# DEVELOPMENT AND VALIDATION OF MALARIA KNOWLEDGE QUESTIONNAIRE AND THE LEVEL OF MALARIA KNOWLEDGE AMONG POPULATION IN KUALA KRAI AND GUA MUSANG, KELANTAN

**DR MOHD HAFIZ BIN CHE ISMAIL**

**UNIVERSITI SAINS MALAYSIA**

**2024**

# DEVELOPMENT AND VALIDATION OF MALARIA KNOWLEDGE QUESTIONNAIRE AND THE LEVEL OF MALARIA KNOWLEDGE AMONG POPULATION IN KUALA KRAI AND GUA MUSANG, KELANTAN

**by**

**DR MOHD HAFIZ BIN CHE ISMAIL**

**Thesis submitted in fulfilment of the requirements**

**for the degree of**

**Doctor of Public Health**

**JUNE 2024**

## ACKNOWLEDGEMENTS

Bismillahirrahmanirrahim.

Alhamdulillah, all praises and thanks be to Allah, the Most Gracious and the Most Merciful, for granting me the strength, patience, and perseverance to complete this dissertation.

First and foremost, I would like to express my heartfelt gratitude to my supervisor, Associate Professor Dr Nor Azwany Yaacob, for her unwavering support, insightful guidance, and invaluable expertise throughout this research. Her patience, encouragement, and constructive feedback have been vital in shaping the direction and quality of this dissertation. I also extend my sincere thanks to my co-supervisor, Dr. Anis Kausar Ghazali, for her continuous support and invaluable contributions to this work.

I am profoundly thankful to the faculty and staff at the Department of Community Medicine, School of Health Sciences, Universiti Sains Malaysia, for their continuous support and for providing the necessary resources and a conducive environment for my research. My appreciation also goes to all the lecturers of the DrPH program for their intellectual support and guidance throughout my academic journey. Their insightful discussions and shared experiences have enriched my research and personal growth.

I extend my deepest gratitude to the Jeli District Health Office, Kuala Krai District Health Office, and Gua Musang District Health Office, as well as their dedicated staff for their collaboration and assistance in facilitating data collection. Their cooperation and commitment were crucial to the successful execution of this study.

I want to express my appreciation to the residents of Jeli, Kuala Krai, and Gua Musang, Kelantan, who participated in this study. Their willingness to participate and share their knowledge has been invaluable to this research. I am also thankful to the community leaders for their support in coordinating the survey activities.

I am deeply grateful to my colleagues for their motivation and encouragement, providing the necessary push forward for the completion of this dissertation. Their camaraderie and support have been invaluable, helping me stay focused and determined throughout this journey.

I owe my deepest gratitude to my family for their unwavering support, understanding, and encouragement. To my beloved wife, Siti Akmazni Shamsudin, your patience, love, and sacrifice have been my anchor during this challenging journey. Your constant support and belief in me have been invaluable. To my two sons, Haaziq and Aqeel, your smiles and innocence have been a source of great joy and motivation, reminding me of the importance of perseverance and dedication.

I also wish to express my profound gratitude to my mother, Rahani Mamat, for her endless prayers, love, and encouragement. Your strength and faith have been a guiding light for me. To my late father, Che Ismail Ab'llah, I am forever grateful for your wisdom, love, and the values you instilled in me. Your memory continues to inspire and motivate me to strive for excellence.

This dissertation is a testament to the collective efforts and contributions of all these individuals and institutions. Thank you for making this journey a rewarding and memorable one.

Dr Mohd Hafiz bin Che Ismail

June 2024

# DECLARATION

I, Mohd Hafiz bin Che Ismail, hereby declare that the content presented in this thesis is entirely my own. Any information from external sources was clearly acknowledged in the thesis. This thesis was written according to the alternative format that has been approved by the School of Medical Sciences, Universiti Sains Malaysia.

Name : Mohd Hafiz bin Che Ismail

Student ID : P-UD0009/21

Date : 2nd of June 2024

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF APPENDICES

# LIST OF SYMBOLS

| | |
|---|---|
| % | Percentage |
| & | And |
| < | Less than |
| = | Equal |
| *df* | Degree of freedom |
| *p* | *p* value |
| $x^2$ | Chi-square |
| $x^2$/df | Normed chi-square |

## LIST OF ABREVIATIONS

| | |
|---|---|
| 1-PL IRT | 1-Parameter Logistic Item Response Theory |
| 2-PL IRT | 2- Parameter Logistic Item Response Theory |
| 3-PL IRT | 3- Parameter Logistic Item Response Theory |
| ANOVA | Analysis of Variance |
| AOR | Adjusted Odd Ratio |
| BFMP | Blood Films for Malaria Parasites |
| CFA | Confirmatory Factor Analysis |
| CFI | Comparative Fit Index |
| CI | Confidence Interval |
| EFA | Exploratory Factor Analysis |
| FVI | Face Validity Index |
| I-CVI | Item-level Content Validity Index |
| I-FVI | Item-level Face Validity Index |
| IRS | Indoor Residual Spray |
| IRT | Item Response Theory |
| ITN | Insecticide-Treated Net |
| LLIN | Long-Lasting Insecticidal Net |
| MOH | Ministry of Health Malaysia |
| NGT | Nominal Group Technique |
| OR | Odd Ratio |
| *P. falciparum* | *Plasmodium falciparum* |
| *P. malariae* | *Plasmodium malariae* |
| *P. ovale* | *Plasmodium ovale* |
| *P. vivax* | *Plasmodium vivax* |
| RMSEA | Root Mean Square Error of Approximation |
| S-CVI | Scale-level Content Validity Index |
| S-CVI/Ave | Average of Scale-level Content Validity Index |
| S-CVI/UA | Universal Agreement of Scale-level Content Validity Index |

| | |
|---|---|
| S-FVI | Scale-level Face Validity Index |
| S-FVI/Ave | Average of Scale-level Face Validity Index |
| S-FVI/UA | Universal Agreement of Scale-level Face Validity Index |
| TLI | Tucker-Lewis Index |
| WHO | World Health Organization |

# ABSTRAK

## PEMBANGUNAN DAN PENGESAHAN SOAL SELIDIK PENGETAHUAN MALARIA DAN TAHAP PENGETAHUAN MALARIA DALAM KALANGAN POPULASI DI KUALA KRAI DAN GUA MUSANG, KELANTAN

*Latar Belakang*: Malaysia telah mencapai kemajuan yang ketara dalam mengurangkan kes malaria, dan mencapai sifar penularan tempatan sejak tahun 2018. Walau bagaimanapun, kes import terus menimbulkan risiko pengenalan semula malaria. Penilaian pengetahuan tempatan adalah penting untuk pendidikan yang bersasar kerana ia dapat memperkasakan komuniti dengan pengetahuan yang perlu untuk mengambil tindakan yang sesuai untuk mencegah malaria, seterusnya dapat mengurangkan risiko penyebaran dan menyumbang ke arah matlamat eliminasi malaria.

*Objektif:* Kajian ini adalah bertujuan untuk membangunkan dan mengesahkan soal selidik yang menilai pengetahuan berkaitan malaria dalam kalangan komuniti tempatan dan membandingkan pengetahuan ini dalam kalangan penduduk di kawasan berisiko rendah, sederhana, dan tinggi di Kelantan, Malaysia.

*Metodologi*: Kajian ini dijalankan dari Jun 2023 hingga Februari 2024. Ia terdiri daripada dua fasa. Fasa 1 menumpukan kepada Pembangunan dan pengesahan soal selidik yang baharu. Draf soal selidik dibangunkan dari tinjauan literatur dan pandangan pakar melalui Teknik Kumpulan Nominal. Kemudian, soal selidik tersebut disahkan menggunakan kajian pengesahan kandungan, pengesahan kejelasan dan kefahaman, pengesahan gagasan. Kajian pengesahan kandungan dilakukan dalam kalangan pakar kesihatan awam, dan kajian pengesahan kejelasan dan kefahaman dalam kalangan komuniti tempatan. Pengesahan gagasan dianalisis menggunakan respons item logistik dua parameter (2-PL IRT), melibatkan 300 peserta. Seterusnya, Fasa 2 melibatkan kajian hirisan lintang melibatkan 159 peserta untuk menilai pengetahuan mengenai pencegahan malaria dalam kalangan penduduk di kawasan berisiko rendah, sederhana, dan tinggi di daerah Kuala Krai dan Gua Musang, Kelantan. Soal selidik layan diri yang telah melalui kajian pengesahan dari Fasa 1 digunakan. Data kemudian dianalisis secara deskriptif dan analisis ANOVA dua hala.

*Keputusan:* Soal selidik baharu ini terdiri daripada 53 item merentasi tujuh domain. Domain tersebut adalah penularan, risiko jangkitan malaria, vektor, gejala, komplikasi, rawatan dan pengurusan, dan langkah pencegahan. Soal selidik ini menunjukkan pengesahan kandungan (S-CVI/Ave = 0.99, S-CVI/UA = 0.92) dan pengesahan kejelasan dan kefahaman (S-FVI = 1.0, S-FVI/UA = 0.99) yang baik. Analisis 2-PL IRT menunjukkan bahawa soal selidik ini mempunyai kesepadanan model yang baik dan parameter kesukaran dan diskriminasi yang boleh diterima, dengan kebolehpercayaan domain antara 0.62 hingga 0.83. Analisis ANOVA menunjukkan bahawa penduduk di kawasan berisiko tinggi mempunyai skor pengetahuan min marginal tertinggi sebanyak 35.0 (95% CI: 32.8, 37.2), diikuti oleh mereka di kawasan berisiko sederhana, 34.4 (95% CI: 32.2, 36.6), dengan skor terendah di kawasan berisiko rendah, 29.0 (95% CI: 26.8, 37.2). Penduduk di kawasan berisiko tinggi dan sederhana mempunyai skor pengetahuan yang lebih tinggi secara signifikan berbanding penduduk di kawasan berisiko rendah ($p < 0.001$), namun tiada perbezaan yang signifikan antara penduduk di kawasan berisiko tinggi dan penduduk di kawasan berisiko sederhana ($p$ = 0.927).

*Kesimpulan:* Soal selidik yang dibangunkan boleh dipercayai untuk menilai pengetahuan malaria sesuai dengan konteks masyarakat tempatan di Malaysia. Penduduk di kawasan berisiko rendah menunjukkan defisit pengetahuan yang lebih ketara berbanding dengan kawasan berisiko sederhana dan tinggi. Pendidikan kesihatan komuniti yang menyeluruh termasuk di kawasan berisiko rendah perlu di teruskan memandangkan masih terdapat potensi risiko penularan malaria.
*Kata kunci:* malaria, pengetahuan, soal selidik, pengesahan, Malaysia

## ABSTRACT

## DEVELOPMENT AND VALIDATION OF MALARIA KNOWLEDGE QUESTIONNAIRE AND THE LEVEL OF MALARIA KNOWLEDGE AMONG POPULATION IN KUALA KRAI AND GUA MUSANG, KELANTAN

*Background:* Malaysia has made significant progress in reducing malaria cases, achieving zero local transmission in 2018. However, imported cases continue to pose risks of reintroduction. Assessing local knowledge is vital for targeted education as it empowers communities with the information necessary to take appropriate actions to prevent malaria transmission, thereby reducing the risk of transmission and contributing to the overall goal of malaria elimination.

Objective: This study aimed to develop and validate a questionnaire assessing local communities' malaria knowledge and compare this knowledge among residents in low, medium, and high-risk areas in Kelantan, Malaysia.

Methodology: The study was conducted from June 2023 to February 2024. It is comprised of two phases. Phase 1 focused on developing a new questionnaire and validating it. A draft of the questionnaire was established from a literature review and expert input via the Nominal Group Technique. Then, the questionnaire was validated using content validity, face validity and construct validity. Content validity was conducted among experts in public health, and face validity among local communities. Construct validity was analysed using a two-parameter item response theory, involving 300 participants. Subsequently, Phase 2 involved a cross-sectional study involving 159 participants assessing the knowledge on malaria among residents in low, medium, and high-risk areas in Kuala Krai and Gua Musang districts, Kelantan. The newly validated self-administered questionnaire from Phase 1 was utilised. The data was then subjected to descriptive analysis and two-way ANOVA analysis.

*Result*: The new questionnaire comprised of 53 items across the seven domains. The domains are transmission, risk of malaria infection, vector, symptoms, complications, treatment and management, and prevention measures. The questionnaire demonstrated good content (S-CVI/Ave = 0.99, S-CVI/UA = 0.92) and face validity (S-FVI = 1.0, S-FVI/UA = 0.99). The 2-PL IRT analysis show that the questionnaire has good model fitness and acceptable difficulties and discrimination parameters, with reliability of the domains ranges from 0.62 to 0.83. The ANOVA analysis revealed that residents in high-risk areas had the highest estimated marginal mean knowledge score of 35.0 (95% CI: 32.8, 37.2), followed by those in medium-risk areas, 34.4 (95% CI: 32.2, 36.6), with the lowest scores in low-risk areas, 29.0 (95% CI: 26.8, 37.2). The high and medium-risk area residents had significantly higher knowledge scores than low-risk residents ($p < 0.001$), however there is no significant difference between high-risk area residents and medium-risk residents ($p = 0.927$).

Conclusion: The developed questionnaire is reliable for assessing malaria knowledge in the context of the local community in Malaysia. Residents in low-risk areas exhibited a more significant knowledge deficit compared to those in medium- and high-risk areas. Comprehensive community health education, including in low-risk areas, should be continued given the potential risk of malaria transmission.
Keywords: malaria, knowledge, questionnaire, validation, Malaysia

# CHAPTER 1 INTRODUCTION

## 1.1 Background

Malaria is a vector-borne disease caused by plasmodium species named *P. falciparum*, *P. vivax*, *P. malariae*, and *P. ovale*, which are transmitted from human to human by female *Anopheles* mosquito. Apart from that, there is also simian malaria, caused by other plasmodium species such as *P. knowlesi*, *P. inui*, and *P. cynomolgi*, which require reservoir for transmission of the disease (Hartmeyer et al., 2019; Sam et al., 2022). According to WHO (2022), there were approximately 247 million malaria cases in 2021, accounting for 619 thousand deaths worldwide, and since 2016, the trend has increased each year. In Malaysia, there are 23 214 malaria cases reported from 2015 to 2021 (WHO, 2021). Kelantan, one of the states in Malaysia, recorded an average incident rate of 9 per 100,000 population from 2013 to 2017, which is the highest as compared to other states in Peninsular Malaysia (Hussin et al., 2020). In 2022, among the districts in Kelantan, Gua Musang recorded the highest number of malaria cases, followed by Kuala Krai and Jeli, regardless of the source and parasite species (Kelantan State Health Department, 2023). This is due to the suitability of the ecosystem including the presence of malaria vector and suitable environment for breeding.

Following the introduction of the National Strategic Plan for Malaria Elimination in 2011, the number of malaria cases was reducing in trend. Subsequently, Malaysia was able to achieve zero indigenous cases beginning in 2018 (Chin et al., 2020). Despite achieving zero indigenous cases, from 2018 to 2022, Malaysia recorded 1634 imported cases (WHO, 2023b). The cases were mainly from undocumented migrant workers from neighbouring endemic countries such as Myanmar, Thailand, Cambodia, Indonesia, Papua New Guinea, the Philippines, and also from Malaysians who work in endemic countries (Barber et al., 2017; Chin et al., 2020). Since there are areas in Malaysia that has suitable ecosystem and the presence of malaria vectors, the presence of imported cases in that area will make the transmission of the disease more likely to happen. Imported cases, if not detected and treated promptly, will lead to the recirculation of the malaria parasite in the mosquito, and subsequently malaria transmission to the local communities in Malaysia.

Therefore, as part of the strategies to prevent reintroduction in Malaysia, risk stratification of the areas has been done, categorizing the areas into low-risk, medium-risk, and high-risk as outlined by WHO (Mohd Ngesom, 2016; WHO & Global Malaria Programme, 2017). The risk stratification was done by taking into account the risk of receptivity and vulnerability of the area. Malaria receptivity is defined as "degree to which an ecosystem in a given area at a given time allows for the transmission of *Plasmodium* spp. from a human through a vector mosquito to another human", while vulnerability refers to "the frequency of influx of infected individuals or groups and/or infective *anopheline* mosquitoes" (WHO, 2016). Kelantan, a state in Malaysia, has been identified as one of the areas with a significant influx of people from other countries, particularly from malaria-endemic regions (Hussin et al., 2020).

Local people who reside in areas that have an influx of people from endemic countries and suitable ecosystems, such as the presence of malaria vectors near forest areas, are at risk of getting malaria. Therefore, they need to have a good knowledge of malaria in order to prevent the transmission of the disease.

## 1.2 Problem Statement

In areas where the risk is high, preventive activities such as indoor residual spray (IRS), distribution of insecticide-treated net (ITN) or long-lasting insecticidal net (LLIN), and health education should be prioritized, although no indigenous case has been reported since 2018. The local community in high-risk areas should be empowered to take preventive measures to minimize the local transmission risk from imported cases. However, current knowledge on whether communities living in high-risk areas are adequately informed to play their role in prevention is still lacking.

There are studies assessing malaria knowledge in Malaysia, however they did not compare the knowledge based on risk areas. While local questionnaires exist, they either lacked generalisability or did not undergo a proper validation process (Abdul Rahim et al., 2023; Ali et al., 2020; Munajat et al., 2021). Additionally, existing questionnaires on malaria knowledge developed outside Malaysia have limitations, as they did not address the sociocultural aspect of malaria infection (Bashar et al., 2012; Singh et al., 2014).

## 1.3 Rationale

The lack of studies assessing malaria knowledge based on risk areas is concerning because there are people who live day to day in malaria areas. Their level of knowledge of malaria can directly impact the spread of malaria in the country.

Therefore, this study aims to develop and validate a questionnaire tailored to assess malaria knowledge in the current situation in Malaysia. Using this questionnaire, we can then compare whether those in high-risk areas have superior preventative knowledge compared to medium and low-risk areas, as would be expected.

This finding will identify any gaps in knowledge among those living in malaria areas. Since Malaysia has come a long way in combating malaria through the National Strategic Plan for Malaria Elimination, the findings may also reflect the effectiveness of current health promotion strategies. The differences in knowledge scores between different types of risk areas can allow us to evaluate whether our current health promotion reaches the most vulnerable communities or not. Furthermore, it is essential that the questionnaire used is adequately validated to reduce the error and reach the correct conclusion. In addition, it is important to assess this knowledge using a well-developed and validated questionnaire to provide scientific evidence to support further action plans.

## 1.4 Research Question

1. Is the developed questionnaire valid and reliable to assess the knowledge of malaria?
2. Is the level of knowledge about malaria among residents in high-risk malaria areas higher than those in medium and low-risk areas?

## 1.5 Objectives

### 1.5.1 General objective

To study the knowledge of malaria among residents in high, medium and low-risk malaria areas in Kuala Krai and Gua Musang, Kelantan.

### 1.5.2 Specific objectives

Phase 1:

1. To develop a questionnaire assessing malaria knowledge
2. To establish the content, face and construct validity of the developed malaria knowledge questionnaire

Phase 2:

To compare the malaria knowledge score among residents in high, medium and low-risk areas in Kuala Krai and Gua Musang, Kelantan.

## 1.6 Research Hypothesis

1. The newly developed questionnaire is valid and reliable for assessing knowledge of malaria among the population in Kelantan.
2. The level of malaria knowledge among the residents in high risk areas is significantly higher than in medium risk areas, followed by low risk areas.

# CHAPTER 2 LITERATURE REVIEW

The literature search on knowledge of malaria was conducted using search engines such as Scopus, Pubmed, and Google Scholar. Various search strategies were applied, such as combining terms with the use of Boolean operators like "AND", "OR", and "NOT". The recent published literature was selected using keywords such as knowledge, malaria, questionnaire, survey, and prevention.

## 2.1 Malaria

Malaria is a disease caused by *Plasmodium* species infection that is spread by female mosquito bites belonging to the genus *Anopheles*. While there are approximately 156 *Plasmodium* species infecting different vertebrates, the majority of malaria cases among humans are caused by five primary species, namely *P. falciparum*, *P. vivax*, *P. malariae*, *P. ovale*, and *P. knowlesi*. The first four species are classified as human malaria since they use humans almost exclusively as a natural intermediate host, whereas the latter is classified as simian or zoonotic malaria since there is no evidence of direct human-to-human transmission (CDC, 2024; WHO & Global Malaria Programme, 2017).

Malaria transmission may occur where there is an interaction between host, vector, and agent, in a suitable environment. The life cycle of the malaria parasite involves two hosts, *Anopheles* mosquito and human. (Vythilingam et al., 2018). Human is the intermediate host for human malaria, in which the asexual life cycle of *Plasmodium* occurs. The asexual life cycle can be further divided into liver and blood stages. In the liver stage, sporozoites were injected into the human bloodstream following the bite of an infected *Anopheles* mosquito. These sporozoites travel to the liver, where they invade hepatocytes and transform into schizonts. This stage is clinically asymptomatic and can last for 5-16 days, depending on the *Plasmodium* species. The schizonts eventually rupture, releasing thousands of merozoites into the bloodstream (Prudêncio et al., 2006). In blood stage, merozoites invade red blood cells, starting the symptomatic phase of malaria. Within red blood cells, the parasites undergo a series of transformations: ring stage, trophozoite stage, and schizont stage. The schizonts again rupture, releasing new merozoites that infect additional red blood cells. This cyclical process is responsible for the periodic fever and chills characteristic of malaria. Some merozoites differentiate into gametocytes, starting the sexual life cycle of the parasite (Cowman et al., 2016; Schneider & Reece, 2021). When a mosquito bites an infected human, it ingests gametocytes along with the blood meal. Within the mosquito midgut, male and female gametocytes mature into gametes. Fertilization occurs, forming a zygote, which then develops into an ookinete. The ookinete traverses the midgut wall and forms an oocyst. Inside the oocyst, thousands of sporozoites are produced. Upon maturation, the oocyst ruptures, releasing sporozoites into the mosquito's salivary glands. These sporozoites are ready to be transmitted to a new human host during the mosquito's next blood meal (Schneider & Reece, 2021).

*Anopheles maculatus* has been identified as the main vector for human malaria in Peninsular Malaysia (Alias et al., 2014; Vythilingam et al., 2008). A study by Rohani et al. (2010) showed that *An. maculatus* prefer to breed in water pockets along riverbanks and waterfalls, favouring shallow pools with clear water, mud substrate, and some vegetation or floatage, within 100-400 meters of human settlements. This proximity allows adult mosquitoes to have easier access to blood meals necessary for egg development. *An. maculatus* was observed biting throughout the night, with peak indoor biting time at 2130H, and outdoor biting was higher after midnight (Hassan et al., 2001). *An. maculatu*s was found resting both outdoors and indoors, with a slight preference for outdoors (Sumruayphol et al., 2020).

The incubation period for malaria is variable, depending on the species of the *Plasmodium* parasite involved. For instance, *P. falciparum* typically has an incubation period of seven to 14 days (Valle et al., 2022). *P. vivax*, which has a mean incubation period of 13.9 days, can remain dormant in the human liver for up to four years (Lover & Coker, 2013). Knowing the incubation period helps in accurately diagnosing malaria. Symptoms that emerge within a specific timeframe after exposure can guide healthcare professionals in considering malaria as a differential diagnosis, especially in endemic areas or among travelers returning from such regions. Prompt and accurate diagnosis is essential for effective treatment and can significantly reduce morbidity and mortality associated with the disease. In addition, understanding the incubation period is essential for epidemiological investigations to determine the source and place of infection. By knowing the time frame in which symptoms appear, public health authorities can trace back to identify the possible locations and sources of exposure. This can be particularly useful in identifying and controlling localized outbreaks, as well as in tracking the spread of the disease to new areas.

The initial symptoms of malaria are usually nonspecific, mimicking viral infections. The symptoms include fever, chills, sweats, headaches, body aches, malaise, and gastrointestinal disturbances such as nausea, vomiting, and diarrhea (Bittaye et al., 2022; Mahmood et al., 2006; Reisinger et al., 2005). The classical paroxysm of malaria, which is characteristic of malaria infections, involves the cyclical occurrence of symptoms, which are rigor, fever, and profuse sweating (Mandell et al., 2009; MOH, 2014). It is often described as a sequence of events starting with sudden coldness with rigors, in which the patient shakes visibly. It is then followed by a spike in temperature, and the patient may be restless, and some may vomit or convulse. The classic paroxysms of fever can last for 4-8 hours (Andriopoulos et al., 2013). Finally, the fever is reduced, and the patient will sweat profusely. Different *Plasmodium* species exhibit distinct intervals between episodes. For instance, in *P. vivax* and *P. ovale* infections, the paroxysm occurs every two days, while in *P. malariae* infections, it occurs every three days (Samuel et al., 2018). Although the malaria paroxysm is a characteristic of the disease, not all patients may present with this classical pattern. Research has indicated that only 50-70% of patients may exhibit the typical paroxysms at regular intervals, highlighting the variability in the clinical presentation of malaria (Andriopoulos et al., 2013).

Regarding treatment, the WHO (2017) recommends the use of Artemisinin-based Combination Therapy (ACT) as the standard treatment of malaria that replaces oral monotherapy in view of resistance issues. Injectable monotherapy formulation should be used for the treatment of severe malaria only as injectable combination treatments do not yet exist for the treatment of severe malaria. In Malaysia, the drug of choice for uncomplicated malaria is the Artemether-Lumefantrine combination, while for severe malaria, intravenous Artesunate and oral doxycycline (MOH, 2014). In the case of *P. falciparum* infection, one dose of oral Primaquine is added to kill gametocytes, while in *P. vivax* infection, the same drug is prescribed for 14 days to kill dormant hypnozoites (Chotivanich et al., 2006; Khan et al., 2023).

Malaria, if not treated using the recommended regimens promptly, can lead to severe malaria with several complications and, ultimately, death. The case fatality rate for severe malaria in hospital care is 20%, and it goes up to more than 90% when the patient remains at home (Thwing et al., 2011). Cerebral malaria, which is often associated with *P. falciparum* infections, can lead to impaired consciousness, coma, seizures, and neurological deficits (Mishra & Newton, 2009). Acute kidney injury can occur in up to 40% of adult patients with severe malaria infection (Koopmans et al., 2015; Plewes et al., 2018). Other complications include anaemia, thrombocytopenia, haemolysis, liver dysfunction, and multi-organ dysfunction syndrome (Jain et al., 2014; Mangshetty et al., 2015; Mishra et al., 2007). The odds for miscarriage among the pregnant mothers were 2.7 (95% CI: 2.1, 3.4) for *P. falciparum* infection and 3.1 (95% CI: 2.4, 3.9) for *P. vivax* when compared to pregnant mothers with no malaria infection (McGready et al., 2012).

## 2.2 Burden of malaria

According to the World Health Organization (WHO, 2023b), there were an estimated 249 million malaria cases worldwide in 2022, which is a 5 million increase from 2021. This translates to an incidence of 58.4 per 1000 population at risk. The estimated death in 2022 was 426,000 globally, with a mortality rate of 14.3 per 100,000 population at risk. On the other hand, there are countries that are progressing well towards elimination (Figure 2.1). For example, China and El Salvador in Central America were certified malaria-free in 2021, while Belize in Central America was in 2023.

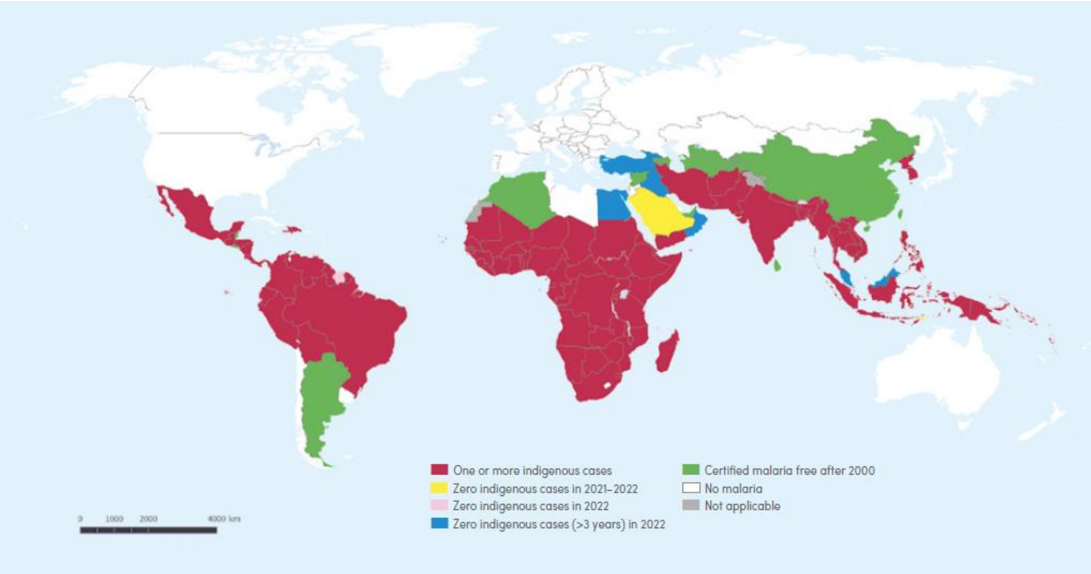


Figure 2.1: Elimination status of the countries in 2022, adapted from the WHO (2023b)

In 2022, Malaysia reported zero indigenous cases caused by human *Plasmodium* species for the fifth consecutive year. Despite that, Malaysia's neighbouring countries, such as Thailand, Indonesia, Myanmar, Papua New Guinea, and the Philippines, still recorded indigenous cases, which could threaten the elimination efforts in Malaysia.

Kelantan, a state located in the northeast of Peninsular Malaysia, recorded 186 imported malaria cases from 2014 to 2023 (Kelantan State Health Department, 2024). The district in Kelantan that has highest number of malaria cases were Gua Musang, Kuala Krai and Jeli (Kelantan State Health Department, 2023). The population at risk is the person who reside or visit the malarious areas, and those who participate in the risk activities, such as agriculture, logging, gathering forest produce and hunting (Ekawati et al., 2020; Erhart et al., 2004; Sanann et al., 2019).

## 2.3 Elimination of Malaria

In 1955, the WHO has approved the Global Malaria Eradication Program (WHO, 1973). It defines eradication as ‘‘the ending of the transmission of malaria and the elimination of the reservoir of infective cases in a campaign limited in time and carried out to such a degree of perfection that when it comes to an end, there is no resumption of transmission’’ (WHO, 1957). The program has achieved a considerable reduction in malaria cases globally, and in some regions, permanently eliminated. However, it failed to achieve global eradication, mainly due to treatment resistance, as well as economic and financial constraints (Nájera et al., 2011). After 14 years, in 1969, the WHO recognised that there were countries where eradication was not feasible in the short term. It aimed to eliminate the disease where possible and control it where it could not be eliminated while reaffirming that eradication remained the ultimate objective (WHO, 1973).

Following the Global Malaria Eradication Program, Malaysia introduced the Malaria Eradication Program in 1960. Malaria survey data has shown the reduction of reduce malaria cases from 240 000 cases in 1961 to 40 000 in 1980 (K. M. Rahman, 1982). Malaysia is able to reduce the cases further to cases less than 1 per 1000 population in 2011 and entered the elimination phase. Malaria elimination is achieved when there is an interruption of local transmission of a specified malaria parasite, which also means zero incidence of indigenous malaria in a defined geographical area as a result of deliberate activities (WHO, 2021). The deliberate activities might include vector control, environmental management, good case management, surveillance and response, community engagement and education, and strenghtening the health system.

Indigenous malaria is defined as “a case contracted locally with no evidence of importation and no direct link to transmission from an imported case” (WHO, 2021). For certification of malaria elimination, the country will require that local transmission is interrupted for all human malaria parasites. To achieve elimination status, in 2010, Malaysia has launched the National Strategic Plan for Malaria Elimination 2011-2020 (MOH, 2010). It addressed seven strategies, which are surveillance system, control of malaria vector using the concept of integrated vector management, early detection and treatment, preparedness and response to malaria outbreak, community and social mobilisation, capacity building, and malaria research.

## 2.4 Prevention and control of malaria

Achieving zero incidence of indigenous malaria is not equal to stopping the prevention and control measures of malaria. Prevention and control of malaria should continue to prevent the reintroduction of malaria, which is defined as the occurrence of introduced cases (cases of the first-generation local transmission that are epidemiologically linked to a confirmed imported case) in a country or area where the disease had previously been eliminated (WHO, 2016).

According to WHO (2023a) guidelines, prevention and control of malaria varied according to transmission settings. High transmission settings are defined as having annual parasite incidence exceeding 250 cases per 1,000 population per year, or the prevalence of *P. falciparum* or *P. vivax* infections among children aged 2-10 years is greater than 10%. In high transmission settings, the WHO recommends the large-scale deployment of Insecticide-Treated Net (ITN), especially (Long-lasting Insecticidal Net) LLIN, and Indoor Residual Spray (IRS), as primary interventions.

Due to the habitat and behaviour of the *Anopheles* mosquito, ITN or the newer version of it, LLIN, when used, can prevent most indoor exposure. These nets are designed to act as a physical barrier and kill mosquitoes that carry the malaria parasite, thereby reducing transmission rates. High coverage of ITN and LLIN has been associated with significant reductions in malaria burdens in various regions, highlighting their effectiveness in malaria control (Kamuliwo et al., 2013; Kitau et al., 2012). Conventional ITN requires periodic re-treatment to maintain its effectiveness, usually every 6 months, while LLIN is able to retain its insecticidal properties for an extended period, typically 3-5 years, without the need for re-treatment (Patipong & Yongchaitrakul, 2010).

IRS involves the application of long-acting residual insecticides on the interior walls and surfaces of houses and structures where malaria-transmitting mosquitoes may rest (WHO, 2015). The insecticides used in IRS remain effective for several months, killing mosquitoes that come into contact with the treated surfaces. Studies have demonstrated that IRS, when applied correctly, can lead to substantial reductions in malaria incidence. A meta-regression analysis of 13 studies found that IRS significantly reduces malaria prevalence, with a summary relative risk of 0.38 (95% CI: 0.31, 0.46), indicating a 62% reduction in risk (Kim et al., 2012).

Apart from ITN and IRS, WHO (2023a) also recommend supplementary vector control strategies, such as larval source management (LSM), to further enhance the effectiveness of ITNs and IRS. LSM encompasses habitat modification and manipulation, larviciding, and the introduction of biological control agents like larvivorous fish. While these supplementary interventions are conditionally recommended due to varying degrees of evidence certainty, they provide an additional layer of control in areas where traditional methods may not suffice.

Preventive chemotherapies play a pivotal role in high transmission settings, especially for vulnerable populations such as children and pregnant women. Seasonal Malaria Chemoprevention (SMC) is recommended for children aged 3-59 months, particularly in regions with highly seasonal malaria transmission (WHO, 2023a). SMC involves administering antimalarial drugs at specific intervals during the transmission season to reduce the incidence of malaria. Additionally, Intermittent Preventive Treatment in pregnancy (IPTp) and Intermittent Preventive Treatment of malaria in infants (IPTi) are recommended to protect pregnant women and infants, respectively. These interventions have shown to significantly reduce the disease burden and adverse outcomes associated with malaria during pregnancy and early childhood.

Mass Drug Administration (MDA) is another strategy employed in high transmission settings to achieve rapid reductions in malaria incidence. MDA involves the administration of therapeutic doses of antimalarial drugs to entire populations, regardless of their infection status, to reduce the overall parasite reservoir. This intervention is particularly useful in emergency situations or during outbreaks, providing short-term reductions in malaria cases. However, MDA should be integrated with other control measures, such as effective case management and vector control, to sustain its impact.

Low transmission settings are defined as annual parasite incidence is less than 250 cases per 1,000 population per year or prevalence of malaria infections among children aged 2-10 years is less than 10%. In this transmission setting, the continued use of ITNs and IRS is crucial, with strategies tailored to the local context to ensure optimal coverage and effectiveness. These interventions are complemented by enhanced surveillance systems to monitor vector populations and detect any increase in transmission promptly. Supplementary interventions become increasingly important in low transmission areas. These may include the use of repellents and insecticide-treated clothing, particularly for individuals who are at higher risk of mosquito exposure. While the evidence supporting these measures varies, they can provide additional protection in specific scenarios, such as for outdoor workers or during peak mosquito activity periods. MDA remains a viable option to reduce the parasite reservoir and interrupt transmission chains in low transmission settings. When implemented effectively, MDA can quickly lower the incidence of malaria, though its impact is often short-lived. Therefore, it should be part of a comprehensive malaria elimination strategy, integrated with case management and other preventive tools to ensure sustained control and eventual elimination of the disease.

For the countries approaching malaria elimination, such as Malaysia, the focus shifts to intensified surveillance and targeted interventions. Enhanced surveillance systems are critical for the early detection and response to malaria cases. This includes disease surveillance and entomological surveillance. Disease surveillance, including Active Case Detection (ACD) and blood examination survey, is closely related to the vulnerability of the area (Mohd Ngesom, 2016). ACD refers to the identification of malaria cases by healthcare professionals at the community and household levels, particularly among population groups who are deemed to be at a higher risk. Active case detection is the process of screening individuals for fever, and subsequently doing parasitological examinations on all individuals who exhibit fever symptoms (WHO, 2021). Some occupations and activities, especially those involving the agricultural sector and forest-related activities, were associated with an increased risk of malaria infection (Ekawati et al., 2020; Erhart et al., 2004). In Malaysia, these activities might include fishing at rivers, logging, collecting forest produce, rubber tapping, and working in estates. Therefore, these groups of people were targeted for ACD (Mohd Ngesom, 2016). The ACD will be conducted at least monthly, with priority in high-risk areas. This is supported by the dormant nature of the malaria parasite and the fact that individuals can be infected with malaria multiple times, with infections potentially involving multiple genotypes of parasites (Lover & Coker, 2013; Nkhoma et al., 2012).

Community surveillance can also be established at suitable localities such as estates and villages. This can be done by giving health education to the community and empowering them to act as health agents for that area. These disease surveillance strategies can allow for early detection of malaria infection and prompt treatment, and subsequently prevent the transmission of the disease (Kaehler et al., 2019). Entomological surveillance is also critical to monitor vector populations and their susceptibility to control measures. This encompasses the examination of both mosquito larvae and adult mosquitoes, which will be utilized to determine the specific types of mosquitoes present and the level of mosquito population in that particular region (O’Flaherty et al., 2021). Furthermore, the effectiveness of control measures aimed at eliminating mosquitoes, such as insecticide-treated bed nets (ITN) and indoor residual spraying (IRS), was assessed using wall and bednet bioassay tests. In addition, an insecticide resistance test was undertaken to assess the mosquito's susceptibility to the insecticide (Xu et al., 2021).

The targeted intervention strategies are applied to people with a higher risk of infection as compared to the general population, which can be due to their occupation and activities. The recommended strategy is targeted drug administration, while targeted testing and treatment are only recommended if people at a higher risk of infection can be easily identified and chemoprevention is not acceptable to the population (WHO, 2023a). In Malaysia, doxycycline as chemoprophylaxis is offered upon consultation at health facilities (MOH, 2014).

In some high-risk areas with the presence of a new population of foreign workers from endemic countries, a blood examination survey will be done, regardless of their symptoms (Mohd Ngesom, 2016). It is due to the fact that individuals in malaria-endemic areas can develop a state of "malaria-tolerance" rather than immunity, where they harbor parasites at subclinical levels without showing symptoms, potentially serving as a reservoir for transmission (Shanks, 2019). When foreign workers from malaria-endemic countries come to Malaysia, they can potentially spread malaria, especially if they harbor the parasites subclinically. Therefore, it is crucial to screen them by performing blood-film for malaria parasite (BFMP), a gold standard for malaria diagnosis in Malaysia (MOH, 2014a)

Apart from chemoprophylaxis and targeted testing, Malaysia did further by implementing IRS and/or distributing ITN/LLIN in high and medium-risk areas for reintroduction (MOH, 2022). In Malaysia, most of the net used has been changed to LLIN, which can be washed for a minimum of 20 times while retaining its insecticidal properties (WHO, 2013). However, significant risks occur before bedtime, when people spend time doing outdoor activities such as eating, gathering, and relaxing (Finda et al., 2019; Govella & Ferguson, 2012). Therefore, supplementary intervention using LSM, such as habitat modification, habitat manipulation, larviciding, and biological control, is recommended.

The reactive strategies are implemented in response to individual cases. Reactive strategies are implemented in and around the likely location of infection, as well as among any people co-exposed with the index case. This includes reactive drug administration, case detection and treatment, and indoor residual spray (WHO, 2023a). In Malaysia, malaria cases will be admitted to hospitals and treated according to the guidelines. Apart from LLIN, IRS, and LSM, space spraying, such as thermal fogging, can be deployed as a supplementary intervention in areas with reported human malaria cases with gametocytes (MOH, 2022).

## 2.5 Knowledge of malaria prevention and control

Knowledge forms the foundational basis of effective behaviour change, which can affect the components within the Health Belief Model (HBM) (Becker, 1974). Without adequate knowledge about malaria prevention, individuals are unlikely to adopt positive attitudes or practices, as they may not perceive the seriousness of the disease or their susceptibility to it. Comprehensive and detailed knowledge of malaria, instead of general knowledge, empowers individuals to make informed decisions about their health, enhancing their perceived severity of the disease and susceptibility to it. Knowledge of malaria as an infectious disease transmitted by mosquitoes is an example of general knowledge that has already been disseminated since the initiation of the Malaria Eradication Program in Malaysia. However, understanding the specific health risks and benefits of health practices is crucial for decision-making and sustained behaviour change (Bandura, 2004). The risk includes activities that increase exposure to mosquitoes, such as hunting and fishing in the forest, which can heighten an individual's perceived susceptibility. An example of the benefits of health practices includes using insecticide-treated nets (ITNs) to kill mosquitoes and protect the individual and family from malaria infection, reinforcing the perceived benefits of preventive actions. Detailed knowledge also can influence an individual's perceived risk and belief in the efficacy of preventive behaviours (Rimal, 2003), which aligns with the HBM's concepts of perceived severity, susceptibility, benefits, and barriers. Detailed knowledge can shape positive attitudes and increase motivation toward practicing it by reducing perceived barriers and enhancing self-efficacy, another key construct of the HBM. Lack of knowledge and, more so, misconceptions can result in negative attitudes and barriers to preventive actions, reducing individuals' confidence in their ability to perform these behaviours (Ajzen, 1991). Understanding the science behind preventive action also helps people grasp their rationale, thus enhancing motivation and engagement (Ajzen, 1991; Bandura, 2004). Therefore, it is important to focus on establishing comprehensive knowledge first, which will subsequently influence perceived severity, susceptibility, benefits, and self-efficacy, before exploring attitudes and practices (Cohen et al., 2002; Valente et al., 1998).

Exploring attitudes and practices can be studied using both quantitatively and qualitatively. However, measuring attitude and practice using quantitative study may not always be suitable since they have limits in accurately portraying the complexity of human behaviour. While quantitative research is useful for gathering numerical data, it often inadequate to completely comprehend the complex and multidimensional aspects of attitudes and practices. For instance, qualitative research allows for a deeper exploration of social phenomena, preconceived biases, and complex attitudes that quantitative research alone may not fully capture. Additionally, qualitative research enables researchers to delve into the lived experiences and subjective interpretations that underlie attitudes, providing a richer understanding of individuals' perspectives (Roberts & Castell, 2016).

The knowledge of malaria transmission varies across different populations, ranging from 53.9% to 86.2%, as evidenced by several studies. In Cameroon, 86.2% of respondents correctly identified mosquito bites as the mode of transmission for malaria (Kimbi et al., 2014). In Northern Nigeria, 55.1% of respondents were aware that mosquito bites can cause malaria (Singh et al., 2014). The same study also found that only 9.6% knew that the *Plasmodium* organism is the main cause of malaria.

However, the study by Kimbi et al. (2014) also revealed that 10.2% of respondents held misconceptions, attributing malaria transmission to factors such as drinking dirty water, consuming contaminated food, staying by the fireside, poor personal hygiene, and bites from other insects, indicating the presence of incorrect beliefs. Furthermore, a structured interview in Turkey conducted by Şimşek & Kurçer (2005) found that 67.3% of respondents were aware that malaria is caused by mosquito bites, while

14.2% believed it could be caused by drinking dirty water. Similarly, in Cabo Verde, where there has been zero indigenous malaria since 2019, 85.3% of respondents were aware that malaria is transmitted by mosquito bites (DePina et al., 2019). Only a small proportion of respondents believed that malaria could be transmitted through contaminated food (1.1%), contact with infected individuals (0.8%), and poor personal hygiene (5.0%). In Bangladesh, 77.5% of respondents in high malaria endemic zones knew that malaria could be contracted from mosquito bites, but only 11.3% were aware that the transmission involves a mosquito feeding on a malaria-infected person (Bashar et al., 2012).

In Malaysia, a study by Abdul Rahim et al. (2023) reported that the proportion of Malaysian population with correct knowledge of malaria transmission is 53.9 (95% CI: 50.2, 57.7), with 55.2 (95% CI: 50.5, 59.7) in urban area and 50.1 (95% CI: 44.3, 55.9) in rural area. However, this study classifies the area of residence into urban and rural. This classification of urban and rural areas of residence does not accurately represent the risk of malaria transmission for that area. Living in a rural area does not necessarily mean living in a high-risk area because it depends on the vulnerability and receptivity of that area. This might be the reason this study found no significant differences in knowledge between rural and urban areas. Furthermore, it is more important to understand the level of knowledge on malaria in different risk areas, especially the high-risk areas as compared to urban/rural areas.

Regarding signs and symptoms of malaria, a study by DePina et al. (2019) showed that 82.8% of respondents know fever as one of the symptoms of malaria, followed by headaches (62.1%), muscle aches (36.0%) and cold/tremble (21.1%). In Bangladesh, among the respondents in the high endemic zone, 66.2% are aware that fever with rigor is a symptom of malaria. However, only a small proportion of respondents know that intermittent fever (11.0%) and fever with sweating (4.4%) were also associated with malaria symptoms. Similarly, in Northern Nigeria, 65.2% correctly identified fever with shivering were the symptoms of malaria, followed by vomiting (20.9%) and weakness (17.1%) (Singh et al., 2014). In Cameroon, it is reported that 87.8% know at least one correct sign and symptom of malaria, including fever, headache, nausea/vomiting, body weakness, and body/joint pain (Kimbi et al., 2014). However, 8.1% of the respondents give wrong answers, including yellow urine, swollen eyes, catarrh, and cough. The same study also shows that about 40% of the respondents understand that malaria can lead to anemia and death. Only about 20% of the respondents know that malaria can lead to convulsion. In Malaysia, 24.1% (95% CI: 21.2, 27.2) of the respondents have correct knowledge of malaria symptoms, which include fever, chills, and rigor (94%). However, 60% of the respondents think that flu and rashes are the symptoms of malaria, followed by prolonged cough and constipation, 36% (Abdul Rahim et al., 2023).

Regarding mosquito behaviour, the study by Singh et al. (2014) in Northern Nigeria showed that knowledge about malaria vectors was relatively high. Mosquito breeding sites such as stagnant water were correctly identified by 64.5% of the respondents. The majority (81.0%) knew that nighttime is the biting time of the mosquito. Knowing that most respondents are aware that nighttime is the peak biting time for mosquitoes, the distribution and promotion of ITNs can be optimized. Since people already understand the risk associated with nighttime mosquito bites, reinforcing this behaviour can lead to better compliance with ITN use. Regarding the resting place, 70.0% identified the dark place inside the house as the resting place of malaria mosquitoes during the