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A participatory study on community perspectives of zoonotic malaria (*Plasmodium knowlesi*) and malaria preventive behavior: A protocol paper

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Abstract

Introduction: *Plasmodium knowlesi* malaria is a zoonotic mosquito-borne disease with complex epidemiology. We describe a participatory research (PR) design for a study aimed at exploring the social context and malaria preventive behavior of communities exposed to *P. knowlesi* malaria. According to the World Health Organization (WHO), the prevention and control of vector-borne diseases requires community participation to increase the coherence between malaria interventions and sustaining the public health programs.

Methods: The PR will be conducted over a period of 12 months, from March 2022 to March 2023, among adults (>18 years old) who are permanent residents in a rural village exposed to *P. knowlesi* malaria in Sabah, Malaysia. We will select patients who were diagnosed with *P. knowlesi* infection within January to December 2021 for the focus group discussion (FGD), as they can provide perspectives on disease from the point of view of those previously diagnosed with infection. In-depth interviews (IDI) with people of importance in the community, such as the head of the village will also be conducted. Both FGD and IDI will be conducted from March 2022 until June 2022. Concurrently, a photovoice with adults over 18 years old who reside in the community will be conducted. All participants will provide consent prior to participation. We will use a study framework as a theoretical lens to guide the exploration of the beliefs, social contexts, barriers, and drivers surrounding zoonotic malaria preventive behavior.

Discussion: The participatory approach can facilitate policymakers in designing future zoonotic malaria control programs by investigating the community perspectives and concerns about zoonotic malaria from a local context.

Ethical and dissemination: The study has ethical approval by NMRR/MREC and Universiti Kebangsaan Malaysia Research.. The results will be published in international peer-reviewed journals and presented at conferences and other platforms.

Strengths and limitations of the study

- The participatory approach protocol is geared toward conducting a research process with the adult > 18 years old in communities exposed to *P. knowlesi* malaria in Sabah, Malaysia to facilitate policymakers in designing future zoonotic malaria control programs
- The PR method will use a theoretical framework that integrates three models as a lens to guide the study
- The PR aims to create collaboration between researchers and participants, answer specific research questions, facilitate communication, and enable knowledge acquisition in a natural setting
- The study will use a participatoryapproach to explore the challenges of the communities to practise malaria preventive behaviour against zoonotic malaria in their local settings
- To build trust with participants, researchers require sufficient time, competencies, skills, and a high degree of flexibility and reflexivity throughout the study

Introduction

Since 2020, the World Health Organization (WHO) has included *Plasmodium knowlesi* malaria in its World Malaria Report [1]. The increasing incidence of *P. knowlesi* malaria among humans is a public health concern [1]. Malaria generally affects poor communities with low levels of education and limited access to health services [1, 2]. Individuals working as planters, farmers, or agricultural workers who may come into contact with macaques and *Anopheles* mosquitoes are at risk of *P. knowles*i malaria [3-5]. Ecological changes due to deforestation and other anthropogenic activities increase the risk of zoonotic malaria [3-5]. Adults males are typically at higher risk than women and children, in particular individuals who work in or visit forested areas [2, 5].

Vector control measures such as insecticide-treated nets (ITNs) and long-lasting insecticide nets (LLINs) are used to control the incidence of malaria [1-6]. However, the suitability of preventive measures such as protective clothing and bednets was perceived as "uncomfortable" by individuals who worked in the forest [7]. Close proximity housing to the forest increases the exposure of women and children to zoonotic malaria infection, leading to their asymptomatic carriage of *P. knowlesi* malaria parasites [5]. Further research that focuses on human behavioral factors that contribute to disease transmission is warranted [5, 8].

Malaria control strategy: socio-context and human behavior

Based on the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR), understanding the behavior of members of a community and its socio-contexts can inform preventive measures [2]. People have difficulty understanding the complexity of the epidemiology of zoonotic malaria [3, 12]. Quantitative surveys often fail to account for the underlying causes of human behavior [8], and social contexts such as lifestyle,

socio-cultural belief, economic factors, and behavioral factors can influence malaria exposure and usage of preventive measures [7-11], social gatherings and activities before bedtime increase the risk of mosquito bites [9]. Furthermore, ITNs are not effective when communities do not use them properly [7, 9]. In addition, cultural and economic activities also affect the acceptance and usage of malaria preventive measures [7, 9], and can influence health-seeking behaviors and compliance with preventive measures [2]. Malaria exposure is highest for communities living in rural areas, and low-income households [1, 2], and these high risk and marginalised communities require urgent complementary antimalarial measures that help them to avoid outdoor biting mosquitoes [2, 6].

Numerous previous studies have been conducted on local beliefs concerning illness in different regions of the world [2, 7, 10]. In Indonesia, belief in a supernatural cause of malaria influences individuals to consume certain foods, use pendants, and "*jampi*" (magic). They apply these measures rather than implementing evidence-based antimalarial measures or seeking treatment at healthcare centers [7]. Individuals seek treatment with traditional practitioners because of cost, and claim that these are more effective and reliable [2, 7].

Studies from Africa, Indonesia and the Philippines suggest that cultural and religious beliefs influence understandings of the causation of malaria [2, 7, 9]. These beliefs impact on adherence to bednet usage and influence attitudes towards health seeking behavior [2, 7]. Understanding how communities perceive malaria and preventive measures such as bednet compliance can inform future malaria control programs [2, 6]. Along with understanding community behavior, existing traditional knowledge should also be assessed prior to the design and implementation of malaria control strategies. For a program to be sustainable, the community should be involved in its planning, implementation, and evaluation [2, 6]. Rather than focusing on the individual, community empowerment helps to increase the sustainability of interventions [2, 6]. As one of the pillars of a multisectoral approach to vector borne disease

control, community participation is a powerful component that is cost-effective, practical, and facilitates behavioral changes that focus on enhanced vector control measures [6].

The failures of "one size fits all" strategies for malaria control have prompted a re-evaluation of the importance of communities' local priorities and needs [2, 6]. For example, participatory research approaches can be used to explore the influence of social context on the surrounding environment as well as community behaviors that increase exposure to zoonotic malaria. It is crucial to investigate and explore opportunities for improving malaria disease control. This will assist acceptance in local communities [6].

Participatory research (PR), also known as 'community-based PR' and 'community research' [11] is a collaborative and iterative research design involving input from researchers and participants. It focuses on research processes that involve local people. PR incorporates community perspectives and emphasises the direct engagement of local priorities [11]. PR differs from participatory action research (PAR) by shifting the emphasis from action and changing to collaborative research activities [11]. PR aims to produce knowledge in collaboration between researchers and participants. This can lead to new insights [11]. The advantage of PR is that researchers can conduct systematic inquiries with participants to gather local knowledge and experience from those who are immediately affected by the ongoing issues [11]. This approach provides findings that may facilitate social change, and these changes can then be translated into action [11].

The characteristics of the participatory approach

Discrete differences exist between PR and other research methodologies [11]. For example, in PR studies, power lies with the participants. It emphasises a "bottom-up" approach by incorporating local knowledge in future planning and program implementation [11]. In contrast, other research designs often aim to generate knowledge from research without

incorporating local priorities and perspectives. This oversight may result in inappropriate recommendations [11]. PR is an alternative approach for empowering, engaging, and creating a cohesive and sustainable vector control program. Such a program addresses local issues. Below we describe the methods that will be used and the analyses that will be conducted in this study.

Study perspective and health behavior model

From a constructivist perspective, the meaning and experience of phenomena are socially constructed, for example by social norms, beliefs, and environment, rather than inherent within individuals. This paradigm emphasises the generation of understanding an issue "from the bottom up" [12]. Therefore, this study seeks to incorporate an understanding of socio-cultural contexts and their structural conditions on malaria preventative behavior among individuals and communities exposed to *P. knowlesi*. Previous studies have shown that individuals and communities have their own native and socio-cultural beliefs toward the disease and that these influence malaria preventive behavior [2]. There are also drivers and barriers to malaria preventative behavior in the community [2]. Participants in the study can provide local perspectives on preventive measures [2, 7], and opinions for future improvement of communication methods and tools to deliver preventative messages [2, 6].

The study framework

The study framework will integrate the ideation model [13], the explanatory model [14], and Murdock's illness causal model [15]. This framework will act as a theoretical lens for knowledge processing in this study. Theory can convey a clear signpost of the study and provide guidance on how and what method will help to answer the research questions [33].

The ideation model is a predictive model of behavior change involving both individuals and communities. It is a socioecological approach involving communication and behavior change that integrates multiple theories [16, 17]. The ideation model acts as a conceptual tool that can identify common psychosocial variables that may influence malaria related behavior [13, 16, 17]. This framework identifies a set of psychosocial variables grouped into three domains: cognitive, social support and emotion; (i) cognitive: attitudes towards the recommended behavior, perceived risk and self-efficacy to protect self and others; (ii) emotional: feelings of fear relating to the condition that influences the intention of performing the behavior (iii) social: social support and peer pressure to practice or avoid the recommended behavior and interpersonal communication with others about recommended practices [13, 16, 17].

The explanatory model is a tool for medical and public health professionals to investigate cultural variations in illness experiences, diagnosis, and treatment. The model aids in developing rapid assessments through direct communication with patients, family members, and relatives [8, 14]. The data produced can facilitate the translation of interventions that consider the local perceptions of illness, circumstances that result in a risk pattern, and community structures that might support the intervention [8, 14].

Murdock's illness causal model conceptualised the local perception of causation of disease [15]. According to this theory, it is important to distinguish between beliefs about natural and supernatural causes of illness, which are diverse worldwide, as they influence how disease treatment and behavior are perceived [10, 15]. This framework has not been applied to research on *P. knowlesi* malaria to date.

Study aim

This study aims to explore the key anthropological drivers of and barriers to zoonotic malaria preventative behavior among communities exposed to *P. knowlesi i*nfection. This study will be conducted among adults (age > 18 years old), including those with a history of *P. knowlesi* malaria infection, and those who live in areas with a high incidence of infection.

The study will address the primary research question: “According to adults (age > 18 years old), including those with past history of this infection, and live in an area exposed to *P. knowlesi* malaria infection, how and why does their beliefs towards the disease, and social, cultural and environmental challenges, underlie the zoonotic malaria preventive behavior?”. We will then translate the views of the communities into information for policymakers. Thus, addressing the other research question: “How can the views and concerns of this communities on zoonotic malaria infection and its challenges to preventive behavior can be translated into information for future *P. knowlesi* malaria control programme?”.

Methods and analysis

Study location

This study will be conducted in Sabah, the second largest state in Malaysia after Sarawak. It has a high incidence of *P. knowlesi* malaria [19, 20]. Sabah covers 73,904 sq km, with an estimated population of 3.90 million in 2019 [21]. Geographically, Sabah is composed of a mix of mountainous regions, coastlines, and tropical rainforests. A study by Cooper *et al.* reported five districts in Sabah with a high incidence of *P. knowlesi* malaria; Ranau, Keningau, Tenom, Tambunan, and Kota Marudu [22]. The present study will be conducted in the northern region of Sabah in Kudat region, the location of several recent studies on zoonotic malaria [3, 5, 23]. This district has a high incidence of *P. knowlesi* malaria, defined as >

1/1000 persons [24]. This location was selected after obtaining a list districts with village names from the Sabah State Health Department, within areas with high incidences of *P. knowlesi* in 2020. (see Figure 1)

Study participants

The study participants will be men and women above 18 years old who can provide informed consent prior to the focus group discussion (FGD), in-depth interview (IDI), and photovoice. The study will include participants who are permanent residents of the village, are mobile, without known cognitive or mental health issues, and are able to answer questions in Malay or English. Due to restrictions imposed by the current COVID-19 pandemic, participants with access to electronic communication tools will be preferred [25, 26]. The sampling method for the FGD will be purposive sampling among individuals who were previously diagnosed with *P. knowlesi* infection between January 2021 and December 2021. It will consider the need to conduct discussions *via* electronic communication if there are restrictions against direct fieldwork. Community leaders will be selected for IDI. Subsequently, a snowballing technique will be used to recruit other information-rich individuals. The FGD and IDI method is planned for the four months from March 2022 through to June 2022. For the photovoice, a recruitment pamphlet will be distributed in the village, and we will use purposive sampling to recruit the participants. Similar to the FGD, individuals with good electronic connectivity will be preferred in order to faciliatate remote discussions in adherence with COVID-19 restrictions. Excluded from the study will be non-residents, people with known cognitive or mental health issues, and those who are unable to attend interviews or FDGs after two invites. All these methods will be conducted concurrently (between March and June 2022).

Sample size

For FGDs, 8 to 10 participants will be enrolled [27], while IDI may be up to 12 participants [28]. Data will be collected until data saturation is reached [27-29]. To maintain homogeneity of the FGD groups, participants will be stratified into gender and age-specific groups [27]. For example, males and females over 18 years old will be in different FGD groups to males and females over 65 years old. Earlier studies using photovoice methods reported enrolling four and up to 122 participants [30]. We aim to recruit 10 to 15 participants.

Categorisation of participation

The gradation of participation in this study is informed by Arnstein's categorisation, termed a "ladder of citizen participation" [31]. This ladder distinguishes three main participation categories: citizen power, tokenism, and non-participation; and eight levels: manipulation, therapy, informing, consultation, placation, partnership, delegated power, and client control [31]. We will utilise tokenism in our study. During the FGD, IDI, and photovoice methods, we will ensure that communication between researchers and participants allows them the opportunity to influence the decisions [31]. To ensure meaningful "tokenism" between researchers and participants in the photovoice method, we will provide a training workshop and an introduction prior to commencing. The workshop will ensure a safe working environment, and agreements will be reached between the researchers and participants [32, 33]. During the photovoice progress, we will regularly discuss the conditions for cooperation with the participants. The research questions will be shared with participants [32-34]. We will communicate in a clear manner in the Malay language and tailor communication to the literacy and coping level of the participants. The participants will receive a "token" for participating in the study. Participants will have the right to withdraw from the study at any point.

Study design

The study is a multimethod design using the PR approach. This study will be conducted over a 12 months period. The study will use FGD, IDI, and the photovoice method, which offers the advantage of triangulating the data (Figure 2). The views of individuals above 18 years old will be compared and interpreted with participants with a history of *P. knowlesi* infection. The photovoice method will raise their concerns using an iterative and collaborative process. Due to the COVID-19 pandemic, research methods may be modified to accommodate social distancing requirements [25, 26].

The study will have semi-structured interview guides. Rapport will be established with individuals so that topics can be freely discussed. Lastly, the study will use a participatory visual method (PVM); the photovoice. The researchers' role will be to introduce the research, the technique of photography, create a dialogue with participants (co-researchers), and conduct an exhibition or otherwise share the results with policymakers [32, 33].

The study phases

Phase 1: Preparation

The first phase of the study is to conduct a systematic literature review to understand: i) the behavior or activities that expose humans to *P. knowlesi* infection, and ii) how data on behavior were collected in previous studies. The literature searched was from standard scientific databases. The article abstracts were screened and assessed by three researchers, and any disagreement on the quality of the studies was resolved by consensus. The Joanna Briggs Institute critical appraisal checklist was used to rate the quality of the studies. A gray literature search was also performed from the WHO website.

The next step was to develop a research framework that would function as the theoretical lens for this study. The theoretical lens is the study's assumptions that will guide

the study methodology. This framework focused on factors that possibly influence malaria preventative behavior. The third stage will be selection of participants. A pamphlet will be distributed in the village to recruit participants for the photovoice project. Only those individuals who show interest and match our eligibility criteria will be recruited. The photovoice participants will attend a workshop introducing the study, discussing ethical considerations, distributing tasks, and outlining responsibilities. Participation will continue throughout the study duration.

Phase 2: Implementation of the study

The implementation of the study is as follows: FGD and IDIs will be conducted with participants to answer the specific research questions. Participants will participate in discussions and undergo an interview using the research questions as a guide. Data will be collected and analysed by the research team. Both FGD and IDIs will be recorded, transcribed *verbatim* by the research team, and analysed using thematic analysis [35]. We will use the qualitative software program ATLAS.Ti Version 9.

The FGD and IDI will be performed in a place familiar to the participants. The FGD will start with a general question about what participants perceive about *P. knowlesi* infection, explore their beliefs concerning illness causation, and how and why these beliefs influence their malaria-preventative behavior. Prompts will also be used to gather information and to generate the codes and themes. The FGD will be conducted for approximately 90 minutes, preferably without breaks [27]. The session will continue until a clear pattern emerges and subsequent groups do not produce new information [27-29]. Semi-structured, in-depth interviews will be conducted individually using an interview guide. Potential key informants, such as people of influence in the community [36], such as the head of village and faith

leaders will be contacted by formal letter. A meeting will be arranged with this gatekeeper to build rapport and to request permission to conduct the study at the site [37].

Face-to-face interviews or modified interviews may be conducted using electronic communication depending on the COVID-19 situation. The duration of the interview will be approximately 60-90 minutes [27]. The session will be written and recorded. As a means to maintain trustworthiness, member-checking and external coding will be used to validate the interpretation and coding [38]. Interviews will continue until data saturation is reached [27-29].

In the photovoice method, participants will take photographs, discuss them through the FGD method, and select the photos that best reflects the community [39-42]. Photovoice research teams will work as closely as possible with the local structures and institutions to facilitate meaningful long-term participation. The goals, strategies, and limitations for social change will be clearly and realistically defined and communicated to avoid raising the expectations of participants [41, 42]. The participants will have specific rules; such as prior consent before taking pictures of adults and avoiding pictures of children. A WhatsApp group will be created by the researchers through which the participants will be encouraged to share the photos. The photographs taken by the participants, that will be shared with policymakers and the public, have value in that they provide the opportunity for virtual display when words are difficult to express their views [24, 25, 32, 33]. Previous research suggests that participants take an average of 50 photos each [42]. We will recommend 10 photos per participant. The photographs can be taken anywhere, such as the home, street, or other aspects of the participant's environment, target actions, places, and situations [24, 25, 32, 33, 39]. We will use the SHOWED algorithm to reveal the participants' reflections of their photos [32]. The narrative caption of the photos will reveal meaningful experiences that can improve awareness of relevant issues [32, 33, 39].

Phase 3: Dissemination

Due to the ongoing COVID-19 epidemic and resulting restrictions, we will look for opportunities to present the research findings on appropriate platforms, apart from the photos produced in the photovoice study, which will be exhibited [39]. Thus, dissemination will be through online research presentations, various scientific presentations, and a book [39]. The book will include coloured photos and narratives from participants that illustrate their perspectives on local beliefs, and the drivers and barriers to malaria preventative behavior. All the photovoice participants, including those that contribute photos will be given an opportunity to review the initial draft. Hardcopies will be disseminated to policymakers (for example the Sabah state health department).

Supervisory committee

The supervisory committee will monitor the study process, from initiation to the end of the study, and provide advice on the content of the study and its appropriateness with respect to the study aims. Monthly meetings are planned, and members of the supervisory committee will be asked for further input, if needed. Researchers and stakeholders will be a part of this supervisory committee.

Patients and public involvement

Participants were not directly involved in the study design. However, the snowballing technique will involve the recruited participants, in which the participants of the FGD and IDI will only act as research participants, and the participants in photovoice will conduct the photography session, give inputs in analysis, and participate in the exhibition. The researchers will conduct the final reporting and dissemination plan of this research.

Data analysis

Data will be collected by the researcher and research assistants (RAs) proficient in the local language. The RA will be trained by senior researchers (public health specialists and anthropologists) and will be the observers, notetakers and translators. The RA will assist in transcribing the data from the local language into English. The data will be exported into ATLAS.Ti software Version 9 to facilitate data analysis.

Thematic analysis

Thematic analysis will be used to generate codes and themes from the data [35, 43]. Data familiarisation will be through re-reading the transcripts. Initial codes will be generated systematically across the whole data set. Themes will be identified within codes, and these themes will be named and defined. Prior to the writeup, a review of the themes will be conducted [35, 43].

Rigor and data trustworthiness

Rigor is defined as the demonstration of integrity and competence within a study [44]. Data trustworthiness will be gained through feedback from participants (credibility, dependability), checks by participants and policymakers (confirmability), and a thorough description of data collection and analysis (transferability) [38]. Member-checking will be performed after all sessions of the chosen methods are completed [38]. For example, after an IDI session is completed, a summary will be given to participants to confirm or comment on the researcher's understanding throughout the session, and to maintain data accuracy. It will provide the opportunity to modify errors or wrong interpretations [38]. External coding will increase the validity of the data.[38] The coding process will be individually applied to the IDI, FGD, and

photovoice data. The data will be triangulated to answer the research questions (RQs); and the interpretation of the data will be enriched by triangulation, as well as by creating new themes [35, 43].

Reflexivity of the researcher

Reflexivity and subjectivity are important characteristics of qualitative studies using thematic analyses [35, 43]. The PR method encourages a self-reflective, engaged, and self-critical role among researchers [11]. The primary investigator (PI) in this study has 10 years of experience of working as a primary care medical practitioner in a rural district in Sabah, Malaysia. The PI will be the "facilitator" or "moderator" to guide the discussion between participants [27, 37].

The study outcome

Community participation in research is critical for developing information, education, and communication tools to produce and promote public health programmes [11]. The views and reflections of the community in the study are relevant for culturally sensitive and effective future malaria-intervention programs, and could result in sustained malaria interventions [6]. The outcome of this study will be used to inform the development of community-friendly and appropriate communication tools [6]. This approach is viewed as an essential component of ethical good practice in research. It brings community health benefits by increasing the chances of success of an intervention [2, 6]. Intervention can be in the form of education, reflection, and discussion [6, 41, 42].

Discussion

Efforts have been made to assess how PR can be an effective research methodology for malaria intervention. A PR project contributed to increasing knowledge and awareness on

malaria in the community in the Philippines [24]. Many previous programs have failed because of a lack of genuine community participation and also of recognition of community perceptions of illness and prevention [6]. Engaging communities has improved communication tools for the promotion of effective and sustainable interventions, enhanced their relevance and feasibility, and improved data utilisation by all stakeholders [6]. We hope to provide empirical evidence to help develop future zoonotic malaria control programs. Community engagement and feedback in our research will increase the reliability and validity of the study through local knowledge and theory based on experiences [2, 6, 33]. Participants will be empowered when their views and voices are heard [32, 33, 39]. Future studies and collaborations that combine PR and emphasise community participation will reinforce additional knowledge and appropriate behavior changes [41].

Study limitation

It is possible that, we may encounter a lack of trust among community members with the study, due to the limitation of time and space to engage with the whole community members due to the current COVID-19 pandemic. We will attempt to minimise this by establishing trust through early communication and engagement with the head of the village. Community members may be sceptical about participating in the study in case their opinions are considered invalid, thus a poor response rate in certain phases of this study may be encountered. A qualitative study is not a generalisable design but has the potential to develop an in-depth understanding of the community from a small number of participants. Due to differences in overall philosophy, assumptions, beliefs, decision-making, and values, conflicts can arise between study members and different organisations.

Conclusion

The PR has important implications for the sustainability and appropriateness of malaria interventions. The PR provides insights from local people to improve the quality of research and ensure validity. The use of PR in health research promises far-reaching changes. Changing the relationship between researchers and those who participate in the research involves a transformation of power and views of the issues that provokes a more flexible and reflexive process among researchers.

Ethical approval

This study has been approved by the Medical Research and Ethics Committee Ministry of Health Malaysia (NMRR ID-21-01980-JEH), and the Research and Innovation Secretariat, Faculty of Medicine, Universiti Kebangsaan Malaysia (FF-2021-462).

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Author contributions

NAN was the principal investigator responsible for the design of the study and study protocol. MRH was the coordinating investigator. RC, MSJ, RH, KA, and MRH contributed equally to the content of the study protocol with important intellectual revisions. NAN drafted the manuscript. All authors read and approved the final protocol manuscript.

Conflicts of interest

There are no conflicts of interest associated with this protocol.

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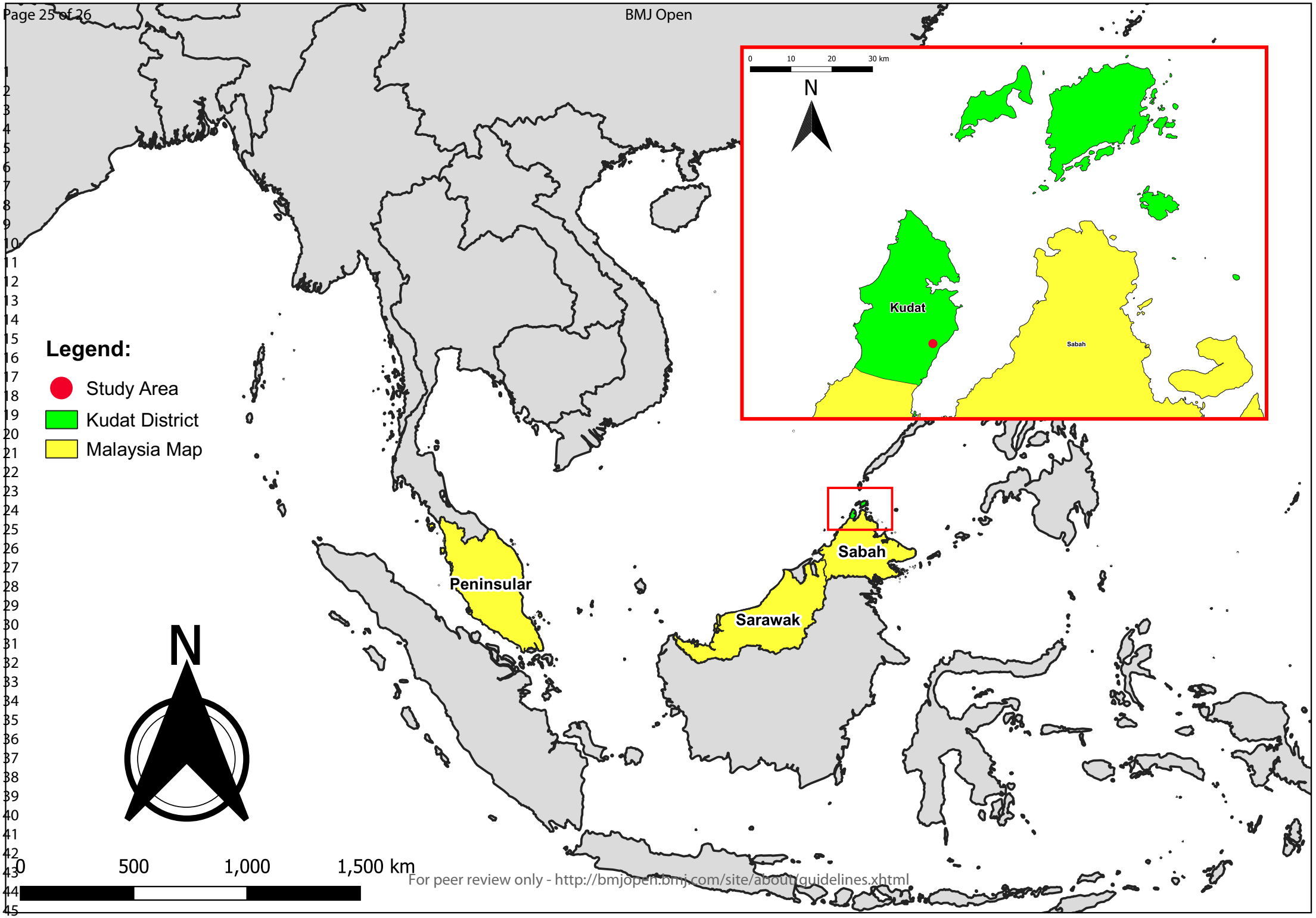

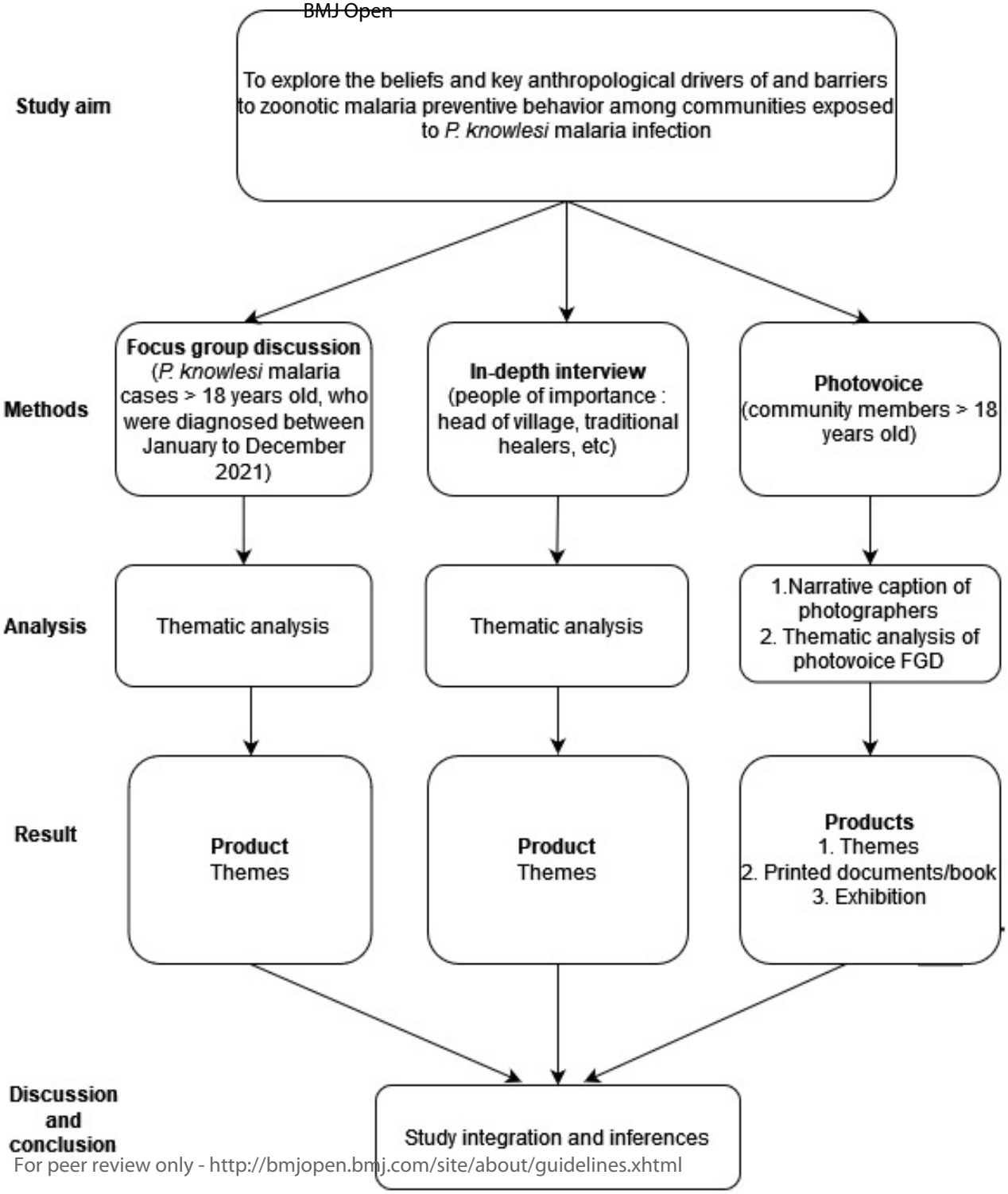

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Exploring the key anthropological drivers of and barriers to zoonotic malaria preventative behavior in a community exposed to Plasmodium knowlesi infection in Malaysia: protocol for a qualitative study with a participatory research design

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Exploring the key anthropological drivers of and barriers to zoonotic malaria preventative behavior in a community exposed to *Plasmodium knowlesi* infection in Malaysia: protocol for a qualitative study with a participatory research design

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ABSTRACT

Introduction: *Plasmodium knowlesi* malaria is a zoonotic mosquito-borne disease with complex epidemiology. According to the World Health Organization, the prevention and control of vector-borne diseases requires community participation to increase coherence between malaria interventions and sustainable public health programs. We describe a participatory research (PR) design for a study aimed at exploring the key anthropological drivers of and barriers to zoonotic malaria preventive behaviour among communities exposed to *P. knowlesi* infection in Malaysia. Participatory approaches can facilitate policymakers in designing future zoonotic malaria control programs by investigating community perspectives and concerns about zoonotic malaria in a local context.

Methods and analysis: The PR will be conducted over a period of 12 months, from March 2022 to March 2023, among adults (>18 years old) who are permanent residents in a rural village exposed to *P. knowlesi* malaria in Sabah, Malaysia. We will select patients who were diagnosed with *P. knowlesi* infection from January to December 2021 for focus group discussions (FGDs), as they can provide perspectives on disease from the point of view of those previously diagnosed with infection. In-depth interviews (IDIs) with people of importance in the community, such as village heads, will also be conducted. Both FGDs and IDIs will be conducted from March 2022 until June 2022. Concurrently, a photovoice with adults over 18 years old who reside in the community will be conducted. The target sample sizes for FGDs, IDIs and photovoice is 6-8, 12, and 10-15 participants, respectively. We will use a study framework as a theoretical lens to guide the exploration of the beliefs, social contexts, barriers, and drivers surrounding zoonotic malaria preventive behaviour.

Ethics and dissemination: This study has been approved by the Medical Research and Ethics Committee Ministry of Health Malaysia (NMRR ID-21-01980-JEH) and the Research and Innovation Secretariat, Faculty of Medicine, Universiti Kebangsaan Malaysia (FF-2021-

462). All participants will provide consent prior to participation The results will be reported in international peer-reviewed journals and presented at conferences and on other platforms.

Strengths and limitations of this study

- The study will use a participatory approach to explore the challenges facing communities practicing preventive behaviour against zoonotic malaria in their local settings.
- The participatory approach protocol is geared toward conducting a research process with adults >18 years old in communities exposed to *Plasmodium knowlesi* malaria in Sabah, Malaysia to explore their perspectives on malaria and facilitate policymakers in designing future zoonotic malaria control programs.
- The participatory research method will use a theoretical framework that has been generated from expert consensus.
- Qualitative studies are difficult to replicate in different settings and the results may not be relevant to other communities and larger populations.
- The study is time-consuming and continuous engagement is needed with all community members in order to build trust with researchers.

INTRODUCTION

In 2020, the World Health Organization (WHO) included *Plasmodium knowlesi* (*P. knowlesi*) malaria in its World Malaria Report for the first time.[1] Since the first report of *P. knowlesi* cases in Kapit, Sarawak, Malaysia in 2004, the parasite has been reported infecting people in other countries throughout the South-East Asia region.[2, 3] The increasing incidence of *P. knowlesi* malaria among humans is a possible public health threat in the future.[3] The highest number of *P. knowlesi* cases in humans occur in Sabah and Sarawak states, Malaysian Borneo.[4] Despite positive progress towards achieving elimination of human malaria in Malaysia, the increasing incidence of *P. knowlesi* requires the application of interim strategies to reduce its transmission.[3] The threat of zoonotic malaria infection has increased dramatically, and thus it is critical to revisit current malaria control strategies and design interventions specific to zoonotic malaria.[3]

In Sabah state, cases of P. knowlesi malaria infection increased from 100 cases per year in the year 2000 to 1325 cases in 2014.[4] In 2018, there were 4131 reported *P. knowlesi* cases throughout Malaysia, with the highest incidence rate of 0.13 cases per 1000 population.[4] Malaysia reported its last indigenous human malaria cases in 2017, with only 85 cases.[4] *P. knowlesi* malaria cases were commonly diagnosed in adult males and persons who performed forest related work.[5] While majority of cases were uncomplicated, fatalities were reported in patients as young as 31 years old.[6] Furthermore, the detection of asymptomatic cases of *P. knowlesi* malaria in human populations, including in children and within families, suggest potential target populations for interventions.[3, 7]

Malaria generally affects poor communities with low levels of education and limited access to health services.[1] Individuals who may come into contact with macaques and *Anopheles* mosquitoes are at risk of *P. knowles*i malaria.[2-10] Ecological changes due to deforestation and other anthropogenic activities increase the risk of zoonotic malaria.[8]

Zoonotic spillovers expose communities living in rural and semirural areas to *P. knowlesi* malaria infection due to the destruction of the natural hosts' habitat. Macaque monkeys move father from logging activities and favour human settlements.[9] In addition, *Anopheles* mosquito vectors from the *Leucospyrus* group prefer to breed in muddy ground pools, swamp water and water pockets.[10] Vectors may also breed in sites like bamboo stumps, tins and other artificial containers.[10] The potential impact of this zoonotic spillover into vulnerable communities requires interim strategies and multisectoral approaches for its prevention and control.[7, 11]

In 1961, Malaysia launched its Malaria Eradication Program.[12] Various vector control measures were introduced including indoor residual spraying (IRS) and the distribution of insecticide treated bednets (ITNs).[12] The provision of free malaria tools has reduced human malaria cases by 7-fold over 30 years.[4] Zoonotic malaria, however, may not be controlled to the same degree as human-restricted malaria due to the different factors that control its transmission.[5] Exacerbating this problem, persuading the local populations to adopt different control measures for what they perceive as the same problem is difficult. In Indonesia, for example, zoonotic-malaria specific preventive measures such as protective clothing and bednets were perceived as "uncomfortable" by community members.[13] Among the indigenous tribes people of Peninsular Malaysia, there is a belief that malaria has a supernatural origin, causing the community to perceive zoonotic malaria differently.[14]. Further research that explores the social context and human related factors that contribute to disease transmission is warranted.[5]

Malaria control strategy: socio-context and human behaviour

Based on the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR), understanding the behaviour of members of a community and its

socio-contexts can inform preventive measures.[15] Quantitative surveys often fail to account for the underlying causes of human behaviour that lead to exposure to health risks.[15, 16] Furthermore, social contexts such as lifestyle, socio-cultural belief, economic factors, and behavioural factors can influence malaria exposure and the usage of preventive measures.[3, 15-17] Social gatherings and other activities that are performed before bedtime can increase the risk of mosquito bites.[18-20]. Furthermore, ITNs are not effective when communities do not use them throughout the night.[19] *P. knowlesi* vectors are typically exophagic, exophilic and bite early during the night-time, thus indoor-based interventions are unlikely to provide sufficient protection.[10] Recently, mosquitoes of the *Umbrosus* group were found to bite early (from 11:00 in the afternoon), thus increasing the risk to communities performing day-time activities.[20] In addition, cultural and economic activities also affect the acceptance and usage of malaria preventive measures.[5] Farming communities and agricultural sector workers in oil palm farm and rubber estates were non-complaint with preventive measures due to various factors such as inconvenience and low perceive threat.[5, 13] These populations are at high risk to exposure to *P. knowlesi* malaria and thus complementary antimalarial strategies are required.[3, 7, 21]. For example, the One Health initiatives enforce ecological regulations that limit deforestation.[21] *P. knowlesi* malaria control measures should integrate a transdisciplinary approaches through identification of the risks of vector-human contact during outdoor activities.[5, 7, 21]

Numerous previous studies have been conducted on local beliefs concerning malaria in different regions of the world.[14, 22-24] In Indonesia, belief in a supernatural cause of malaria influences individuals to consume certain foods and to use pendants and "*jampi*" (magic). They apply these measures rather than implementing evidence-based antimalarial measures or seeking treatment at healthcare centres.[13] Individuals seek treatment with

traditional practitioners because of cost, and claim that these are more effective and reliable. [13, 25]

Studies from Malaysia, Africa, Indonesia, India and the Philippines suggest that cultural and religious beliefs influence understandings of the causation of malaria.[15, 23-25] These beliefs impact on adherence to bednet usage and influence attitudes towards health seeking behaviour. Understanding how communities perceive malaria and preventive measures such as bednet compliance can inform future *P. knowlesi* malaria control programs.[3] Along with understanding community behaviour, existing traditional knowledge should also be assessed prior to the design and implementation of *P. knowlesi* malaria control strategies.[3] For a program to be sustainable, the community should be involved in its planning, implementation, and evaluation.[11, 15] Rather than focusing on the individual, community empowerment helps to increase the sustainability of interventions.[11] As one of the pillars of a multisectoral approach to vector borne disease control, community participation is a powerful component that is cost-effective, practical, and facilitates behavioural changes that focus on enhanced vector control measures.[11]

The failures of "one size fits all" strategies for malaria control have prompted a re-evaluation of the importance of communities' local priorities and needs.[11, 15] For example, participatory research approaches can be used to explore the influence of social context on the surrounding environment as well as community behaviours that increase exposure to zoonotic malaria. It is crucial to investigate and explore opportunities for improving malaria disease control. This will assist acceptance in local communities.

Participatory research (PR), also known as 'community-based PR (CBPR)' or 'community research' is a collaborative and iterative research design involving input from researchers and participants.[26] It focuses on research processes that involve local people.[27, 28] The term is used interchangeably, thus throughout this protocol manuscript,

the term CBPR will be used. Israel *et al* described CBPR as a constructivist and critical theoretical perspective that argues with positivist ideology.[28] Through CBPR, the findings can facilitate improvements in health-related interventions, and generate evidence based practices.[27, 28] CBPR incorporates community perspectives and emphasises the direct engagement of local priorities.[27] CBPR differs from participatory action research (PAR) by shifting the emphasis from action to collaborative research activities.[27, 28]

CBPR aims to produce knowledge through collaboration between researchers and research participants.[27, 28] CBPR embeds the practice of knowledge democracy by using multiple ways of exploring community knowledge through expressions such as local narratives and songs.[27] This can lead to new insights regarding health research , and can act as a tool for exploring social activity in relation to social action and health equity.[27] Greater sensitivity to communities involving listening to their voices, can generate trust and build partnerships and relationships between researchers and participants.[27] In CBPR studies, both quantitative and qualitative methods can be used.[27] The advantage of CBPR is that researchers can conduct systematic inquiries with study participants. Often these are marginalized or disenfranchised communities, who are immediately affected by the ongoing issues.[27, 28]

Characteristics of the community-based participatory approach

Discrete differences exist between CBPR and other research methodologies.[27] CBPR democratizes participant knowledge by instilling the belief that people exert a positive influence on their circumstances.[27] CBPR reduces the gap between theory, research and practical recommendations.[27, 28] There are guidelines such as those described by Israel *et al.,*[28] however each research is unique in that it is dependent on local issues.[27] For example, CBPR studies emphasise a "bottom-up" approach by incorporating local knowledge

in future planning and program implementation.[27] The co-learning process between researchers and participants facilitates reciprocal transfer of knowledge, skills and capacity.[27] In contrast, other research designs often aim to generate knowledge from research without incorporating local priorities and perspectives. This oversight may result in inappropriate recommendations.[27, 28] CBPR also places an emphasis on the empowerment of community members as co-researchers, by allowing the sharing of information, decision making, and partnerships.[27] CBPR is an alternative approach for empowering, engaging, and creating cohesive and sustainable vector control programmes addressing local issues.[29] In the Philippines, through the Participatory Visual Method (PVM) using photovoice methodology, researchers gained access to the live and social context of the communities through images captured by the participants.[29] The images act as a powerful tool to informed policymakers on communities' belief and preventive measures against malaria, through the eye of community members.[29] Below we describe the methods that will be used and the analyses that will be conducted in this study.

Study perspective and health behaviour model

From a constructivist perspective, the meaning and experience of phenomena are socially constructed, for example by social norms, beliefs, and environment, rather than inherent within individuals.[30] This paradigm emphasises the generation of understanding an issue "from the bottom up" approach.[30] In CBPR studies, community involved in the research through their participation in addressing the research inquiry, through discussion of the data and interpretation of the findings. This process is valued and underpinned by the concept of critical consciousness[31] and feminist theory.[32] Through this ideology, the Brazilian educator Paulo Freire, proposed the concept of education through collective dialogue with the oppressed and poor people.[31] In feminist theory, participants are able to participate in

the decision making process through the power that arises from the voice of people who live within the issues.[32]

This study seeks to incorporate an understanding of socio-cultural contexts and their structural conditions on malaria preventative behaviour among individuals and communities exposed to *P. knowlesi* malaria. Previous studies have shown that individuals and communities have their own native and socio-cultural beliefs toward the disease and that influenced malaria preventive behaviour.[13-15] In addition, there are also drivers to and barriers of malaria preventative behaviour in the communities.[15, 18, 19] Participants in the study can provide local perspectives on their beliefs and preventive measures, and offer opinions for future improvement of methods and tools to deliver preventative messages..

Study framework

The study framework will integrate the ideation model,[33] the explanatory model,[34] and Murdock's illness causal model.[35] This framework will act as a theoretical lens for knowledge processing in this study. Theory can convey a clear signpost of the study and provide guidance on how and what method will help to answer the research questions.[30]

The ideation model is a predictive model of behaviour change involving both individuals and communities.[33, 36] It is a socioecological approach involving the integration of communication and multiple behaviour theories.[33, 36] The model acts as a conceptual tool that can identify common psychosocial variables that may influence malaria related behaviour [37-39] This framework identifies a set of psychosocial variables grouped into three domains: cognitive, social support and emotion.[33] For example, cognitive variables or factors include the attitude towards the recommended preventive behaviour, perceived risk and self-efficacy to avoid malaria infection. While emotion, could described the feelings of fear towards malaria infection. Social support variables or factors embrace the community

support and peer pressure to practice or avoid the recommended preventive behaviour.[37-39]

The explanatory model is a tool for medical and public health professionals to investigate cultural variations in illness experiences, diagnosis, and treatment.[34] The model aids in developing rapid assessments through direct communication with patients, family members, and relatives.[16, 34] The data produced can facilitate the translation of interventions that consider the local perceptions of illness, circumstances that result in a risk pattern, and community structures that might support the intervention.[16, 34]

Murdock's illness causal model conceptualised the local perception of causation of disease.[35] According to this theory, it is important to distinguish between beliefs about natural and supernatural causes of illness, which are diverse worldwide, as they influence how disease treatment and behaviour are perceived.[35, 40]

Study aim

This study aims to explore the key anthropological drivers of and barriers to zoonotic malaria preventative behaviour among communities exposed to *P. knowlesi* malaria infection. This study will be conducted among adults (age > 18 years old), including those with a history of *P. knowlesi* malaria infection, and those who live in areas with a high incidence of the infection.

The study will address the primary research question: “According to adults (age > 18 years old), including those with past history of this infection, and who live in an area exposed to *P. knowlesi* malaria infection, how and why do their beliefs towards the disease, and social, cultural and environmental challenges, influence zoonotic malaria preventive behaviour?”. In view of the fact that current vector control measures do not protect against *Anopheles* mosquito bites, we defined preventive behaviour as ‘avoidance of mosquito bites’. We will

then translate the views of the communities into information for policymakers, thus addressing the second research question: “How can the views and concerns of these communities regarding zoonotic malaria infection inform future *P. knowlesi* malaria control programme?”.

METHODS AND ANALYSIS

Study setting

This study will be conducted in the highly *P. knowlesi* endemic state of Sabah, Malaysia.[41] Sabah covers 73,904 sq km, with an estimated population of 3.90 million in 2019.[42] Geographically, Sabah is composed of a mix of mountainous regions, coastlines, and tropical rainforests. In Sabah, *Anopheles leucosphyrus* group mosquitoes are the major vector for *P. knowlesi* malaria infection.[43] A study by Cooper *et al.* reported five districts in Sabah with a high incidence of *P. knowlesi* malaria; Ranau, Keningau, Tenom, Tambunan, and Kota Marudu, which are located along the Crocker range.[44] The present study will be conducted in the northern region of Sabah in Kudat region, the location of several recent studies on zoonotic malaria.[8, 9, 43, 45] (figure 1).The incidence in Kudat district is estimated at 0.90 to 1.36 per 1000 population.[44] The location was selected after obtaining a list districts with village names from the Sabah State Health Department, within areas with high incidences of *P. knowlesi* in 2020.

Study participants

The study participants will be adult men and women (above 18 years old) who can provide informed consent prior to the focus group discussions (FGDs), in-depth interviews (IDIs), and photovoice. The study will include participants who are permanent residents of the village, are mobile, without known cognitive or mental health issues, and are able to answer

questions in Malay or English language. Due to restrictions imposed by the current COVID-19 pandemic, participants with access to electronic communication tools will be preferred.[46, 47] We anticipate the recruitment of participants with access to electronic communication tools will cause bias in the study results. However, in view of the improved COVID-19 situation in Malaysia and the ability to conduct fieldwork with strict Standard Operating Procedures (SOPs), this bias may be minimized by conducting the study at the study sites and via face to face interviews. The sampling method for the FGDs will be purposive sampling among individuals who were previously diagnosed with *P. knowlesi* malaria infection between January 2021 and December 2021. Community leaders will be selected for IDIs. Subsequently, a snowballing technique will be used to recruit other information-rich individuals. For the photovoice, a recruitment pamphlet will be distributed in the village, and we will use purposive sampling to recruit the participants. Excluded from the study will be non-residents, people with known cognitive or mental health issues, and those who are unable to attend interviews or FDGs after two invites. All these methods will be conducted concurrently for twelve months from March 2022 through to March 2023.

Sample size

For FGDs, 6 to 8 participants will be enrolled,[48] while the sample size fo IDIs may be up to 12 participants.[49] Data will be collected until data saturation is reached, defined as when there is no new information collected from subsequent participants.[48, 49] Earlier studies using photovoice reported enrolling between four and 122 participants.[50] We aim to recruit 10 to 15 participants.

Categorisation of participation

The gradation of participation in this study is informed by Arnstein's "ladder of citizen participation" categorization.[51] This ladder distinguishes three main participation categories: citizen power, tokenism, and non-participation; and eight levels: manipulation, therapy, informing, consultation, placation, partnership, delegated power, and client control.[51] We will utilise tokenism in our study. During the FGDs, IDIs, and photovoice, we will ensure that communication between researchers and participants allows them the opportunity to influence the discussion and analysis. However, those with power (e.g policymakers) will have power over decisions.[51] For example, to ensure meaningful "tokenism" between researchers and participants in photovoice, we will provide an introduction and training workshop prior to commencing the method. The workshop will ensure a safe working environment, and agreements will be reached between the researchers and participants upon the methodology.[52, 53] During the photovoice progress, we will regularly discuss the conditions for cooperation with the participants. The research questions will be shared with participants.[53] We will communicate in a clear manner in the Malay language and tailor communication to the literacy and coping level of the participants. The participants will receive a "token" for participating in the study. Participants will have the right to withdraw from the study at any point.

Study design

The study is a multimethod design using the CBPR methodology.[27] This study will be conducted over a 12 month period. Rapport will be established with individuals so that topics can be freely discussed.[27] The study will use FGD, IDI, and the photovoice method, which offers the advantage of triangulating the data. A semi-structured interview guides have been prepared and approved by the research supervisory and ethical committees. The views of all

participants which will be recruited in different methods, will be compared and interpreted to achieve data triangulation. The photovoice will raise their perspectives and concerns using an iterative and collaborative process.[50, 54] The researchers' role will be to introduce the research aims and questions to the participants. In view of study using the CBPR methodology, the creation of discussion will be conducted through dialogues with participants (co-researchers).[27] The dissemination of study findings with policymakers will either be conducted through exhibition (e.g at local townhall) or different platforms (e.g colored book, peer-reviewed manuscript, conference presentations).[53-55] (figure 2) However, due to the COVID-19 pandemic, research methods may be modified to accommodate social distancing requirements and other SOPs.

Study phases

Phase 1: Preparation

The first phase of the study is to conduct a systematic literature review to understand: i) the behaviour or activities that expose humans to *P. knowlesi* malaria infection, and ii) how data on behaviour were collected in previous studies.[5] The literature searched was from standard scientific databases. The article abstracts were screened and assessed by three researchers, and any disagreement on the quality of the studies was resolved by consensus of the co-authors.[5] The Joanna Briggs Institute critical appraisal checklist was used to rate the quality of the studies. A grey literature search was also performed from the WHO website. It was found that the that majority of the included studies were done quantitatively, limiting a deep understanding of human behaviour.[5] Several factors such as socioeconomic status, beliefs, perceived threats, motivation, and coping issues can influence communities' malaria preventive behaviour.[5] Future studies must consider using qualitative study designs in order to generate a rich information and address how human behaviour can influence the exposure

to zoonotic malaria.[5] Furthermore, the importance of community perspective on *P. knowlesi* malaria control is critical to strategize a specific *P. knowlesi* malaria control guidelines.[5, 7]

The next step was to develop a research framework that would function as the theoretical lens for this study. The theoretical lens is the study's assumptions that will guide the study methodology.[30] Using the modified Delphi study, new themes were generated through the consensus of experts.[56] The experts were selected based on the inclusion criteria as per the protocol.[56] Twelve experts were selected based on (I) having more than five years of experience working or practicing in any research institutions, having an administrative post in any organization and conducting malaria research, (II) individuals who have published more than one study on malaria in peer-reviewed journals and (III) consented. This framework focused on factors that possibly influence malaria preventative behaviour in communities exposed to *P. knowlesi* malaria infection through the collective agreement among the expert panels.[56] (figure 3).

The third stage will be selection of participants. A pamphlet using the Malay language were distributed in the village to recruit participants for photovoice (figure 4). The distribution were done after the meeting with the community leaders. Only those individuals who show interest and match our eligibility criteria will be recruited. The purposive and convenience sampling method will be used to avoid participants' dropouts. The photovoice participants will attend a workshop introducing the study, discussing ethical considerations, distributing tasks, and outlining responsibilities. Participation will continue throughout the study duration.[55]

Phase 2: Implementation of the study

The implementation of the study is as follows: FGDs and IDIs will be conducted with participants to answer the specific research questions. Participants will participate in discussions and undergo interviews using the interview guides. Data will be collected and

analysed by the research team. The research team consists of epidemiologists, public health specialists, medical anthropologists, infectious disease experts and a postgraduate student. FGDs, IDIs, and photovoice will be recorded, transcribed *verbatim* by the research team, and analysed using thematic analysis by Braun and Clark approach.[57]

The FGDs and IDIs will be performed in a place familiar to the participants.[58] The FGDs will start with a general question about what participants perceive about *P. knowlesi* malaria infection, explore their beliefs concerning illness causation, and how and why these beliefs influence their malaria-preventive behaviour. Prompts will also be used to gather information and to generate a richer data. The FGDs will be conducted for approximately 90 minutes, preferably without breaks.[58] The session will continue until a clear pattern emerges and subsequent interviews do not produce new information.[57] IDIs will be conducted individually using an interview guide. Potential key informants, such as people of influence in the community, such as the head of village and faith leaders,[59] will be contacted by formal letter, individually. A meeting has been arranged with this gatekeeper to build rapport and to request permission to conduct the study at the site.[60]

Interviews will be conducted using face to face sessions, however electronic communication may be warranted depending on the COVID-19 situation. The duration of the interview will be approximately 60-90 minutes.[57, 58] The session will be written in fieldnotes and recorded, audio and verbally. As a means to maintain data trustworthiness, member-checking and external coding will be used to validate the data .interpretation and coding.[61]

In photovoice, participants will take photographs (e.g using camera or smartphones), discuss them through the FGDs, and select the photos that best reflects the community for future dissemination of study findings.[62, 63] Photovoice research team will work as closely as possible with the local structures and institutions to facilitate meaningful long-term participation.[62] The goals, strategies, and limitations for social change will be clearly and

realistically defined and communicated to avoid raising the expectations of participants.[54, 63] The photovoice participants will have specific rules; such as the requirement of consent before taking pictures of adults and avoiding pictures of children. A WhatsApp group will be created by the researchers through which the participants will be encouraged to share the photos. The photographs taken by the participants, that will be shared with policymakers, have value in that they provide the opportunity for virtual display when words are difficult to express their views.[54, 62] Previous research described participants shared around 9-182 photographs and suggests that participants take an average of 40 to 50 photos each.[62] We will recommend 10 photos per participant. The photographs can be taken anywhere, such as the home, street, or other aspects of the participant's environment, target actions, places, and situations.[55, 62, 63] We will use the SHOWeD algorithm to reveal the participants' reflections of their photos.[63] The narrative caption of the photos will reveal meaningful experiences that can improve awareness of relevant issues.[63]

Phase 3: Dissemination

Due to the ongoing COVID-19 epidemic and resulting restrictions, we will look for opportunities to present the research findings on appropriate platforms. Thus, dissemination will not only be at the local townhall with the participants, but also through online research presentations, various scientific presentations, and a book.[55] The book will include coloured photos and narratives from participants that illustrate their perspectives on local beliefs, and the drivers and barriers to malaria preventive behaviour. All the photovoice participants, will be given an opportunity to review the initial draft. Hardcopies will be disseminated to policymakers (for example the Sabah State Health Department and Ministry of Health Malaysia).

Supervisory committee

The supervisory committee will monitor the study process, from initiation to the end of the study. They will provide advice on the content of the study and its appropriateness with respect to the study aims. Monthly meetings are planned, and members of the supervisory committee will be asked for further input, if needed. Researchers and stakeholders will be a part of this supervisory committee.

Patient and public involvement

Participants were not directly involved in the study design. The FGD and IDI participants will only act as research participants. Meanwhile, the photovoice participants will conduct the photography session, give inputs in analysis, and participate in the exhibition. The researchers will conduct the final reporting and dissemination plan of this research.

DATA ANALYSIS

Data will be collected by the researcher and research assistants (RAs), who are proficient in the local language. The RAs will be trained by the research team and will be the observers, notetakers and translators. The RAs will assist in transcribing the data from the local language into English. We will use the qualitative software program ATLAS.ti Version 9 (ATLAS.ti Scientific Software Development GmbH), to assist with data handling, storing, and creating networks images, quotations, codes, themes, in a systematic way.

Thematic analysis

Thematic analysis by Braun and Clark will be used to generate codes and themes from the data.[57] Data familiarisation will be through re-reading the verbatim and re-viewing the

photographs.[57] Familiarisation, is a time-consuming process which includes the phase of immersion, where researchers engage deeply with the data to find a richer meanings and generate patterns from the data.[57] In addition, this phase include critical engagement and note-making of thoughts related with the data.[57] Then, Initial codes will be generated systematically across the whole data set.[57] Themes will be identified within codes, and these themes will be named and defined.[57] Prior to the writeup, a review of the themes will be conducted.[57]

Rigor and data trustworthiness

Rigor is defined as the demonstration of integrity and competence within a study.[64] Data trustworthiness will be gained through feedback from participants (credibility, dependability), checks by participants and the research team (confirmability), and a thorough description of data collection and analysis (transferability).[61] Member-checking will be performed after all sessions of the chosen methods are completed.[61] For example, after an IDI session is completed, a summary will be given to participants to confirm or comment on the researcher's understanding throughout the session, and to maintain data accuracy. It will provide the opportunity to modify errors or wrong interpretations.[61] External coding will increase the validity of the data.[61] The coding process will be individually applied to the IDIs, FGDs, and photovoice data. The data will be triangulated to answer the research questions (RQs), as well as by generating new themes.[57]

Reflexivity of the researcher

Reflexivity and subjectivity are important characteristics of qualitative studies using thematic analyses.[57] The CBPR method encourages a self-reflective, engaged, and self-critical role among researchers.[27] The primary investigator (PI) in this study has 10 years of experience

of working as a primary care medical practitioner in a rural district in Sabah, Malaysia. The PI will be the "facilitator" or "moderator" to guide the discussion between participants.[30]

Study outcome

Community participation in research is critical for developing information, education, and communication tools to produce and promote public health programmes.[27] The views and reflections of the community in the study are relevant for culturally sensitive and effective future *P. knowlesi* malaria-intervention programs. Furthermore, it could result in a more sustainable malaria interventions.[11] The outcome of this study will be used to inform the development of community-friendly and appropriate intervention tools. This approach is viewed as an essential component of ethical good practice in research.[27] It brings the communities' perspective and voices a way forward, through engagement in research, health equity and increasing the chances of success of an intervention.[11, 27] Intervention can be in the form of education, reflection, and discussion.[27]

Study status

The preliminary study was conducted from the 30th of December 2021 to the 28th of February 2022. As part of the participatory approach, the gatekeepers (the healthcare workers and community leaders in the study sites), were met to introduce the study and discussed on the methodological feasibility and appropriateness of conducting the study during the COVID-19 pandemic. In view of COVID-19 disease prevention, only fully vaccinated community members will be allowed to participate in the study and all participants needs to adhere to COVID -19 SOPs such as wearing masks and social distancing. The results of this preliminary study will be disseminated in future peer-reviewed manuscript.

Ethics and dissemination

This study has been approved by the Medical Research and Ethics Committee, Ministry of Health Malaysia (NMRR ID-21-01980-JEH), and the Research and Innovation Secretariat, Faculty of Medicine, Universiti Kebangsaan Malaysia (FF-2021-462). All the participants will provide consent prior to participation. Participants are allowed to withdraw at any point during the study. The results will be disseminated in various academic (*e.g.* conferences, journals) and non-academic (*e.g.* town hall meetings) platforms.

DISCUSSION

Efforts have been made to assess how CBPR can be an effective research methodology for *P. knowlesi* malaria intervention. CBPR has possible important implications for the sustainability and appropriateness of *P. knowlesi* malaria interventions. Many previous programs have failed because of a lack of genuine community participation.[11] CBPR provides insights from local people to improve the quality of research, ensure validity and improve public health intervention.[27] The recognition of community perspectives on the aetiology of illness, drivers of and barriers to preventive measures can provide a fresh perspective on research issues, and helps to facilitate intervention tailored to local conditions.[27] The engagement of communities has improved communication tools for the promotion of effective and sustainable interventions, enhanced their relevance and feasibility, and improved data utilisation by all stakeholders.[11, 27] The use of CBPR in health research promises far-reaching changes in short- and long-term outcomes.[27] We hope to provide empirical evidence to help develop future zoonotic malaria control programs. Community engagement and feedback in our research will increase the reliability and validity of the study through local knowledge and theory based on experiences. Changing the relationship between researchers and those who participate in research involves a transformation of

power and views of the issues that should promote a more flexible and reflexive process among researchers.[27] Participants will be empowered when their views and voices are heard.[54] Future studies and collaborations that combine CBPR methodology and emphasise on community participation will reinforce additional knowledge and appropriate behaviour changes.[27]

Study limitations

It is possible that we may encounter a lack of trust among community members with the study, due to the limitation of time and space to engage with the whole community members due to the current COVID-19 pandemic. We will attempt to minimise this by establishing trust through early communication and engagement with the head of the villages. Community members may be sceptical about participating in the study in case their opinions are considered invalid, thus a poor response rate in certain phases of this study may be encountered. A qualitative study is not a generalisable design but has the potential to develop an in-depth understanding of the community from a small number of participants.[30] Due to differences in overall philosophy, assumptions, beliefs, decision-making, and values, conflicts can arise between study members and different organisations.

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Contributors

NAN was the principal investigator responsible for the design of the study and drafting the manuscript. MRH was the coordinating investigator. RC, MSJ, RH, KA, and MRH contributed equally to the content of the study protocol with important intellectual revisions. All authors read and approved the final protocol manuscript.

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Competing interests

There are no conflicts of interest associated with this protocol.

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Figure titles

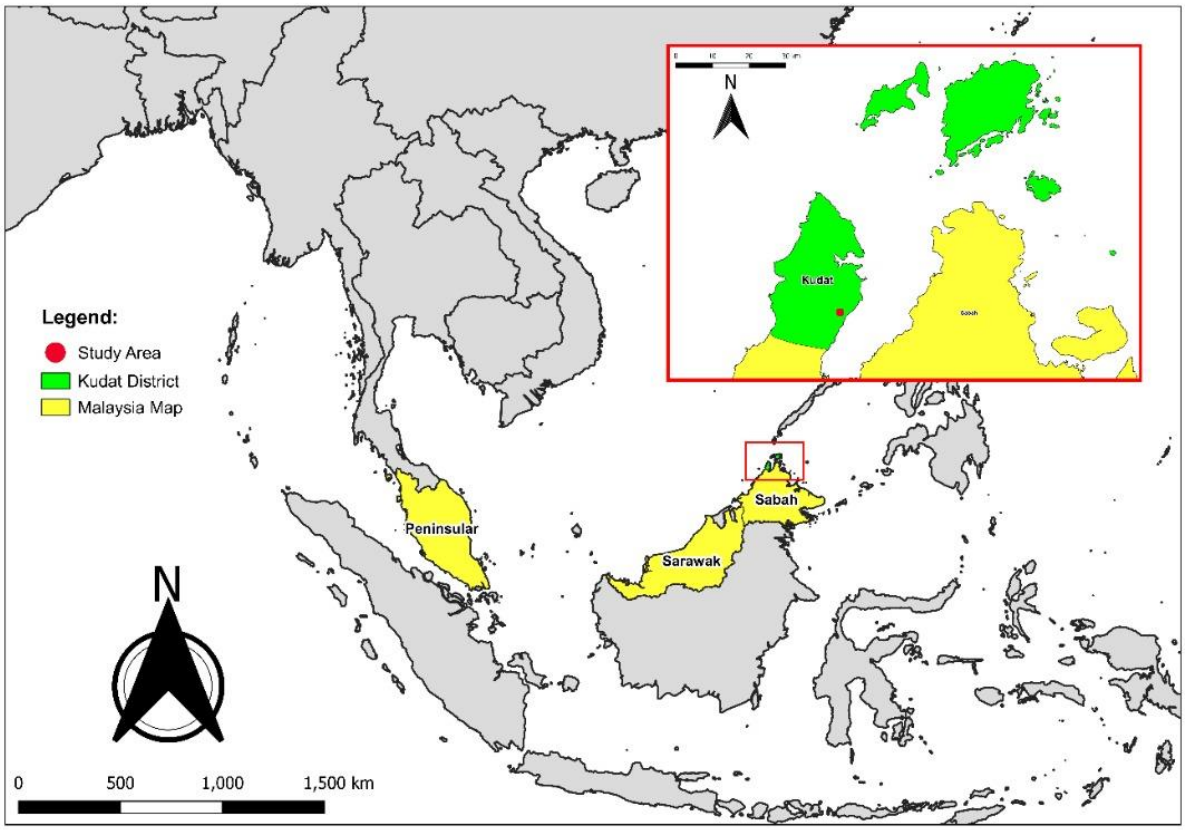
Figure 1. The study area

Figure 2. The study flowchart

Figure 3. The study framework

Figure 4. The photovoice recruitment pamphlet in the Malay language

Figure 1. The study area



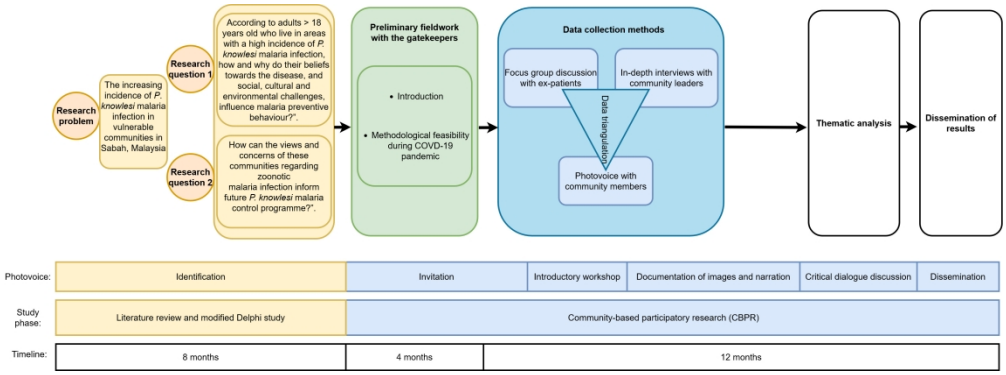


Figure 2. The study flowchart

1204x442mm (72 x 72 DPI)

Figure 3. The study framework

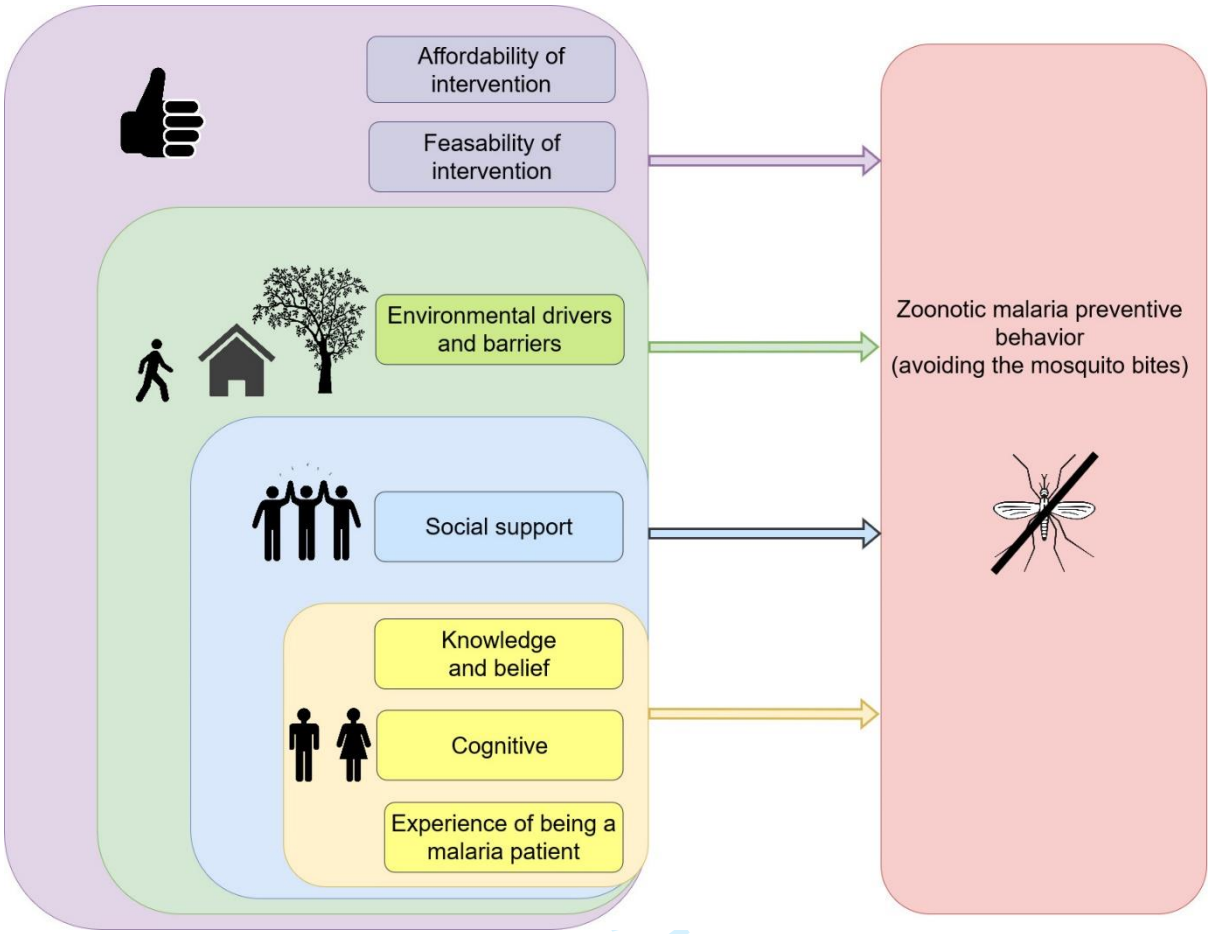


Figure 4. The photovoice recruitment pamphlet in the Malay language