes toward *Plasmodium knowlesi* (*P. knowlesi*) malaria prevention behaviours using the Integrated Behavioural Model (IBM) as a guiding framework. This study also presents efforts and challenges faced by district health officers in Peninsular Malaysia in their role as the health authority for mitigating the disease. Seventeen informants were selected from at-risk areas in three states with high cases of *P. knowlesi* in 2019 (Johor, Pahang, Kelantan) to be interviewed. Semi-structured interview questions were developed guided by the IBM framework. Three district health officers who were involved in malaria prevention efforts in the selected states were also interviewed. Qualitative data analysis using Atlas.ti 8 software was used to facilitate thematic coding. Five prevention behaviours were found to be prevalent among the informants and are hypothesised to be suited for behavioural improvement intervention among at-risk communities. The prevention behaviours identified are: consuming prophylaxis, wearing long sleeves, using bed nets, mosquito coils and insect repellent. Current efforts by health district officers for *P. knowlesi* malaria prevention include erecting warning signs, community education programmes, and empowering community influencers. Challenges faced by the health district officers include difficulty accessing remote locations, limited facilities, and military-specific issues. This study suggests that future prevention efforts focused on behavioural improvement among at-risk communities in Malaysia should concentrate on the five prevention efforts most prevalent among these communities.

Keywords: *P. knowlesi malaria, attitude, prevention challenges, prevention efforts, peninsular Malaysia.*

INTRODUCTION

The threat posed by *Plasmodium knowlesi* malaria to humans has received significant attention in the World Malaria Report (World Health Organization [WHO], 2020), among malaria experts in the Evidence Review Group on *P. knowlesi* malaria (WHO, 2017), and from the World Health Organization Malaria Policy Advisory Group (WHO MPAG, 2021). Malaria is common in the east

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coast of Peninsular Malaysia, with *P. knowlesi* being the common parasite (Hussin et al., 2020). In East Malaysia, the incidence 48 of P. knowlesi was 5.9 per 100,000 people in 2017 (Rahim et al., 2020), with a case fatality rate of 2.5% per 1000 individuals (Rajahram et al., 2019). Malaria has repeatedly been reported to be prevalent among the Orang Asli community in Peninsular Malaysia (Norhayati et al., 2001; Kaur, G., 2009; Jiram et al., 2016), and people who were involved in agriculture and army-related occupations (Pramasivan et al., 2021 & Roughton & Green, 2012).

Moreover, it was discovered that standard preventive measures such as insecticide-treated nets (ITN) and indoor residual spraying (IRS) were insufficient to protect the Orang Asli community from mosquitoes when they were outside their houses (Manin et al., 2016). In some studies, the use of personal protective antimalarial measures, such as bed nets and mosquito repellent, appeared to protect against mosquito bites (Ipa et al., 2020; Aung et al., 2022; Pandit et al., 2010 & Killeen at al., 2017).

The Ministry of Health of Malaysia (MOH) recommends applying mosquito repellent or wearing long-sleeved, brightly-colored clothing as the simplest preventive measure for mosquito bites (Fradin, 2001 & Curtis, 1992). A preliminary study on malaria prevention attitude among visitors at selected recreational parks in Peninsular Malaysia showed the most popular method for preventing mosquito bites was by using repellent (56.1%) followed by the use of aerosol spray (53.4%). The result of the study also showed that 62.2% of respondents used repellent before performing outdoor activities (Rafidah et al., 2020).

The Integrated Behavioural Model (IBM) is a theory of behavioural prediction that is useful for planning intervention programmes. IBM suggests that an individual's intention to perform a target behaviour is driven by attitudes, perceived norms, and personal agency (Montano & Kasprzyk, 2008). Attitudes are known as an individual's beliefs that a target behaviour will have advantageous or disadvantageous consequences (Hagger et al., 2020). A study conducted among science teachers found that attitudes toward incorporating environmental risk education was the most important predictor of intention to act on it (Zint, 2002). In a similar study, it was found that the stronger participants' level of environmental attitude, the more motivated they were to protect the environment and the more interested they were in relevant applications. Attitude was positively related to health intentions; the stronger a person's health attitude is, the more likely they are to act in a healthy way (Brügger & Hochli, 2019). In addition, results of a quantitative study showed that a positive attitude significantly predicted success in eating behaviour change of participants becoming vegetarian (Ogden et al., 2006).

Although there are many prevention behaviours for *P. knowlesi* malaria, it would be strategic to target the most prevalent ones and those with higher positive attitudes among targeted communities to increase the chances of them performing the prevention behaviour. Specifically, this paper will present findings related to attitudes toward *P. knowlesi* prevention behaviours. This inductive study provides local evidence that is valuable to tailor make intervention programs with better success.

METHODOLOGY

Semi-structured in-depth interviews were utilised as a method for this study. Two groups of informants interviewed in the study were the at-risk community group and the district health officer group. Interview questions for the at-risk community group were developed and guided by the variables in IBM related to *P. knowlesi* prevention behaviours. Table 1 shows the list of questions related to attitudes in the interviews with the at-risk community group. These questions were adopted and adapted from Montano and Kasprzyk (2008).

Table 1: List of questions related to attitudes toward prevention behaviours.

Constructs	**Dimensions**	**Questions**
Feelings about behaviour	Experiential Attitude	1. How do you feel about the idea of (insert prevention behaviour)? 2. What do you like or dislike about (insert prevention behaviour)?
Behavioural beliefs	Instrumental Attitude	1. What are the advantages of you doing (insert prevention behaviour)? 2. What are the disadvantages of you doing (insert prevention behaviour)? 3. What are the benefits that might result from doing (insert prevention behaviour)? 4. What are the negative effects that might result from performing (insert prevention behaviour)?

For the district health officer group, qualitative exploratory interview questions were designed to gain an in-depth understanding of efforts carried out by health officers at the district level. The instrument focused on general questions encouraging health officers to share their efforts, challenges, and initiatives to combat the spread of *P. knowlesi* malaria among their communities. The in-depth interviews were conducted in the local language, recorded and then transcribed.

Data Collection and Analysis

Gua Musang (4.8843° N, 101.9682° E), Kuala Lipis (4.1843° N, 102.0542° E) and Kota Tinggi (1.7294° N, 103.8992° E) districts located in Kelantan, Pahang and Johor, respectively, were selected as study locations. Figure 1 shows the geographical locations of the three districts selected in this study.

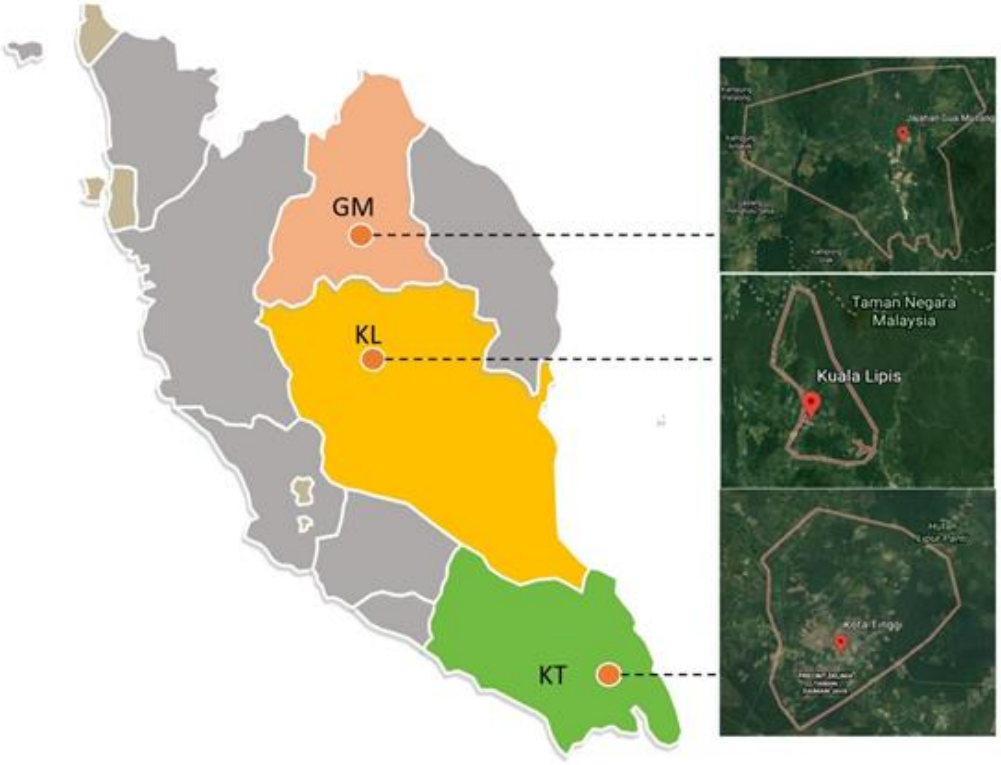

Figure 1: Geographical location of the selected districts and states.

These three districts recorded the highest number of cases of *P. knowlesi* malaria in Peninsular Malaysia in 2018. The data collection was carried out from June until August 2019. In analysing the transcripts, semi-structured coding was performed by two coders through Atlas.ti version 8. For the at-risk community group, thematic analysis was conducted according to the IBM attitude dimensions while for the health district officer group, the analysis was organised according to efforts and challenges.

a. At-Risk Community Informants

According to Francis et al. (2010), he reached data saturation at the 17th interview for all their pre-determined theoretical constructs and this was supported by Bertaux (1981) which he stated that the smallest acceptable qualitative sample size is fifteen interviews. For this study, in total, seventeen individuals who had or had not been infected with *P. knowlesi* malaria from the three at-risk areas took part in the in-depth interviews. The inclusion criteria for this study were as follows: (1) age ≥ 18 years, (2) Malaysian resident. There were three community groups in these locations identified as at-risk communities i.e: local people, Orang Asli group, and the military. Demographic characteristics and details are summarised in Table 2 and Table 3.

Table 2: Characteristics of the informant

Characteristic	N
Gender	
Female	5
Male	12
Age (years)	
18-27	2
28-37	5
38-47	2
48-57	2
58-67	4
68-77	1
78-87	1
District/Region	
Kota Tinggi	5
Kuala Lipis	6
Gua Musang	6
Occupation	
Agriculture/Forestry	5
Military/pensioner	5
Housewife	3
Others	4
Community group	
Local people	10
Orang Asli	4
Military	3

Table 3: Demographic details of the informants

District	Respondent Code	Community Group	Occupation
Kota Tinggi	KT1	Local	Military pensioner
	KT2	Local	Businesswoman
	KT3	Military	Military
	KT4	Military	Military
	KT5	Military	Military
Kuala Lipis	KL1	Local	Housewife
	KL2	Local	Housewife
	KL3	Local	Veterinary pensioner
	KL4	Local	Housewife
	KL5	Local	Driver
	KL6	Local	Miner
Gua Musang	GM1	Local	Military pensioner
	GM2	Local	Farm worker
	GM3	Orang Asli	Farm worker
	GM4	Orang Asli	Farm worker
	GM5	Orang Asli	Farm worker
	GM6	Orang Asli	Farm worker

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b. District Health Officers Informants

One health officer in each district was interviewed to find out efforts and existing strategies conducted to combat *P. knowlesi* malaria at the community level. Challenges refer to problems faced by the health officers in implementing these strategies. Refer Table 4 for demographic details of the three Ministry of Health district officers involved in this study.

Table 4: Demographic details of Ministry of Health district officers

District	Respondent Code	Race	Age	Years of Service	Position
Kota Tinggi	KT-HO	Malay	36	12 years	Environmental Health Officer Assistant
Kuala Lipis	KL-HO	Malay	47	23 years	Environmental Health Officer Assistant
Gua Musang	GM-HO	Malay	32	9 years	Environmental Health Officer Assistant

Ethical Considerations

The study protocol was approved by the National Medical Research Review Board (NMRR-19-962-47606). Written informed consent from all informants was obtained.

RESULTS

P. knowlesi Malaria Prevention Behaviours

A total of 14 prevention behaviours in Table 5 were shortlisted at the preliminary stage of the study, as advised by the Malaysian health authorities.

Table 5: List of prevention behaviours

Prevention Behaviours	Label
Larviciding	PB1
Use of prophylaxis	PB2
Stopping outdoor activities after 7 pm	PB3
Wearing long-sleeve clothing and long pants	PB4
Using insect repellent	PB5
Using a bed net while sleeping	PB6
Mosquito aerosol spray	PB7
Mosquito coil	PB8
Electric mosquito repellent	PB9
Mosquito repellent gel	PB10
Insecticide-treated clothing	PB11
Mosquito mat	PB12
Closing windows and doors at home	PB13
Rubbing exposed body parts with mashed leaves of plants with mosquito repellent effect	PB14

However, during the interviews, five prevention behaviours were identified as most prevalent among the informants. These prevention behaviours were the most practised by informants in their day-to-day routine and frequently mentioned during the interviews. The prevention behaviours were, use of prophylaxis (PB2), wearing long sleeve clothing and long pants (PB4), using insect repellent (PB5), using a bed net while sleeping (PB6) and using mosquito coil (PB8). The prevention behaviours identified were further explored and catagorised according to the dimensions of the IBM framework.

Attitudes Toward Prevention Behaviours

There are two constructs of attitude according to the IBM framework i.e: instrumental attitude and experiential attitude. Experiential attitude refers to feelings about performing the behaviour and instrumental attitude refers to beliefs about performing the behaviour (Ajzen, 1991; Ajzen, 2002; Ajzen & Driver, 1992). Both experiential and instrumental attitudes can be both positive and negative feelings or beliefs towards performing a behaviour.

a. Use of Prophylaxis

Prophylaxis is most commonly used as a prevention behaviour by the military group. According to all military informants, as a standard practice, they are provided with and required to take prophylaxes before they participate in any training in the forest.

In terms of their attitude towards taking prophylaxis, informants in the military group showed a positive attitude toward this prevention behaviour. Nonetheless, some informants reported disliking prophylaxis as it may cause side effects. Among potential side effects of prophylaxis include dizziness, nausea, and vomiting which may interfere with military performance. However, informants generally acknowledged that consuming prophylaxis would help prevent *P. knowlesi* malaria infection. Some examples of instrumental and experiential attitudes expressed by the informants regarding the use of prophylaxis are as follows:

> **Positive Experiential**
> *Interviewer: So do you like taking this medicine (prophylaxis)?*
> Informant KT5: I really don't mind because I have no issue with taking medicines. I had previous experience not taking (prophylaxis) because I was too preoccupied with other tasks at the time… and coincidentally I had an on-and-off fever (while in the forest). That experience (although not knowlesi malaria related) made me feel like it is not worth risking it. So since then, I made sure that I take the medicine (prophylaxis).

> **Negative Instrumental**
> *Interviewer: How about prophylaxis?*
> Informant KT3: We can't be sure that it has an effect because even when we consume (prophylaxis), we could still get mosquitoes bites. So for prophylaxis, it is more for internal precaution. I feel it is more convenient to bring insect repellent when we are outdoors.

None of the informants shared any negative experiential or positive instrumental attitudes for this preventive measure. Informants did not have any negative feelings about consuming prophylaxis but also did not share any positive beliefs toward this prevention behaviour. The informants did not believe that taking prophylaxis was enough as it can only prevent them from getting *P. knowlesi* malaria infection but leave them exposed to mosquito bites. It was also observed that the reason informants consume prophylaxis is mainly to follow orders from their superiors.

b. Wearing Long-Sleeve Clothings

Some informants expressed negative attitudes toward this prevention measure because of how it made them feel. Specifically, wearing long sleeve clothings outdoors in a warm climate country like Malaysia may be uncomfortable because of the heat and causing people to sweat. Even though most informants from Orang Asli and local groups were aware that covering their skin would help reduce the risk of mosquito bites, they were not motivated enough to wear long sleeves and pants outdoors. However, female informants among the local community group showed a more positive attitude toward wearing covered clothes. Particularly for Muslim females, covering their body is part of a religious practice and thus wearing long-sleeve shirts and pants has become a predisposed habit. Muslim female informants also attached positive benefits to this prevention behaviour.

Positive Experiential

Interviewer: Do you like sleeping with long sleeves? Or is it something that you don't prefer?
Informant KT5: I feel cold easily (at night) and so I prefer to wear this (showing her long sleeve military uniform). We have another shirt that can be worn at night, it is a long sleeved jersey, made from cotton, thick cloth.

Negative Experiential

Informant KT5: The type of fabric you wear (when sleeping in the forest) is important. When you want to sleep, it's actually quite hot and less comfortable to wear a long sleeve shirt. There are also different types of fabric. Some are soft and some are not. Some fabric is not comfortable.
Interviewer: Do you wear a long sleeve shirt (to work)?
Informant GM5: No, I don't. I don't want to. It makes me sweat.

Positive Instrumental

Interviewer: What benefits do you get from wearing a long sleeve shirt?
Informant KT4: Firstly, it is comfortable. Because if we wear long sleeve shirts, we don't feel very cold (at night), right? We don't have any blankets in the forest. Secondly, mosquitoes bite less when we wear long sleeve shirts.
Interviewer: What do you like about wearing long sleeve shirts?
Informant KT4: Mosquitoes won't bite. Mosquitoes would only bite where skin is exposed.

Negative Instrumental

Informant GM2: I usually wear short sleeves.
Interviewer: How about long sleeves?
Informant GM2: I don't like it.
Interviewer: Why not?
Informant GM2: Because it causes me to sweat.

It was observed that the reason why wearing long sleeves is not preferred is related to the hot climate. However, informants were aware that wearing long sleeves would be helpful to prevent mosquito bites.

c. Using Insect Repellent

This prevention behaviour is preferred by the local community group. Informants in this group showed a positive attitude towards insect repellent as it is more convenient for them. The informants also observed that they don't get as many mosquito bites if they apply insect repellent.

Positive Experiential

Informant KT5: As I mentioned earlier, it is easier to carry (insect repellent) anywhere and it is easy to apply because we don't need additional tools like a lighter.

Informant KT3: We can bring and use this (insect repellent) anywhere while we are in the forest.

Negative Experiential

Interviewer: If you go fishing, do you use insect repellent to get rid of mosquitoes?

Informant KL6: I don't.

Interviewer: Do you know that there are different kinds of insect repellents like spray…

Informant KL6: I know…for leech and all that, but I don't use it.

Interviewer: Why not?

Informant KL6: I just feel it is unnecessary (laughing)

Positive Instrumental

Interviewer: What are the benefits you could get from using a mosquito repellent?

Informant KT3: You don't get bitten by mosquitoes.

Interviewer: What are the benefits that you will get if you use insect repellent?

Informant KT4: Firstly, we don't get mosquito bites. Secondly, it can prevent us from dengue or maybe malaria.

Informant KT2: Since I used this insect repellent (spray), there have been fewer mosquitoes here at my food stall. There are usually many mosquitoes especially during hot weather. There are also mosquitoes, ants and flies here. I spray it on the table and just leave it. Less insects when I do this.

Negative Instrumental

Interviewer: Why don't you use insect repellent?

Informant KL2: You need to use it frequently, so the cost is high.

d. Using A Bed Net While Sleeping

The majority of informants own bed nets provided by the authorities for free. The Orang Asli group showed a positive attitude towards the use of bed nets at night. They noted that bed nets could reduce exposure to mosquito bites. However, a local community informant reported that they avoided using bed nets as sleeping in them is often hot, sweaty and uncomfortable. The military group on the other hand, mentioned that using bed nets is unsuitable when they are training in the forest. Lighting a bonfire at night is a preferred alternative to lessen the chance of getting bitten by mosquitoes in the forest.

Positive Experiential

Interviewer: Do you use a bed net at night?
Informant GM3: Yes, I use a bed net when I sleep. I'm afraid that if I don't… We don't know when mosquitoes are around.
Interviewer: Are there a lot of mosquitoes at night?
Informant GM3: Yes. Usually they are around in the middle of the night. We must use a bed net. I've been infected already… It (bed net) is provided by the health department.

Negative Instrumental

Interviewer: What do you think about using a bed net in the forest?
Informant KT5: I think it is a good idea, but it also has its weaknesses. A bed net can tear easily and it takes up a lot of space. Maybe there are people who would bring (bed net), but a majority wouldn't.
Interviewer: Have you ever seen people use bed nets in the forest?
Informant KT5: I have used it before during my first operation.
Interviewer: So do you like the idea of using bed net?
Informant KT5: Yes, I just don't like it because it takes up quite a lot of space in the camp.
Informant GM6: The disadvantages (of using a bed net) are that it is hot, and it is not comfortable, sometimes. If a house or room is quite small, it will feel stuffy… But for safety purposes, yes we won't get bitten by mosquitoes if we use a bed net.
Interviewer: What do you think of the idea of using a bed net in the forest? Is it okay to use them?
Informant KT4: Not okay. We enter (the forest) for training right? Not for camping.
Interviewer: Why do you feel it's not suitable?
Informant KT4: It's just not suitable. Normally we don't even use tents. We sleep on the ground…. it will be damaged easily. If it gets stuck on wood, it will be torn.

Informants did not share any negative feelings and positive beliefs about using bed nets as a preventive measure.

e. Mosquito Coil

The majority of the local informants have a negative attitude toward using mosquito coils. Informants mentioned health hazards as risks to using mosquito coils, specifically around elderly or small children. These groups tend not to use mosquito coils as the smoke from the mosquito coils can induce cough and difficulty in breathing. However, the Orang Asli and military groups showed positive attitudes toward the idea of using mosquito coils for prevention.

Negative Experiential

Interviewer: What about indoors, do you use mosquito coils?
Informant GM1: No.
Interviewer: Why not?
Informant GM1: It's hard. I have grandchildren. They play here. It's difficult because the smoke from mosquito coils… The children will get a runny nose later.

Positive Instrumental

Interviewer: What do you think about the idea of bringing mosquito coils (into the forest)?
Informant KT5: I think it helps a bit. I think people who do not bring mosquito coils would get a lot of mosquito bites. In this thick forest, there are a lot of mosquitoes. So I usually bring a mosquito coil.
Interviewer: So among all the preventive measures we discussed, what do you think is the best, or the most beneficial for you if you are in the forest?
Informant KT4: For me, the most effective would be mosquito coil and bed net because from my own experience, they can reduce the chances of getting bitten by mosquitoes. We usually use lotion (insect repellent) as a supplement. Even though we use mosquito coils, we will still use lotion to reduce the risk of mosquito bites. But I think the most effective method is to use mosquito coils and bed nets
Informant GM4: We always … We use mosquito coils.
Interviewer: What are the advantages of using a mosquito coil?
Informant GM4: The advantage is that we don't get bitten by mosquitoes as much.

Negative Instrumental

Informant KT5: There are certain times when we cannot use mosquito coils. For example when it rains heavily or when the lighter runs out, we cannot use it.
Interviewer: Are there any negative effects when using this mosquito coil?
Informant KT5: The negative effect is the smoke. It has a bad side effect on us too, that's what I feel.

Efforts and Challenges from Health District Officers in Combating P. knowlesi

a. Erecting Warning Signs

The utilisation of warning signs as a strategy to prevent *P. knowlesi* malaria infection were specified by health officers in Kota Tinggi and Kuala Lipis. Although the health officers in both districts utilised this strategy for the same purpose, which is to emphasise the need to take precautionary measures against malaria infection, a notable distinction in how and when it was used between the districts was found. Table 6 presents the use of warning signs in each district.

Table 6: The utilisation of warning signs

District	Medium	Purpose
Kota Tinggi	Signboard	To inform of the risk of entering the forest
Kuala Lipis	Signboard	To inform of the risks of conducting activities in high-risk areas such as the forest, rivers, and farms
	Poster	To make the community aware of high-risk situations (when a high number of cases are recorded or during the rainy season)

The military and forest explorers are the most at-risk of malaria infection in Kota Tinggi as they enter the forest frequently. Health officers in these two districts used signboards to caution people entering the forest of malaria risk and to take necessary measures such as consuming prophylaxis. Posters were also designed to remind people to implement prevention measures such as installing bed nets.

> There are still cases detected from activities in the forest, but there is nothing we can do about it.... What we are able to do is to provide signboards to deliver information and stress the importance of performing prevention behaviours such as using bed nets and providing an emergency line to contact when it is necessary for them (Informant KT-HO).

In Kuala Lipis, it was highlighted by the health district officers that people often engage in outdoor activities like fishing, hunting and farming. The signboards are therefore placed at forest entrances and other areas such as farms and at the riverside, where these activities are performed.

> People in Kuala Lipis like outdoor activities like fishing and hunting. Most of these activities are performed in the evening or late at night. … to alert them, we installed signboards at certain locations in the village area (Informant KL-HO).

b. Educating The Community

Health officers also established health education programmes at the three districts to communicate with at-risk communities. Although consistent efforts to reach out and educate these communities are visible, these activities were often planned and initiated by the officers themselves. Each district office is allocated a budget for community education and engagement programmes, but the amount is shared across different health concerns. The limited resources

restrict the type, frequency and efficacy of these programmes. As such, officers have had to be mindful of how they conduct the programmes to maximise their effectiveness.

The analysis revealed that health education delivery in each district is similar in their approach, which is by mixing interpersonal and mediated communication. For instance, health officers in Gua Musang not only consistently visited each house in the local community, but also often screened informational films to educate people about *P. knowlesi* malaria.

> We enter remote areas and bring the films to show along with our prevention and intervention programmes with the community. We gather them in one location and screen the video. Through this, they will learn about malaria and how it is transmitted from the mosquito to the human body, and we found this method successful in making them understand (Informant GM-HO).

The same approach was also identified in the Kuala Lipis district. Nonetheless, a face-to-face communication approach was more dominantly used compared to in Gua Musang. Health officers in this district often included education delivery as one of the components in their intervention programme. As stated by the informant, after the health office conducts prevention activities such as distributing bed nets and administering indoor/outdoor residual spray, they spend time to discuss and provide advice to the community so that they are more cautious of the risks of malaria infection.

> Right after a case is detected, we will investigate and conduct active case detection with contacts around the patient's house... …followed by fogging. If we know that the infection came from the forest, we will start with control measures. We also observe the houses, make sure that they are equipped with bed nets and supply them if they are not... …After that, we apply indoor residual spray and in the meantime, take a few minutes to talk to them, giving them advice, like they need to be cautious when doing night activities, or to protect themselves with mosquito repellent when involved in activities that risk infection (Informant KL-HO).

In the Kota Tinggi district, the health officers regularly scheduled house visits to distribute malaria pamphlets to the community. Unlike the officers in Gua Musang who included education delivery within their intervention programme, Kota Tinggi health officers conducted this activity along with prevention programmes; pamphlets would be handed out when they conducted blood screening for the community.

> Because they [the community] prefer visual content. Furthermore, we cannot miss out on regular visits to their house. The malaria team will usually visit them at night because most of them work during the day. We negotiate with them and ask them to wait for us at home, and we visit each house for the blood sample. At the same time, we will also deliver pamphlets and educate them, so we do not need to come twice or three times (Informant KT-HO).

c. Assigning Role Models

According to the Gua Musang informant, a role model approach has been proven effective in reducing the number of cases in the district. This strategy is carried out by appointing former *P. knowlesi* malaria patients as communication agents that act as mediators between health officers and the community. The role model will actively deliver important information regarding *P. knowlesi* malaria and educate the community about the importance of taking preventive measures.

> Yes, we encourage the former patients in this village to return and [share] "I got malaria and the health officers gave me repellent. You should use it so you will not get malaria like I did". So they are role models in their community (Informant GM-HO).

Similar role model approach was implemented in Kuala Lipis as well. The health officers in this district partnered with the most influential, respected figure in the community (e.g. the village head) and assigned them as opinion leaders. As mediators and key communicators of *P. knowlesi* malaria in the village, these opinion leaders assist health officers in establishing malaria prevention and intervention programmes by encouraging the community to be actively involved in programmes held in the district.

d. Lack of Access and Facilities

District health officers indicated that geographical factors were a barrier to community access in certain areas, especially when infection cases occurred in remote locations. As a result, health officers limit their visits to these areas to only twice a year, much less than in other areas. These trips often require them to travel on unpaved logging roads and take them hours to reach the location. The vector unit in the Gua Musang health district office admits this as a significant challenge they have faced in their monitoring and surveillance efforts.

> In Gua Musang, it may take six hours to reach one location… Geographic factors often create challenges for us. For example, to reach a particular area, we have to go through hilly areas, and locations such as Pos Gob, Pos Malar, Pos Belatim and Pos Bihai are all only accessible through logging roads. Although the distance is only 15.2 kilometres, it takes approximately an hour for us to arrive at our destination (Informant GM-HO).

In order to deal with this challenge, the health ministry, through the district health office, has opened up opportunities for people in these communities to work as Public Health Intelligence (PHI) to assist in monitoring these areas. They mostly work in plantations and are paid by the plantation owners to help gather valuable information in these communities and communicate it to the health office. It is an ongoing practice and their services must be renewed each year. However, due to geographical challenges, the PHI finds it difficult to send reports to the district health office.

As most positive cases occur in rural areas, health officers often face limited resources to run malaria prevention programmes at community level. Health officers in the Kota Tinggi district for example were unable to conduct a "Malaria Day" programme due to the lack of a suitable location in the rural villages. This situation has led them to relocate their programme to a further location and because of logistic difficulties faced by villagers, the number of participants in the programme reduced significantly.

e. Adoption of and Compliance to Health District Officers' Advice

The health officers claimed that many people in their districts still have a low uptake of preventive behaviours, even if they were commanded by the authorities, such as the use of bed nets and prophylaxes. According to health officers, although the communities were given bed nets, some were still reluctant to install and use them.

> I have told them to use this bed net to avoid mosquito bites. If they did not want to use it over the bed, they could hang it up just like a curtain. Some of them were former malaria patients. We gave them a bed net, but when we asked whether they installed it or not, they said they did not (Informant KT-HO).

Kota Tinggi has forests suitable for trekking and training camps, making it a popular choice for jungle trekkers and the military to run their activities. As a precautionary measure, the Kota Tinggi health office prescribed prophylaxis to prevent malaria infection for those intending to enter the forest. However, the prophylaxis has to be taken daily starting from three days prior to entering the forest up until two weeks after leaving the forest. Although compliance to this advice is important to ensure prevention of malaria infection, the health officers observed that this was difficult to follow.

> They [the army] have been training there [in the forest] for a long time and many have said that they only took the prophylaxis on the last day, when they were leaving. They all know and are aware but they just don't follow the instructions. We really depend on them to follow through (Informant KT-HO).

Another preventive measure that the community has not shown any interest to use is mosquito repellent. Even when the Pahang state health office encouraged local shops in the district to stock mosquito repellent, most merchants were not interested because the local community was not willing to purchase them.

f. Unique Challenges Faced by the Military

The interview with health officers in Kota Tinggi suggests that practices in military training may have indirectly contributed to the increase of *P. knowlesi* malaria cases within the military community. Soldiers are expected to follow the instructions of their commanders and often endure various challenging training exercises. At times, this involves sleeping in the forest without clothing. The use of mosquito repellent is also not encouraged as it gives off a strong

odour and may expose the location of the army in training. Some personnel prefer not to use mosquito coils during their sleep time for this reason.

> They [trainees] said they would use mosquito coils, but I think they may be reluctant to do so because they are worried that it is not allowed by their superiors and they do not want to be teased as 'weak' (Informant KT-HO).

Additionally, the interviews also revealed multiple unintegrated systems in the military on the monitoring and administration of prophylaxis. As mentioned earlier, most members of the military found it difficult to follow the usage instruction of prophylaxis. While the training session is in progress, on-site doctors help oversee and administer the prophylaxis to the trainees. However, when training concludes, soldiers disperse to their respective hometowns throughout the country. This makes it difficult to ensure adherence to the prophylaxis regimen.

> They [soldiers] should undergo a medical follow-up and submit a report four weeks after they leave the forest. But this is an internal issue between them [the military] and their doctors. This is beyond our control. We just ask the doctors to remind soldiers about the four weeks regimen. But this can only happen if the soldiers go back to camp, while in fact, most of them return home (Informant KT-HO).

DISCUSSION

This study highlighted five most prominent prevention behaviours among at-risk communities, which can be targeted for behavioural change interventions against *P. knowlesi* malaria.

One of the prevention behaviours identified was wearing long sleeve clothings. This study identified that clothing material and comfort play a role in informant preferences. Cotton and soft materials were preferred as the informants attributed these materials to being comfortable and airy. A similar study conducted in Myanmar revealed that respondents who did not wear long clothes to work mentioned "too hot" and "not having long clothes available" as the reason. The most frequently cited reasons for these preferred styles were that they were easy to work in (38%), protected against insect bites (37%), and were comfortable to wear (18%) (Crawshaw et al., 2017). The same study also mentioned that the respondents were aware that wearing long sleeves can protect themselves against mosquito bites but they were not motivated enough to wear them outdoors because of the warm climate. This is similar to the result of this study. Improving access to comfortable long sleeve clothings may reduce the negative attitude toward the prevention behaviour.

Another prevention behaviour found in this study was using insect repellent. This preventive measure is favourable among local and military groups as it is perceived to be convenient and effective to repel mosquitoes. A study conducted in Myanmar showed that topical repellents give some protection against the risk of malaria infection. Nevertheless, user compliance was necessary to assure its efficiency (Agius et al., 2020). A study conducted in Cambodia revealed that participant usage of topical repellents was suboptimal, thus it did not contribute to a reduction in the malaria incidence rate (Sluydts et al., 2016). Some of the reasons

that affected compliance were related to perceptions that repellents are harmful and unsafe, particularly for children. In addition, numerous individuals in the study experienced skin-related issues, such as rashes and dry skin (Gryseels et al., 2015). In contrast to these results, none of the informants in our study reported having sensitive skin to the repellent substances. In groups where they are no skin-related issues, promotion to utilize insect repellent would be ideal. However, in groups experiencing skin reactions from insect repellent, it would be less beneficial to promote insect repellent usage. Moreover, a recent systematic review and meta-analysis concluded that topical insect repellents do not provide protection against falciparum or vivax malaria (Wilson et al., 2014 & Tangena et al., 2016). It is believed that these measures are more likely to fail due to the required behavioural change; adherence to topical repellents is challenging because they must be reapplied every few hours (Kader et al., 2022; Van Roey et al., 2014; Gryseels et al., 2015; Oxborough et al., 2014) and extensive distribution must be maintained (Heng et al., 2015).

The other prevention behaviour explored in this study was the use of bed nets while sleeping. This preventive measure is favourable among the Orang Asli group and they also believed that bed nets could reduce exposure to mosquito bites. This is supported by the WHO (2019) which recommends the use of bed nets as an effective preventive measure against Anopheles mosquito bites. However, a study in Northeastern Thailand found that Low bed net provision by the local health authority and non-adherence to the use of bed nets from the communities are the critical failures in the local malaria control programme (Inchana et al., 2013). In our study, the Orang Asli and local communities received complementary bed nets from health authorities. This handout contributes to the uptake of bed net usage among these groups. A separate study among Orang Asli in peninsular Malaysia also discovered that the majority of participants (92.3%) showed a positive attitude toward malaria prevention behaviour and believe it is important to use bed nets while sleeping (Chen-Hussey et al., 2013).

Another prevention behaviour examined in this study was using mosquito coils. Findings from our study revealed that mosquito coils are less preferred by local groups because they believe that smoke from the coil would negatively impact the health of children and the elderly. Particularly, the smoke from mosquito coils was associated to coughing and difficulty breathing.

For each prevention method identified, targeted improvements of attitudes need to be tailored to improve positive feelings and beliefs, while reducing negative attitudes among at-risk communities. Some suggestions from the findings according to each prevention method are as follows;

Prophylaxis: In order to convince the military group to take prophylaxis, intervention needs to focus on reducing negative feelings and beliefs about the potential side effects from taking prophylaxis, particularly on military performance. Additionally, informants do not see an immediate effect of taking prophylaxis towards preventing mosquito bites, as opposed to other prevention measures that focus on reducing mosquito bites.

Wearing long-sleeved clothing: To increase the likelihood of people having more positive attitudes towards wearing long sleeves, it is recommended that intervention programmes target to reduce negative feelings and beliefs on this behaviour. Informants highlighted that wearing long sleeved clothing would be uncomfortable because of the unsuitable material, causing them to sweat. Highlighting different kinds of clothing material that is suitable for warm climates and

making these clothing accessible and affordable may increase the chances of people adopting this prevention behaviour.

Using insect repellent: For insect repellent, a way to improve this behaviour uptake is by correcting people's perception and existing attitudes that insect repellent is unnecessary. This perception may relate to existing perceived norms, additional costs and availability of insect repellent in at-risk areas.

Using a bed net: To increase bed net usage, it is suggested that intervention programmes target to increase positive instrumental attitudes and reduce negative instrumental attitudes. It is recommended that beliefs that bed net usage is effective in preventing infection be increased and beliefs about sleeping in bed nets causing discomfort be discouraged.

Mosquito coils: For those who have negative attitudes toward mosquito coils, particularly the side effects on vulnerable family members, it would be useful to encourage the use of other prevention methods and increase positive attitudes towards them.

Further studies need to be conducted to evaluate the effectiveness and validity of these five prevention behaviours for communities at risk in Malaysia.

A significant effort was observed to optimise the role of the district health office in highly-infected districts in Peninsular Malaysia. District-oriented prevention approaches were also conducted in other countries where each country focussed on different preventive measures such as insecticide spraying and bed nets in India (Rajvanshi et al., 2021), indoor residual spray in Mozambique (Canana, 2021), sulfadoxine-pyrimethamine medicine for pregnant women in Mali (Sangho et al., 2021) and insecticidal nets in Uganda (Cote et al., 2021).

Health officer informants suggested that most *P. knowlesi* cases in the three districts studied were associated with high-risk areas such as the forest, agricultural sites and rivers. This corresponds with the study conducted by Brant et al. (2016), which specified tropical rainforests and palm oil plantation areas as the area most populated by Anopheles mosquitoes in Sabah. In addition, the informants also identified outdoor activities that contributed to prior infections, such as fishing, hunting, jungle trekking and logging activities. Chin et al. (2020), in their systematic review, summarised the distribution of *P. knowlesi* malaria infection in earlier cases according to risky activities and categorised them into; agriculture (29%), plantation (27%), hunting (7%), logging (6%), fishing (5%), collecting forest resources (4%), forest-related work (4%), forest-related recreation (1%), and others (18%). Many of the health education programmes in the districts surveyed were implemented to target those involved in these high-risk activities.

A notable challenge was also found in the military sector, where adherence to the prophylaxis regimen was low. Many members of the military did not consume the medication after leaving the forest as recommended. This was presumed to be the main cause of infection among the military in Malaysia. Non-compliance to the full prophylaxis regimen was also among the main factors of malaria outbreak among soldiers during the US army deployment in Afghanistan (Sangho et al., 2021). An earlier study on prophylaxis intake among members of the military confirms that prophylaxis hesitancy was a significant predictor of malaria infection (Cote et al., 2021). This hesitancy remains a challenge for the malaria vector team in the Kota Tinggi district as there is no enforcement on the consumption of prophylaxis.

Most of the efforts taken by the health officers were based on a social approach, ranging from creative ways to deliver health education messages to assigning role models and empowering community influencers. Although preventive measures such as scheduled indoor and outdoor residual spraying, insecticide-treated bed net distribution and fogging were still conducted regularly, the officers were well aware that the behavioural change aspect is essential for the elimination of the *P. knowlesi* malaria infection among their communities. Despite these efforts, the effectiveness of knowledge delivery to increase community awareness is still debatable. These health officers are not communication experts nor are they formally trained in health education. This may lead them to oversimplify health communication processes and community understanding of malaria. For instance, the health officer in the Gua Musang district claimed that health education through video screening had increased the community's understanding of malaria transmission. Specific studies of malaria knowledge in these communities are required to validate this statement. The state-level health office often provides the content of health education programmes which may be generic and do not reflect the values and practices in specific communities (e.g. the Orang Asli group). Even so, the district health officers often supplement these materials utilising their own budgets. Their efforts are driven by their sense of responsibility to mitigate the disease in their areas.

CONCLUSIONS

The results of this study highlighted attitudes related to the five most prevalent prevention behaviours among three groups of at risk communities in peninsular Malaysia. Each community group has their own preferences for preventive measures that are seen as appropriate in the context of their activities and living environment. The military group depends on taking prophylaxis, using insect repellent, wearing long sleeved clothing, and mosquito coils. Local community groups prefer to use insect repellent while the Orang Asli group prefer to use bed nets and mosquito coils.

District health office efforts to mitigate malaria infections are mostly focused on approaches such as erecting warning signs, delivering health education through several mediums, and assigning community role models. However, there were also challenges faced by the health officers in carrying out their duties. The lack of facilities and access to localities has disrupted their efforts to conduct prevention programmes and deliver health messages to remote locations. Lastly, the lack of authoritative control over prophylaxis administration was noted as the main obstacle for the district health office in reducing the *P. knowlesi* malaria infection among the military group. This study suggests that health officers be formally trained on social and behavioural change communication to ensure that structured and well-planned programmes may be implemented to build community awareness and resistance to *P. knowlesi* infection.

Public health organisations and health care providers will benefit from this study as it has identified specific attitudes that can be improved in behavioural interventions to increase the use of the five identified prevention behaviours. In addition, routine contact between health care professionals and the community plays a significant role in reducing malaria. Recommendations in this study will help the government to strategise behavioural interventions in achieving its plan to eliminate malaria in the country.

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