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# Prevalence of malaria and its risk factors in Sabah, Malaysia

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ABSTRACT

*Objectives:* The aim of this study was to determine the prevalence of malaria in Sabah and its potential risk factors.
*Methods:* This cross-sectional study analysed secondary data obtained from the health clinics in Sabah, Malaysia from January to August 2016. The Pearson Chi-square test was used to analyse the relationships between malaria infection and socio-demographic characteristics. Multivariable logistic regression was performed in order to determine the risk factors for malaria in Sabah.
*Results:* Out of 1222 patients, 410 (33.6%) had a laboratory-confirmed malaria infection. Infection by *Plasmodium knowlesi* accounted for the majority of malaria reports in Sabah ($n$=340, 82.9%). Multivariable analysis indicated that males (prevalence odds ratio 0.023, 95% confidence interval 0.012-0.047) and those living in a rural area (prevalence odds ratio 0.004, 95% confidence interval 0.002-0.009) were at higher risk 24.0–95.9) and those living in a rural area (adjusted odds ratio 212.6, 95% confidence interval 105.8–427.2) were at higher risk of acquiring a malaria infection.
*Conclusions:* Malaria infections in Sabah, Malaysia are common, with *P. knowlesi* being the most common malaria parasite. The infection was associated with several socio-demographic and geographical factors. Thus, mitigation measures should be considered to address modifiable risk factors for malaria infection.


## Introduction

Malaria is a vector-borne endemic infectious disease caused by parasitic protozoa of the genus *Plasmodium*. There are several species of *Plasmodium* causing malaria in humans, including *Plasmodium malariae*, *Plasmodium vivax*, *Plasmodium falciparum*, and *Plasmodium ovale*. It is transmitted to humans through female *Anopheles* mosquitoes, which require a high temperature climate to thrive. Thus, malaria is commonly found in a warmer regions of the world that are closer to the equator, including tropical and subtropical countries. The malaria parasites, which develop in the mosquitoes, also require a warm environment to complete their growth cycle before reaching the stage at which they are ready to be transmitted to humans (Suwonkerd et al., 2013).

### *Prevalence of malaria*

Malaria is distributed worldwide, with the majority of cases reported from the African continent (88%), Southeast Asian region (10%), and Eastern Mediterranean area (2%). According to the World Health Organization (WHO), an estimated 300–500 million cases of malaria are reported each year, with approximately one million deaths, and these occur particularly in developing countries. Most of the deaths are reported among young children. However, the World Malaria Report 2015 reported that the global incidence of malaria decreased by 37% between the years 2000 and 2015 (Chan, 2015).

People who live in malaria endemic countries are at high risk of contracting the disease. Individuals who travel to endemic countries are also at high risk of contracting malaria; therefore prophylaxis is recommended in certain situations. In addition, malaria may be transmitted from an infected mother to her infant antenatally or during delivery (Agomo and Oyibo, 2013). The significant mortality and morbidity associated with infection has an impact on the economies of developing countries. Many countries with a high rate of malaria are underdeveloped nations, and the disease maintains a vicious cycle of disease, poor sanitation, and poverty (Amegah et al., 2013).

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### Distribution of malaria

A number of studies have shown that age and sex are significantly associated with malaria infection. William et al. (2014) found that malaria mainly affected people in the middle-age group. This was attributed to the higher frequency of people in this age group who migrated and travelled to malaria endemic countries, mainly for occupational purposes. In their review, the socio-demographic characteristics of malaria cases from all over Malaysia were assessed, covering the years 2007 to 2011. The data showed that about 16 011 malaria patients were infected with either *P. malariae* or *P. knowlesi*, and these patients had a median age of 31 years (William and Menon, 2014).

In addition, a study by Yadav et al. (2014) showed a significant association between those in the lower income group and malaria. In their study, it was found that the group of people with a household income below 40% of salary and living in wooden houses were at higher risk of malaria infection compared to those in the higher income group who lived in concrete houses. The structure of wooden houses could attract the malaria vector *Anopheles* sp., as this resembles their native habitat (Yadav et al., 2014). In agreement with this, many other studies have found that people in the lower income groups are more susceptible to malaria infection compared to their wealthier peers (Worrall et al., 2005; Lowassa et al., 2012). Apart from the housing factor, a household income also influences the level of education obtained. Poor knowledge and understanding of malaria disease may subsequently lead to an unfavourable attitude and practices towards malaria prevention (Forero et al., 2014). This includes knowledge and understanding of sanitation, solid waste disposal, and awareness of seeking medical advice.

It has been reported that malaria infection occurs in both urban and rural areas, with higher incidence rates recorded in the latter. Currently, active deforestation has exposed semi-urban residents to malaria infection (Nath et al., 2012). The majority of malaria cases reported from urban areas in Malaysia have involved foreigners originating from developing or less developed countries, as well as immigrants from rural regions (Jamaiah et al., 2005). On the other hand, rural communities are more susceptible to malaria, particularly those who live in the vicinity of jungles. Poor access to education within these regions has inadvertently led to bad sanitation practices and has contributed to the increasing number of malaria infections (Deressa et al., 2008). Braima et al. (2013) stated that people who lived by the jungle were at higher risk of contracting malaria, as 35% of malaria cases were recorded within this area (Braima et al., 2013).

### Malaria in Malaysia

In Malaysia, the history of malaria started in the 1960s, when about 240 000 cases of malaria were documented across the country. However, the incidence decreased tremendously to about 40 000 cases by 1980, following the implementation of effective safety measures (Rahman, 1982). In 2008, the number of cases reduced further to only about 7000 cases per year. In line with the declining trend in incidence, the mortality rate for malaria in Malaysia was also reduced, with approximately 0.09% or about 50 deaths reported per year. These statistics show that Malaysia has established effective public health programmes for malaria to improve the local malaria situation (Ministry of Health Malaysia WHO, 2015). The majority of malaria cases in 2011 were caused by *P. vivax* (45.6%), followed by *P. falciparum* (18.3%) and *P. malariae* (17%). *Plasmodium knowlesi*, a known malaria parasite that was thought to infect only animals, has now been shown to infect humans as well (Singh and Daneshvar, 2010; Vythilingam et al., 2014).

Sabah, a state located in eastern Malaysia, had a recorded housing area of 73 600 $km^2$ and a population of 3 485 300 in the year 2016 (DOSM, 2017). There were 105 health clinics and 168 rural health clinics located across the state in 2015 (DOSM, 2015). As Sabah has a lot of rural area, the number of malaria cases in this state is higher compared to the number of cases in Peninsular Malaysia. Peninsular Malaysia and Sarawak showed a decreasing trend in the number of malaria cases from 2010 to 2014, while the burden of malaria in Sabah did not follow suit; approximately 38–45% of all reported malaria cases in Malaysia per year during 2010–2014 were reported from Sabah (Jenarun, 2014). The aim of this study was to determine the prevalence and risk factors for malaria infection in Sabah in order to inform the development of mitigation measures.

## Materials and methods

A cross-sectional study was conducted involving 23 public health clinics in Sabah, Malaysia from January to August 2016. The data were retrieved from the malaria screening programme in the selected primary health clinics that were registered under the Ministry of Health. Clinics that did not participate in the malaria screening programme were excluded from this study. All patient data that fulfilled the inclusion criteria were screened from the overall raw data and included for further analysis. The inclusion criteria for this study were patients aged 18 to 65 years, with a record of clinical fever, who gave consent. Meanwhile, the exclusion criteria were physically or mentally unfit patients and incomplete patient data records extracted from the malaria screening programme.

### Study area

Sabah is the second largest state in Malaysia after Sarawak; both of these Borneo states are located in East Malaysia. Geographically, Sabah comprises a mix of mountainous regions, beaches, and tropical rainforests.

### Sample size calculation

The sample size was calculated using the formula for cross-sectional studies reported by Kish (1965) and was computed using Epi Info 7 (Kish, 1965). The sample size power was set at 80% with a two-sided confidence level at 95% and using the comparative prevalence of malaria in Eastern Rwanda (Rulisa et al., 2013). It was calculated that a minimum sample size of 384 was required. A random sampling list was generated prior to obtaining the patient records from each clinic in order to minimize bias in the study.

### Data collection and management

Data were collected from the patient information data sheets and a blood film for malaria parasites (BFMP) taken during investigations. The BFMP is a microscopic examination of a blood film used to diagnose malaria in the primary healthcare centre. Malaria parasites are distinguished by placing a drop of the patient's blood on a microscope slide, which is smeared and examined under a microscope. The specimen is stained with Giemsa stain prior to examination in order to reveal the distinctive appearance of the parasites. This was the standard method used to confirm the presence of malaria in the laboratory. However, the accuracy of this process depends on many factors, including the quality of the reagents, the microscope, and the experience of the laboratory technician (Boadu, 2014). Based on the BFMP analysis, a patient was diagnosed as 'positive' or 'negative' for malaria in the presence or absence of the malaria parasites, respectively.

### Case definition

The patient's age was defined as the age during the diagnosis of malaria, based on the date of birth stated on a valid identification card. Patients born in the years up to and including 1999 were selected for this study. In this study, the classification of age was defined according to the WHO Standard Population Distribution; age was within the range of 15 years to 69 years. For inferential analysis, age was classified into two categories: ≤35 years and >35 years. Sex was as stated on the identification card, either male or female. Ethnic group was as declared on the identification card. Ethnicity was grouped into Kadazan-Dusun, Bajau, Murut, foreigner, and others. Nationality was as stated on the identification card and was classified as either 'Malaysian' or 'non-Malaysian'. Geographical area was defined as the current house address of the respondent during the survey. The geographical area of the respondent was grouped into two categories including urban and rural (DOSM, 2015). Occupation was defined as the current employment status of the respondent during the screening. This was classified into five categories: self-employed, labourers, government and private worker, famer and forestry worker, and unemployed. Only locally acquired malaria infections were analysed, because some of the risk factors for infection assessed reflect the local conditions and may not extend to non-local infections.

### Statistical analysis

For the data analysis, descriptive statistics and analytical tests were performed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA). The level of statistical significance was set at a $p$-value of $< 0.05$ with 95% confidence intervals (CI). Continuous variables were summarized using the mean and standard deviation (SD) and the majority of categorical data were presented as the number ($n$) and percentage (%). The Pearson Chi-square test was performed to determine the association between socio-demographic and geographical factors associated with malaria infection. In addition, simple logistic regression analysis followed by multivariable logistic regression was performed to determine the risk factors for malaria in Sabah.

## Results

### Study population

The socio-demographic characteristics of the participants are shown in Table 1. The descriptive analysis showed that among the 1222 participants, 473 (38.7%) were men and 749 (61.3%) were women. Their mean age was 36.8 years (SD 12.3 years). The majority of the participants were Malaysian ($n = 985$, 80.6%), with Kadazan-Dusun ($n = 754$, 61.5%) being the largest ethnic group. More than half of the patients were from urban areas ($n = 793$, 64.9%). Regarding occupation, the majority of the participants in this study were self-employed ($n = 500$, 40.9%).

The prevalence of malaria infection is presented in Table 1. During the time course of the study, 410 cases of malaria infection, corresponding to a prevalence of 33.6%, were reported in Sabah. Table 1 also presents the different types of malaria infection in this study. The majority of malaria cases in Sabah were caused by *P. knowlesi* infections ($n = 340$, 82.9%). The other cases of malaria were caused by infections with *P. falciparum*, *P. vivax*, *P. malariae*, and *Plasmodium*-mixed, which contributed fewer than 50 cases. Imported malaria infections were excluded from the analysis.

### Bivariate analysis

The bivariate analysis showed significant associations ($p < 0.05$) between malaria infection and socio-demographic factors including sex, occupation, and geographical area (Table 2). The analysis showed a higher proportion of infection among males (75.3%) than among females (7.2%). Furthermore, with regard to occupation, a higher proportion of employed people (35.4%) than unemployed people (24.4%) had malaria. A higher proportion of people in rural areas (88.6%) had malaria infections than those in urban areas (3.8%). However, no significant association was found between malaria infection and age, ethnicity, or nationality.

**Table 1**
Prevalence of malaria infection and socio-demographic factors ($N = 1222$).

| Characteristic | *N* | % |
|---|---|---|
| Malaria infection | | |
| Yes | 410 | 33.6 |
| No | 812 | 66.4 |
| Types of malaria infection (n = 428) | | |
| P. Falciparum | 23 | 5.6 |
| P. Vivax | 3 | 0.7 |
| P. Malariae | 41 | 10.1 |
| P. Knowlesi | 340 | 82.9 |
| P. Mixed | 3 | 0.7 |
| Age (years) | Mean 36.8 ± SD 12.3 | |
| Gender | | |
| Male | 473 | 38.7 |
| Female | 749 | 61.3 |
| Ethnicity | | |
| Kadazan-Dusun | 752 | 61.5 |
| Bajau | 24 | 2.0 |
| Murut | 108 | 8.8 |
| Foreigner | 170 | 13.9 |
| Others | 168 | 13.7 |
| Nationality | | |
| Malaysian | 985 | 80.6 |
| Non-Malaysian | 237 | 19.4 |
| Occupation | | |
| Self-employed | 500 | 40.9 |
| Labourers | 39 | 3.2 |
| Government and private worker | 192 | 15.7 |
| Farmer and forestry worker | 309 | 25.3 |
| Unemployed | 182 | 14.9 |
| Geographical area | | |
| Urban | 793 | 64.9 |
| Rural | 429 | 35.1 |

SD, standard deviation.

**Table 2**
Bivariate analysis ($N = 1222$)

| Characteristic | *Malaria infection* | | *Chi-square* | *p-Value* |
|---|---|---|---|---|
| | *Yes* (%) | *No* (%) | ($x^2$) | |
| Age (years) | | | | |
| ≤35 years old | 204 (32.1) | 431 (67.9) | 1.205 | 0.27 |
| >35 years old | 206 (35.1) | 381 (64.9) | | |
| Sex | | | | |
| Male | 356 (75.3) | 117 (24.7) | 602.268 | <0.05 |
| Female | 54 (7.2) | 695 (92.8) | | |
| Ethnicity | | | | |
| Sabahan | 313 (32.4) | 653 (67.6) | 2.735 | 0.09 |
| Non-Sabahan | 97 (37.9) | 159 (62.1) | | |
| Nationality | | | | |
| Malaysian | 340 (34.5) | 645 (65.0) | 2.127 | 0.15 |
| Non-Malaysian | 70 (29.5) | 167 (70.5) | | |
| Occupation | | | | |
| Employed | 360 (35.4) | 657 (64.6) | 9.273 | <0.05 |
| Unemployed | 50 (24.4) | 155 (75.6) | | |
| Geographical area | | | | |
| Urban | 30 (3.8) | 763 (96.2) | | |
| Rural | 380 (88.6) | 49 (11.4) | 897.847 | <0.05 |

**Table 3**
Final model for factors associated with malaria infection using multiple logistic regression

| Variables | Simple logistic regression | | Multiple logistic regression | |
|---|---|---|---|---|
| | Crude OR (95% CI) | $p$ | Prevalence OR (95% CI) | $p$ |
| Age >35 years old | 0.9 (0.7–1.1) | 0.27 | | |
| Being male | 0.02 (0.01–0.03) | <0.05 | 0.023 (0.012–0.047) | <0.05 |
| Being person in rural area | 0.005 (0.003–0.008) | <0.05 | 0.004 (0.002–0.009) | <0.05 |
| Being foreigner | 0.8 (0.6–1.1) | 0.15 | 0.5 (0.3–1.0) | 0.06 |
| Being Sabah | 1.3 (0.9–1.7) | 0.09 | | |

**Adjusted $r^2$ = 0.864**.
Backward logistic regression method applied.
Only variables that were included in the final model are presented in the table.
Multicollinearity and interaction term were checked and not found.
Hosmer–Lemeshow test ($p$ = 0.302) and classification table (overall correctly classified percentage = 93.6%), thus the fit of this model is achieved.
The highlighted are the significant variables respectively.

### *Multivariate analysis*

The multivariable logistic regression analysis indicated that being male (prevalence odds ratio (POR) 0.023, 95% CI 0.012–0.047) and living in a rural area (POR 0.004, 95% CI 0.002–0.009) were the two significant risk factors associated with having malaria infection (Table 3). The fit of this model was tested with the Hosmer–Lemeshow test ($p$ = 0.302) and the overall correctly classified percentage was 93.6% (>70%).

## Discussion

### *Prevalence of malaria*

This study reported the prevalence of malaria in Sabah since the launch of the National Malaria Elimination Strategic Plan in the year 2010. The measures outlined in this plan aimed to eliminate locally transmitted malaria in Sabah by 2020. Approximately a third of the community had a malaria infection. This finding is similar to that reported in a previous study, in which the prevalence of malaria infection in Sabah was 45% in 2014 (William and Menon, 2014). The yearly report of 'Laporan Tahunan RKPBV Sabah 2014' listed Sabah as a high contributor to malaria cases in Malaysia, although the incidence showed a declining trend overall (Jenarun, 2014). It is also noticeable that the percentage of human malaria has decreased markedly with the implementation of the strategic plan. However, such a scenario was not observed for infections with *P. knowlesi*, also called simian malaria (Cotter et al., 2013).

The prevalence of malaria in Sabah was mainly contributed by the malaria parasite *P. knowlesi*, which was found in two thirds of all recorded cases. Meanwhile, other types of *Plasmodium* sp contributed to less than 10% of the cases respectively. This finding is similar to that reported in the study by Yusof et al. (2014), which showed the highest proportion of malaria cases being caused by *P. knowlesi* (56.5%). Overall, many studies have reported an increase in detection of *P. knowlesi* in north-east Sabah (William et al., 2014; Goh et al., 2013; Barber et al., 2012). This shows that the previously implemented control and prevention measures have worked effectively on malaria infections caused by parasites other than *P. knowlesi* (William et al., 2013).

In the context of the source of infection, the current results are in contrast to those of previous studies, as the latter have reported that a higher number of cases were observed among the imported malaria infection (Behrens et al., 2010; Dev et al., 2003). Meanwhile, in the current study, a higher number of cases were reported to be locally transmitted, as the reservoir hosts of *P. knowlesi*, including the long-tailed macaque *Macaca fascicularis* and the pig-tailed macaque *Macaca nemestrina*, are found along the Crocker Range of Sabah (Akter et al., 2015; Don and Wilson, 2005; Riley, 2012). The intense activity of deforestation has forced these animals to come into direct contact with humans and this has subsequently increased the chance of spreading zoonotic infections among humans (Nath et al., 2012).

From the geographical aspect, this study showed that two thirds of the reported malaria cases were from urban areas. This was expected, as most of the clinics were situated in urban areas, and was attributed to better health-seeking behaviour among the urban population (Chaturvedi et al., 2009; Dev et al., 2006; Wakgari et al., 2008). A study conducted in south-west Ethiopia showed similar higher records of malaria cases in urban areas (Alemu et al., 2011).

### *Factors associated with malaria*

This study showed significant associations between malaria infection and certain socio-demographic characteristics, including sex and occupation. The majority of males were more susceptible to malaria infection, as a result of their role as breadwinners and their types of occupation. They mainly belonged to the agricultural groups, including farmers, forestry site workers, and loggers, who have a higher risk of exposure to the *Anopheles* sp mosquitoes (Yusof et al., 2014; Das et al., 2007).

With regard to occupation, the majority of employed persons were mainly infected with malaria. This was a consequence of the greater exposure to the disrupted mosquito habitat following deforestation, as most of them were workers from semi-urban areas (Nath et al., 2012). This study found no significant association between certain age groups and malaria infection. However, some studies have reported that malaria infection is significantly associated with the middle-aged group (William and Menon, 2014; Jamaiah et al., 2005) or older age group (Worrall et al., 2005; Ayele et al., 2012; Grigg et al., 2014).

This study has certain strengths and limitations. The objectives of this study were accomplished within a short period of time and at a relatively low cost due to the design of the study (cross-sectional). However, the utilization of secondary data led to a limitation in gaining access to some variables. It was not possible to obtain some variables including house structure, socio-economic factors, environmental factors, and knowledge, attitude and practices on malaria. In addition, the study design only enabled the measurement of prevalence, but was not able to prove any causal relationship. Due to constraints in resources, this study used data only from patients with fever who had sought medical treatment in health clinics in which there were laboratories and technicians to perform BFMP. Thus, the findings of this study may not be a robust representation of the general scenario of malaria infection.

Many aspects need to be revised and improved in order to curb the endemicity of malaria in Sabah. Further studies should be conducted to identify the causes of the increasing malaria cases and should also focus on *P. knowlesi*, the biggest contributor. The occupational health division and employers should equip forestry workers with appropriate safety measures such as gloves, repellent, and protective suits. They should also be responsible for reinforcing education on good sanitation practises among the workers in their workplace. Strengthening the collaboration between the ministry of health and other sectors such as veterinary departments, zoology departments, forestry departments, universities, and private research centres would be invaluable towards reducing the incidence of malaria.

*Conclusions*

In summary, this study demonstrated a high prevalence of malaria in Sabah. Being male and living in a rural locality were factors found to be independently associated with an increased risk of local infection. Interventions to address the high prevalence of locally acquired infections should thus target these higher risk groups in order to reduce the high prevalence of simian malaria in Sabah, Malaysia.

## Ethical approval

This study was approved by the National Medical Research Registration (ID NMRR-17-1503-34800).

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None to be declared.

## Conflict of interest

None to be declared.

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