Nurse Media JOURNAL OF NURSING

Nurse Media Journal of Nursing
e-ISSN: 2406-8799, p-ISSN: 2087-7811
https://medianers.undip.ac.id
14(2):279-293, August 2024
https://doi.org/10.14710/nmjn.v14i2.56285

ORIGINAL RESEARCH

Malaria Prevention Strategies in Kalimantan, Indonesia: A Secondary Analysis of 2018 Basic Health Research Data

Muhammad Rasyid Ridha[1,2], Dicky Andiarsa[1], Ihya Hazairin Noor[3], Erni Wiliyani[3], Tri Ramadhani[2], Ririh Yudhastuti[1]

[1]*Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia*
[2]*Research Center for Public Health and Nutrition, Research Organization for Health, National Research and Innovation Agency, Indonesia*
[3]*Public Health Study Program, Medical Faculty, Universitas Lambung Mangkurat, Banjarmasin, Indonesia*

Article Info

Article History:
Received: 10 July 2023
Revised: 25 August 2024
Accepted: 26 August 2024
Online: 31 August 2024

Keywords:
Household; individual; Kalimantan malaria; prevention

Corresponding Author:
Muhammad Rasyid Ridha
Faculty of Public Health, Universitas Airlangga, Surabaya, Indonesia
Email:
m.rasyid.ridha-2023@fkm.unair.ac.id

Abstract

Background: Kalimantan remains malaria-endemic, particularly in rural areas, where prevention efforts face challenges such as insecticide resistance and limited healthcare access. Despite available measures like insecticide-treated nets, gaps in understanding individual and household prevention practices persist, especially in relation to demographics and effectiveness in reducing malaria transmission.
Purpose: This study aimed to examine the individual and household-level malaria prevention strategies utilized in rural Kalimantan and evaluate their effectiveness in reducing malaria incidence.
Methods: The study was a secondary analysis of the 2018 Indonesian basic health research (Riskesdas). A total of 67,155 respondents in Kalimantan were analyzed including respondent characteristics, memories of malaria infection, and individual and household malaria prevention efforts. The data were collected through the result of the 2018 Riskesdas survey. Bivariate regression and multivariable logistic regression were used in data analysis.
Results: Self-reported malaria rates were higher among older respondents compared to younger ones. Women reported lower malaria rates than men, especially in South Kalimantan. In West Kalimantan, the use of bed nets was associated with higher self-reported malaria rates (OR=1.838, 95%CI 1.147–2.943). Short-term use of insecticide-treated nets (ITNs) showed varying odds across provinces: Central Kalimantan (OR=3.659, 95%CI 1.378–9.717), South Kalimantan (OR=10.811, 95%CI 3.649–32.030), East Kalimantan (OR=2.615, 95%CI 1.041–6.567), and West Kalimantan (OR=2.428, 95%CI 1.446–4.078). In all provinces, preventive measures such as coils or electric mats reduced self-reported malaria cases. The use of mosquito screens was effective in South Kalimantan (OR=0.208, 95%CI 0.027–1.598), Central Kalimantan (OR=0.365, 95%CI 0.120–2.181), and North Kalimantan (OR=0.000, 95%CI 0.000–0.000). The multivariate model highlighted mosquito nets as the most effective household-scale prevention in nearly all Kalimantan provinces except North Kalimantan.
Conclusion: This study showed that individuals aged 25 and over, women, non-farmers, and those using ITNs and other preventive measures, especially in rural areas, were less likely to report malaria, emphasizing the need for targeted interventions from local health authorities.

How to cite: Ridha, M. R., Andiarsa, D., Noor, I. H., Wiliyani, E., Ramadhani, T. & Yudhastuti, R. (2024). Malaria prevention strategies in Kalimantan, Indonesia: A secondary analysis of 2018 basic health research data. *Nurse Media Journal of Nursing, 14*(2), 279-293. https://doi.org/10.14710/nmjn.v14i2.56285

1. Introduction

Malaria remains a major global health threat, causing an estimated 608,000 deaths in 2022, with Southeast Asia receiving only six percent of the total global investment in malaria prevention (Centers for Disease Control and Prevention, 2024). The WHO has set a goal of eliminating malaria by 2030, yet Indonesia, which ranks second in Southeast Asia for malaria cases, continues to face significant challenges in reaching this target (World Health Organization, 2024). Although the number of malaria cases in Indonesia decreased between 2021 and 2022, the trend has remained stable (Lobo et al., 2024). In 2022, Indonesia reported 443,530 malaria cases, with 89% of positive cases coming from Papua Province. In 2024, as of April 25, there were 418,546 malaria cases in Indonesia, of which 120 died. Kalimantan, which has been designated as the new capital of Indonesia, remains particularly vulnerable, with only 42% of its regencies having achieved malaria elimination by 2020 (Sugiarto et al., 2022).

Despite various government efforts, such as distributing insecticide-treated bed nets (ITNs), implementing artemisinin combination therapy (ACT), and utilizing insecticide residual spraying (IRS), malaria remains a persistent problem, particularly in rural and economically disadvantaged areas (Ministry of Health Republic of Indonesia, 2020). These regions face unique challenges, including limited access to healthcare, early diagnosis, and proper housing, which contribute to the continued transmission of malaria (Guntur et al., 2022). This presents a significant barrier to Indonesia's broader malaria elimination goals and sustainable development, especially as Kalimantan prepares to take on the role of the nation's capital.

Malaria prevention efforts in Indonesia are shaped by both individual and contextual factors, which vary between urban and rural areas (Mpimbaza et al., 2017; Ramdzan et al., 2020). Malaria control efforts differ between communities in rural and urban areas, which may be due to socioeconomic and development disparities (Molina Gómez et al., 2017). People in underdeveloped or rural areas may have limited access to better housing, as well as adequate and early diagnosis and treatment, thus contributing to increased malaria transmission (Tusting et al., 2017). Research indicates that implementing malaria treatment and prevention programs in rural communities has been hampered by financial constraints. Malaria transmission in the population varies depending on a variety of factors, including environment and socioeconomic status. Plasmodium, a parasite, Anopheles mosquito, and human host are all constituents of the ecosystem. Gender, age, occupation, and behavior are socioeconomically significant popularity factors (Tadesse et al., 2018). The success of efforts to prevent malaria can also be impacted by contextual factors, personal and family prevention, and other factors (Rassi et al., 2016). At the family level, malaria threat elements are decided through various populations, family conditions, family monetary conditions (income), possession of insecticide-dealt with mosquito nets (ITNs), and cap potential to get admission to health facility (Hsiung et al., 2018). Preventive measures at the individual level, such as the use of electric mosquito rackets, coils, and repellents, are commonly employed (Koduri & Kusneniwar, 2018; Lwin et al., 2014). However, there is a lack of detailed evidence on how these prevention practices are specifically adopted by rural communities in Kalimantan. Therefore, the purpose of the study was to examine the individual and household-level malaria prevention practices employed by rural areas in Kalimantan, Indonesia, and to assess their relationship with the incidence of malaria infection among the adult population.

2. Methods

2.1. Research design

The study conducted a secondary data analysis of the 2018 Indonesian Basic Health Research (Riskesdas 2018). Riskesdas 2018 was a five-year, across-program community-based survey with a nationwide representative sample. Since the data was readily available, complete, and based on a large sample, it could serve as a reliable basis for broader policy-making decisions. This study attempted to evaluate critical public health indicators for policymakers at the national, provincial, and district levels.

2.2. Setting and samples

The study was limited to five provinces in Kalimantan: South, Central, East, West, and North Kalimantan. The area of the island of Kalimantan is about 743,330 km^2, with a total number population of 17.5 million people (Central Bureau of Statistics of Indonesia, 2020). The Riskesdas 2018 sampling framework targeted 300,000 households from 30,000 census blocks of Susenas (national socio-economic survey) 2018, implemented by the Central Bureau of Statistics using probability proportional to size (PPS) with linear systematic sampling. It applied a two-stage sampling approach. First, implicit stratification was conducted on 720,000 census blocks from the 2010 population census, selecting 180,000 blocks (25%) as the sampling frame, from which 30,000 census blocks were systematically chosen across urban and rural strata for each district/city. In the second stage, 10 households per selected block were systematically sampled, stratified implicitly by the highest educational level of household heads to ensure diverse representation (Ministry of Health Republic of Indonesia, 2019).

The analysis was limited to people more than 15 years old for this study (n=67,155) in five provinces of Kalimantan island as the new capital island of Indonesia, namely the Province of South Kalimantan (n=16,701), Central Kalimantan (n=14,851), East Kalimantan (n=11,593), West Kalimantan (n=19,173), and North Kalimantan (n=4,837). In Riskesdas, ethically, interviewed respondents should be 15 years of age or older as they were generally considered to have a better level of understanding to provide valid and reliable information.

Data subsets were evaluated, including respondents' characteristics (age, gender, education, and occupation). The participants referred to individuals who, within the last 12 months before the survey, had been diagnosed with laboratory-confirmed malaria by a local health service provider or physician. It also included practices such as sleeping under untreated mosquito nets, sleeping under insecticide-treated mosquito nets for three years or more, using repellents or materials to prevent mosquito bites, using electric mosquito-repellent devices (e.g., electric mosquito rackets), using mosquito repellents (burning, electric, or spray) in the household, and installing mosquito nets on ventilation openings.

2.3. Measurement and data collection

The Riskesdas was carried out in 2007, 2013, and finally, 2018. The questionnaire had been used in the previous Riskesdas surveys (2007 and 2013). The questionnaire indicators were developed by the program holders of the Ministry of Health of the Republic of Indonesia, the National Development Planning Agency (Bappenas), and the Central Bureau of Statistics of Indonesia (BPS). The indicators were translated into questions that were developed into the questionnaire by health experts (professional organizations, universities, and senior researchers from the Agency for Research and Development) and with input from international organizations (WHO, UNICEF, and World Bank). The questionnaire had also been tested for validity and reliability. However, the validity and reliability of test results were not clearly stated (Ministry of Health Republic of Indonesia, 2018). The complete questionnaire can be downloaded at https://repository.badankebijakan.kemkes.go.id/id/eprint/4616/1/236-kues_ind_rkd18-8.pdf.

The questionnaire consists of 309 questions on access to health facilities, environmental health, communicable diseases, non-communicable diseases, oral health, mental health, disability, and injury. However, this study only focused on eight dichotomous questions related to preventive malaria, scoring 0 for no and 1 for yes. Secondary data for this research were obtained from the 2018 Riskesdas survey, a publicly accessible dataset available through the Indonesian Ministry of Health (data service access page: https://layanandata.kemkes.go.id/). A formal request was submitted to the ministry to collect the data, detailing the research objectives and intended use of the data. Upon approval, the dataset was downloaded in its raw form. Relevant variables, including malaria infection history and individual and household prevention efforts, were extracted for analysis.

2.4. Data analysis

Some statistical analyses were used in this study. Descriptive analysis described the general characteristics (amount, frequency, and proportion) of explanatory variables. A bivariate regression analysis was conducted to look at the relationship between malaria and the explanatory variables. The multivariable logistic regression model included variables with a p-value of <0.2 from the bivariate model. Before assigning variables to the final mode, the variance inflation factor (VIF) was employed to check for multi-collinearity among explanatory variables. After accounting for potential discoverers, a multivariable logistic regression analysis was performed to identify malaria-related covariates. The final model assumed a 5% level of statistical significance. The odds ratio (OR) and the 95% confidence interval (CI) were displayed. The Riskesdas 2018 data sampling structure was complex, necessitating extensive data analysis. All statistical analyses were conducted using SPSS 21 (Chicago, IL, USA). Malaria prevalence map was created in QGIS ver. 3.22 (Meyer & Riechert, 2019). The administrative boundary polygon shapefile was obtained from the Central Bureau of Statistics of Indonesia (Statistical Service Information System) (http://www.silastik.bps.go.id).

2.5. Ethical considerations

The Riskesdas 2018 protocol was evaluated and authorized by the National Ethics Commission for Health Research, Institute for Health Research and Development (NIHRD), Ministry of Health of the Republic of Indonesia (Number: LB.02.01/2/KE.024/2018) on January 24, 2018. Ethical considerations in this study were addressed by ensuring confidentiality and compliance with any data use restriction, as the original data was collected for a national health survey.

3. Results

3.1. Characteristics of respondents

Table 1 shows the socio-demographic characteristics of the subjects. The majority of respondents in the survey were adults over 25 years old (81.33%) in all provinces, with gender representation in the sample appearing to be balanced. A substantial number of respondents in East Kalimantan (54%), North Kalimantan (48.7%), and Central Kalimantan (47.2%) had completed secondary school. In West Kalimantan, however, the majority of respondents had no education (27.2%) or had not completed primary education (26.3%). Agriculture and non-agriculture jobs were approximately evenly distributed across all provinces.

Table 1. General characteristics of the respondents (n=67,155)

Characteristics	West Kalimantan (n=19,173)		Central Kalimantan (n=14,851)		South Kalimantan (n=16,701)		East Kalimantan (n=11,593)		North Kalimantan (n=4,837)		All Kalimantan (n=67,155)	
	f	%	f	%	f	%	f	%	f	%	f	%
Age (years)												
15 – 24	3514	18.3	2677	18	3116	18.7	2190	18.9	1041	21.5	12538	18.67
25 and above	15659	81.7	12174	83	13585	81.3	9403	81.1	3796	78.5	54617	81.33
Gender												
Male	9344	48.7	7200	48.5	7969	47.7	5627	48.5	2353	48.6	32493	48.39
Female	9829	51.3	7651	51.5	8732	52.3	5966	51.5	2484	51.4	34662	51.61
Education												
No education	5210	27.2	2163	14.6	3277	19.6	1793	15.5	936	19.4	13379	19.92
Primary	5051	26.3	4493	30.3	4583	27.4	2272	19.6	959	19.8	17358	25.85
Secondary	7722	40.3	7005	47.2	7345	44	6260	54	2358	48.7	30690	45.7
Tertiary	1190	6.2	1190	8	1496	9	1268	10.9	584	12.1	5728	8.53
Occupation												
Not working	5862	30.6	4834	32.5	5718	34.2	4517	39	1848	38.2	22779	33.92
Farmer	6802	35.5	3442	23.2	3696	22.1	1272	11	596	12.3	15808	23.54
Non-farmer	6509	33.9	6575	44.3	7287	43.6	5804	50	2393	49.5	28568	42.54
Individual preventive measures												
Used mosquito bed nets	8055	42	9507	64	9550	57.2	2634	22.7	1072	22.2	30818	38.65
Used ITNs ≤ 3 years	1197	6.2	645	4.3	392	2.3	498	4.3	102	2.1	2834	3.55
Used ITNs > 3 years	2924	15.3	555	3.7	417	2.5	378	3.3	225	4.7	4499	5.64
Used repellent	9124	47.6	6784	45.7	8682	52	7101	61.3	2439	50.4	34130	42.8
Used electric rackets	1999	10.4	1207	8.1	1870	11.2	1623	14	762	15.8	7461	9.36
Household-level preventive measures												
Used coil/electric mats	14727	76.8	12664	85.3	14545	87.1	9416	81.2	3541	73.2	54893	82.52
Installed window screen	2190	11.4	1958	13.2	3108	18.6	3632	31.3	739	15.3	11627	17.48
Self-reported Malaria	83	43	38	19	25	13	37	19	11	56	194	100

For individual preventive measures, as many as 38.65% of the total respondents said they slept using a bed net. However, 5.64% of all respondents said they had been using insecticide-treated nets (ITNs) for less than three years. West Kalimantan had the highest number of respondents who had used ITNs for under three years out of the five provinces (6.2%). In all provinces, less than 20% of respondents had been using ITNs for over five years. Around half of all responders reported using insect repellent, though only 45.7% in Central Kalimantan did so. Additionally, just 9.36% of participants mentioned using electric mosquito rackets. In addition to household-level preventive measures, approximately 73.2% of respondents in North Kalimantan, yet 87.1% in South Kalimantan used coils or electric mosquito mats in their houses. Mosquito window screens were mostly reported by respondents in East Kalimantan (31.3%) and South Kalimantan (18.6%).

3.2. The prevalence of self-reported malaria by districts

Figure 1a depicts the prevalence of self-reported malaria by provinces. Self-reported malaria data by province was the highest in West Kalimantan (43%) and the lowest in North Kalimantan (6%). The geographical distribution of self-reported malaria prevalence in five provinces can be seen from Figure 1b. Malinau (27.3%) had the greatest prevalence of self-reported malaria, followed by Nunukan (27.3%) and Tarakan (27.3%) in Northern Kalimantan; Paser (27%) and Kutai (27%) in Eastern Kalimantan; Bengkayang (25.4%) in Western Kalimantan; Tanah Bumbu (24%) in Southern Kalimantan; and Gunung Mas (21.2%) in Central Kalimantan.

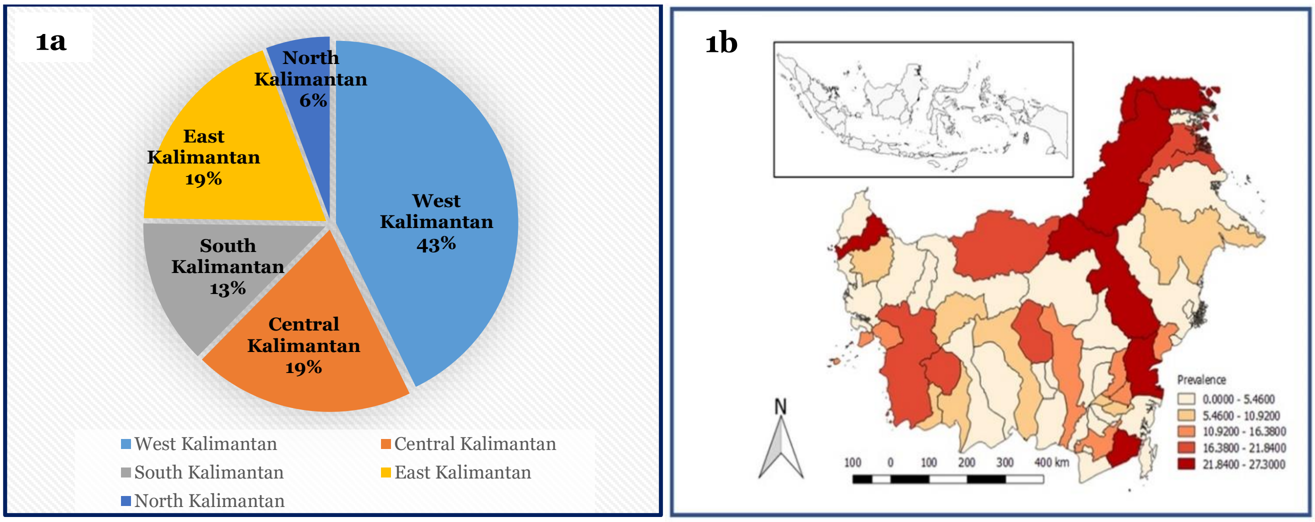

Figure 1. The prevalence of self-reported malaria by district and geographical distribution

3.3. The relationship between self-reported malaria and respondent's characteristics

Table 2 highlights factors related to self-reported malaria across Kalimantan's five provinces, examining demographic characteristics (age, gender, education, and occupation) and preventive measures. Self-reported malaria rates were higher among older individuals. Women generally reported fewer malaria cases than men, especially in South Kalimantan, where the gender difference was statistically significant. Occupational trends showed that farmers had higher self-reported malaria rates than non-farmers, although these differences were not significant.

In terms of preventive measures, the use of bed nets in West Kalimantan was associated with higher odds of self-reported malaria (OR=1.838, 95%CI 1.147-2.943). Self-reported malaria was related to short-term use of insecticide-treated nets (ITNs) in Central (OR=3.659, 95% CI 1.378-9.717), South (OR=10.811, 95% CI 3.649-32.030), and East Kalimantan (OR=2.615, 95% CI 1.041-6.567). Household measures like mosquito coils and window screens were linked to low self-reported malaria, with variation in effectiveness across regions. These findings underscored the importance of tailored malaria prevention strategies that consider regional and demographic differences in Kalimantan.

3.4. The most effective measures in preventing malaria

Findings from the multivariate model (Table 3, see Appendix) show that the most effective malaria prevention practice in almost all Kalimantan provinces was mosquito nets, either without or with ITNs. In West Kalimantan, the two malaria prevention practices were related (aOR=1.824, 95%CI 1.166-2.852 and aOR=2.375, 95%CI 1.166-2.852) with malaria prevention. In Central Kalimantan, only the use of ITN less than 3 years contributed (aOR=3.355, 95%CI 1.306-8.623), as well as in South Kalimantan (aOR=11.034, 95%CI 4.104-29.664) and in East Kalimantan (aOR=2.859, 95%CI 1.165-7.013). Unique findings were found in North Kalimantan, where multivariate analysis had not shown any effective malaria prevention (p>0.05).

In addition, the study also highlighted the use of electric mosquito rackets and mosquito repellents. The use of mosquito repellents reduced the likelihood of self-reported malaria in East Kalimantan (aOR = 0.509, 95% CI 0.261–0.995). Meanwhile, the use of electric mosquito rackets was associated with a reduced likelihood of malaria reports in South Kalimantan (aOR = 2.251, 95% CI 0.752–6.735) and North Kalimantan (aOR = 0.804, 95% CI 0.271–2.386), though the results varied across provinces and were not always statistically significant.

Table 2. The associating factors of self-reported malaria (n=67,155)

Characteristics	Self-Reported Malaria									
	West Kalimantan		Central Kalimantan		South Kalimantan		East Kalimantan		North Kalimantan	
	p	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)	*p*	OR (95%CI)
Age	0.236	0.703 (0.392-1.259)	0.367	0.673 (0.285-1.589)	0.137	0.458 (0.163-1.281)	0.133	0.490 (0.193-1.242)	0.231	3.061 (0.491-19.076)
Gender	0.166	0.720 (0.452-1.146)	0.703	0.874 (0.437-1.749)	0.002*	0.132 (0.038-0.463)	0.433	0.749 (0.363-1.543)	NA	0.000 (0.000-0)
Education	0.322	0.470 (0.106-2.094)	0.621	0.663 (0,130-3.377)	0.920	0.890 (0.090-8.783)	0.312	0.331 (0.039-2.822)	0.992	0.000 (0.000-0)
Occupation	0.284	0.703 (0.369-1.339)	0.989	1.006 (0.406-2.491)	0.744	1.218 (0.373-3.978)	0.736	1.180 (0.450-3.092)	0.070	0.232 (0.048-1.128)
Individual Preventive Measures										
Bed nets	0.011*	1.838 (1.147-2.943)	0.557	1.250 (0.593-2.635)	0.240	1.698 (0.701-4.113)	0.950	0.976 (0.464-2.055)	0.996	1.006 (0.237-2.276)
ITNs ≤ 3 years	0.433	1.403 (0.602-3.270)	0.009*	3.659 (1.378-9.717)	0.000*	10.811 (3.649-32.030)	0.041*	2.615 (1.041-6.567)	0.996	0.000 (0.000-0)
ITNs > 3 years	0.001*	2.428 (1.446-4.078)	0.722	0.694 (0.092-5.218)	0.310	2.287 (0.462-11.315)	0.153	2.184 (0.749-6.367)	0.995	0.000 (0.000-0)
Repellent	0.423	1.204 (0.765-1.897)	0.599	0.836 (0.428-1.631)	0.164	1.826 (0.781-4.165)	0.039*	0.483 (0.241-0.965)	0.432	1.757 (0.431-7.163)
Electric rackets	0.995	0.998 (0.453-2.196)	0.989	0.000 (0.000-0)	0.181	2.151 (0.700-6.607)	0.695	0.804 (0.271-2.386)	0.990	0.000 (0.000-0)
Household-Level Preventive Measures										
Coils/electric mats	0.395	0.805 (0.488-1.328)	0.951	1.028 (0.421-2.509)	0.401	0.614 (0.197-1.918)	0.136	2.281 (0.771-6.750)	0.869	0.881 (0.195-3.978)
Anti-mosquito window screen	0.679	1.161 (0.573-2.354)	0.365	0.511 (0.120-2.181)	0.131	0.208 (0.027-1.598)	0.319	0.609 (0.229-1.615)	0.990	0.000 (0.000-0)

Note. *Significantly different

4. Discussion

Our research focused on a sample of data from a recent community-based national representative survey in Indonesia (Riskesdas 2018), aiming to examine malaria prevention strategies and evaluate their effectiveness in reducing malaria incidence utilized in rural Kalimantan. In this study, we found that reports of malaria were more common among older adults and men in rural areas throughout five provinces in Kalimantan. Our findings are in line with those of a study conducted in Sub-Saharan Africa, South Africa (Kisia et al., 2012), and eastern Indonesia (Dhewantara et al., 2019; Ipa et al., 2020). Malaria is a major public health concern among adults, particularly among economically active males, according to reports. For example, research in Kenya found that Plasmodium falciparum infection was linked to males who were poor and malnourished (Kepha et al., 2016). Compared to men, women were less likely to be diagnosed with malaria and earlier research in Indonesia (Hasyim et al., 2018). Malaria tends to be more common in men and older adults due to several biological, behavioral, and social factors (Quaresima et al., 2021). Biologically, men may be more exposed to Anopheles mosquitoes due to outdoor activities, especially at night when mosquitoes are most active (Mponzi et al., 2022). Socially and economically, men often work in high-risk environments such as agriculture, forestry, or construction areas, which are often close to mosquito habitats (Swai et al., 2016). In addition, immunity to malaria tends to decline with age, especially in individuals living in low-transmission areas, where repeated exposure to the parasite is not enough to maintain immunity (Tadesse et al., 2018). Behavioral factors also play a role, such as the lack of use of preventive measures, including bed nets or repellants, among older men and adults (Gryseels et al., 2015). The combination of these factors makes these groups more susceptible to malaria infection.

The study found a notable relationship between self-reported malaria and occupation. In general, farmers in West Kalimantan, Central Kalimantan, South Kalimantan, and East Kalimantan reported higher malaria rates than those who were unemployed, though these differences were not statistically significant. However, a unique finding emerged in South Kalimantan, where individuals working in non-agricultural sectors reported higher rates of malaria. This result contrasted with the general pattern where agricultural workers tend to report more malaria cases, possibly due to greater exposure to outdoor environments where malaria vectors are more prevalent. The study findings were almost similar to those of a prior study conducted in Ethiopia (Tadesse et al., 2018). The fact that both studies used different statistical approaches could explain some discrepancies. The discrepancies between our findings and the prior study in Ethiopia may be attributed to differences in environmental contexts, access to prevention tools, and definitions of occupational categories. Furthermore, variations in statistical methods and socioeconomic behaviors across regions may also contribute to these differences. For instance, while agricultural workers in Ethiopia might have greater access to preventive measures, those in Kalimantan could face unique challenges, such as limited access to insecticide-treated nets or differences in educational background, which influence malaria prevention practices. The study also discovered a link between education and self-reported malaria. Our research indicated that people who had completed secondary school had a higher likelihood of reporting malaria, although the differences were also not statistically significant. Two previous studies support this finding that individuals who completed secondary school were more likely to report malaria, i.e. education plays a role in increasing awareness and the likelihood of reporting malaria cases (Hasyim et al., 2019; Yimer et al., 2015). In contrast, individuals with lower levels of education were more likely to report malaria in Uganda, likely due to higher exposure to malaria-prone environments (Mpimbaza et al., 2017). These differences highlight the complex interactions between education, awareness, and access to health services in malaria-endemic areas. An individual's socioeconomic status, work, and education are significant risk factors for malaria. This could be explained by the fact that people with higher levels of education are more likely to be knowledgeable about and aware of malaria. Therefore, there was a higher likelihood that individuals would overreport malaria or know about malaria prevention strategies.

The study identified several malaria-prevention measures used by participants in various provinces, including bed nets, insecticide-treated nets (ITNs), repellents and mosquito electric rackets, coils or electric mats, and mosquito screens. Our findings showed that sleeping under a bed net reduced the risk of malaria in West Kalimantan but not in the other areas. This is similar to a study conducted on the border of Myanmar and Thailand which mentioned that mosquito net ownership had an impact on reducing malaria (Pooseesod et al., 2021). The counterintuitive result might suggest improper use or maintenance of bed nets, or it could indicate other confounding factors, such as higher exposure to malaria in areas where bed nets are more commonly used. Particularly in endemic locations, mosquito nets are extremely important for preventing malaria since they physically shield humans from Anopheles mosquito bites, therefore shielding them from the malaria parasite (Fornace et al., 2021). Not only can insecticide-treated nets (ITNs) stop bites, but they also kill mosquitoes that come into touch with them, therefore lowering malaria transmission. Long-term protection at a reasonable cost comes from using Long-Lasting Insecticidal Nets (LLINs) (Ridha et al., 2021). Furthermore, the distribution of bed nets is sometimes accompanied by educational initiatives to increase public awareness of the need for malaria prevention and motivate regular bed nets use, which have been demonstrated to greatly lower malaria incidence (Mosha et al., 2022).

The variation in the effectiveness of ITNs across different provinces, as observed in Kalimantan, suggests several underlying factors that may influence their protective capacity. This result was supported by one study in southern Ethiopia, reporting that malaria prevalence was as high despite frequent bed-net use; the heterogeneity of bed-net use and malaria incidence was demonstrated (Debo & Kassa, 2016). One possible reason for reduced efficacy in certain regions, such as South Kalimantan, could be the improper use or maintenance of ITNs. Frequent use without proper care, such as regular washing or re-treating with insecticide, may reduce the net's effectiveness, especially after several years of use. Debo and Kassa (2016) also support this concern, indicating that incorrect usage or reluctance to use treated nets contributes to continued malaria transmission. Another critical factor may due to insecticide resistance among mosquito populations, which can reduce the protective effect of ITNs. This phenomenon has been observed in various malaria-endemic regions, where mosquitoes have evolved resistance to the pyrethroid insecticides commonly used in bed nets (Lindsay et al., 2021). In Malawi, for example, ITNs showed no significant protective effect against malaria, likely due to such resistance (Mathanga et al., 2015; Mbewe et al., 2022). The differences in mosquito vector behavior and ecology could also explain the regional disparities in ITN's effectiveness (Obala et al., 2015). In some areas, mosquitoes may enter homes and bite at times or places where nets are not used, diminishing the protection they offer (Mponzi et al., 2022).

In contrast, the success of ITN programs in Nigeria, where educational initiatives were combined with net distribution, underscores the importance of community education and engagement in malaria prevention efforts (Olowookere et al., 2013). Education improves compliance with ITN use and ensures the proper handling of nets, maximizing their protective benefits. This suggests that addressing the human factors-such as proper use, consistent application, and understanding of the benefits of ITNs-is crucial for their success. Future interventions should focus on enhancing ITN durability and resistance management, ensuring regular re-treatment or replacement of nets, and conducting behavior change communication campaigns to increase proper usage. Research should also explore regional differences in vector behavior and insecticide resistance patterns to tailor more effective malaria prevention strategies. Ongoing monitoring and evaluation of ITN efficacy, combined with community-driven educational programs, will be key to sustaining malaria control efforts and adapting to evolving challenges.

This study reported that the usage of repellents and mosquito electric rackets was linked to a lower risk of reporting malaria across the provinces. This suggested that these measures were effective at preventing mosquito bites, which reduced malaria transmission. This result was supported by clinical research in Chennai and Raurkela, India, which discovered a weaker relationship between repellents and malaria (Van Eijk et al., 2016). In Afghanistan, however, there were no significant declines in adult malaria cases with mosquito repellents or electric rackets (Rowlands et al., 2004). Similar research found that, despite entomological statistics showing that in more than five hours, the Picaridin repellent reduced mosquito bites by 97%, there was no evidence of a decrease in malaria prevalence in Cambodia (Gryseels et al., 2015). These findings were strengthened by Maia et al. (2018), who pointed out in their study that the evidence supporting the claim that repellent sources, locally or geographically, can stop the spread of malaria is insufficient. Several discrepancies with this study's findings could be explained by a significant desire for repellent application on a regular basis. This was observed particularly among individuals, usually men, who engaged in economic and subsistence activities in the forest, especially in areas with high levels of insect annoyance. Insect annoyance is one of the primary motivators for repellent application in other situations (Yimer et al., 2015).

Our research showed that using coils or applying electric anti-mosquito mats and installing mosquito window screens could minimize the risk of malaria. The finding is consistent with some previous studies. Mosquito window screens significantly decreased mosquito exposure in homes (Morakinyo et al., 2018). Similarly, coils and electric mats effectively lowered malaria risk in rural areas with limited access to other preventive measures (Guerra et al., 2018), while Wanzirah et al. (2015) highlighted the importance of home improvements, including mosquito screens, in reducing malaria transmission. However, the participants in South and North Kalimantan looked to be less protected. One potential explanation for these domestic preventative techniques was that they only protected people who were present in the house. Meanwhile, malaria transmission can occur both inside and outside the house. Given that mosquito vector bites are mostly an outdoor danger for malaria (Iliyasu et al., 2013), the efficacy of domestic prevention strategies is questioned (Guerra et al., 2018). According to our analysis, the majority of residences in all provinces used coils rather than traditional window screens. This discovery is consistent with the results of a Nigerian study, reporting that malaria infection was shown to be higher in people living in unimproved dwellings (Morakinyo et al., 2018). Another study in Uganda found that the rate of human-biting mosquitos was lower in modern dwellings than in traditional ones. Malaria infection rates in modern households are decreasing across all subcounties (Wanzirah et al., 2015). Although dwellings are not the only places where malaria spreads, they remain the principal transmission habitat in many endemic areas (Van Eijk et al., 2016). House upgrades include the complete covering or sealing of apertures, including doors, windows, eaves, and ceiling structures. The goal is to reduce mosquito-human interaction indoors. Although mosquitos bite and transmit disease outside, evidence suggests that they will visit home before biting someone contagious at some point in their lives (Killeen et al., 2016). A Gambian study revealed that when 500 families in a neighborhood were given either total screening, screened ceilings, or no screening at all, more mosquitos were captured in the houses without screening than in the other structures (Kirby et al., 2009).

5. Implications and limitations

The study's findings highlighted significant regional differences in the effectiveness of ITNs, suggesting that improper use and insecticide resistance might undermine malaria prevention in Kalimantan. To improve outcomes, strategies should focus on education campaigns about proper ITNs use, regular net replacement, and monitoring mosquito resistance. Combining these with ITN use could enhance malaria prevention in provinces where other methods like electric mats and screens were effective. For nursing, this study emphasized the role of nurses in health education, improving ITN compliance, and advocating for comprehensive malaria prevention efforts. Nurses could provide direct community engagement, ensuring proper ITN use, early diagnosis, and prompt treatment, which were keys to reducing malaria transmission.

The study's limitations included potential reporting and social desirability biases, where respondents might inaccurately report or overstate their malaria prevention practices. Additionally, the cross-sectional design limits causal inference, as it only provided a snapshot in time without establishing how changes in prevention practices affected malaria incidence. These factors suggested a cautious interpretation of the findings and highlighted the need for longitudinal studies to better understand causal relationships.

6. Conclusion

The study showed that self-reported malaria rates were higher among older individuals and males. The educational factor was less significant in self-reporting of malaria, but based on occupation, farmers were more likely to report malaria. Another result was that in rural areas, individuals using ITNs, insect repellents, and electric mosquito rackets were less likely to report malaria and had a lower probability of contracting malaria. The most effective malaria preventive measures identified in this study included the consistent use of insecticide-treated nets (ITNs), which offer dual protection by physically blocking mosquito bites and killing mosquitoes on contact. The use of ITNs becomes more effective when combined with other prevention strategies to protect against malaria. Indoor residual spraying (IRS) complements the protection of bed nets by killing mosquitoes resting on the walls of the house, while the use of repellants on the skin or clothing provides additional protection during activities outside the home. In addition, wearing protective clothing, especially at night, and using electronic mosquito-repellent devices inside the home can support the effectiveness of mosquito nets. These measures, when accompanied by community education on the importance of bed net use and other preventive measures, provide more comprehensive protection against the risk of malaria transmission, especially in endemic areas. Therefore, this study recommends that the local health authorities establish targeted intervention strategies combined with community education to prevent Malaria in Kalimantan. Longitudinal studies are also needed in the future to explore better causal relationships of Malaria.

Acknowledgment

We thank the Ministry of Health of the Republic of Indonesia for assisting with this research.

Author contribution

MRR, RY: Conceptualization, methodology, formal analysis, writing.
IHN, EWZR: Formal analysis, writing, and editing.
DA, TR: Reviewing, investigation, validation, and editing.

Conflict of interest

The authors declare no conflict of interest.

References

Centers for Disease Control and Prevention. (2024). *Malaria's impact worldwide*. CDC. https://www.cdc.gov/malaria/malaria_worldwide/impact.html#

Central Bureau of Statistics of Indonesia. (2020). *Indonesia in figure (Provincial Bureau of Statistics of East Kalimantan*. Central Bureau of Statistics of Indonesia.

Debo, G. W., & Kassa, D. H. (2016). Prevalence of malaria and associated factors in Benna Tsemay district of pastoralist community, Southern Ethiopia. *Tropical Diseases, Travel Medicine and Vaccines, 2,* 16. https://doi.org/10.1186/s40794-016-0033-x

Dhewantara, P. W., Ipa, M., & Widawati, M. (2019). Individual and contextual factors predicting self-reported malaria among adults in eastern Indonesia: Findings from Indonesian community-based survey. *Malaria Journal*, *18*, 118. https://doi.org/10.1186/s12936-019-2758-2

Fornace, K. M., Diaz, A. V., Lines, J., & Drakeley, C. J. (2021). Achieving global malaria eradication in changing landscapes. *Malaria Journal, 20,* 69. https://doi.org/10.1186/s12936-021-03599-0

Gryseels, C., Uk, S., Sluydts, V., Durnez, L., Phoeuk, P., Suon, S., Set, S., Heng, S., Siv, S., Gerrets, R., & others. (2015). Factors influencing the use of topical repellents: Implications for the effectiveness of malaria elimination strategies. *Scientific Reports*, *5*, 16847. https://doi.org/10.1038/srep16847

Guerra, M., de Sousa, B., Ndong-Mabale, N., Berzosa, P., & Arez, A. P. (2018). Malaria determining risk factors at the household level in two rural villages of mainland Equatorial Guinea. *Malaria Journal*, *17*, 203. https://doi.org/10.1186/s12936-018-2354-x

Guntur, R. D., Kingsley, J., & Amirul Islam, F. M. (2022). Malaria treatment-seeking behaviour and its associated factors: A cross-sectional study in rural East Nusa Tenggara Province, Indonesia. *PLoS ONE, 17*(2), e0263178. https://doi.org/10.1371/journal.pone.0263178

Hasyim, H., Dale, P., Groneberg, D. A., Kuch, U., & Müller, R. (2019). Social determinants of malaria in an endemic area of Indonesia. *Malaria Journal, 18*, 134. https://doi.org/10.1186/s12936-019-2760-8

Hasyim, H., Dhimal, M., Bauer, J., Montag, D., Groneberg, D. A., Kuch, U., & Müller, R. (2018). Does livestock protect from malaria or facilitate malaria prevalence? A cross-sectional study in endemic rural areas of Indonesia. *Malaria Journal, 17,* 302. https://doi.org/10.1186/s12936-018-2447-6

Hsiung, A. C., Boyle, W. A., Cooper, R. J., & Chandler, R. B. (2018). Altitudinal migration: Ecological drivers, knowledge gaps, and conservation implications. *Biological Reviews*, *93*(4), 2049–2070. https://doi.org/10.1111/brv.12435

Iliyasu, Z., Babashani, M., Abubakar, I. S., Salahudeen, A. A., & Aliyu, M. H. (2013). Clinical burden and correlates of HIV and malaria co-infection, in northwest Nigeria. *Acta Tropica*, *128*(3), 630–635. https://doi.org/10.1016/j.actatropica.2013.09.011

Ipa, M., Widawati, M., Laksono, A. D., Kusrini, I., & Dhewantara, P. W. (2020). Variation of preventive practices and its association with malaria infection in eastern Indonesia: Findings from community-based survey. *PloS One*, *15*(5), e0232909. https://doi.org/10.1371/journal.pone.0232909

Kepha, S., Nikolay, B., Nuwaha, F., Mwandawiro, C. S., Nankabirwa, J., Ndibazza, J., Cano, J., Matoke-Muhia, D., Pullan, R. L., Allen, E., Halliday, K. E., & Brooker, S. J. (2016). Plasmodium falciparum parasitaemia and clinical malaria among school children living in a high transmission setting in western Kenya. *Malaria Journal*, *15*, 157. https://doi.org/10.1186/s12936-016-1176-y

Killeen, G. F., Govella, N. J., Lwetoijera, D. W., & Okumu, F. O. (2016). Most outdoor malaria transmission by behaviourally-resistant Anopheles arabiensis is mediated by mosquitoes that have previously been inside houses. *Malaria Journal*, *15*, 225. https://doi.org/10.1186/s12936-016-1280-z

Kirby, M. J., Ameh, D., Bottomley, C., Green, C., Jawara, M., Milligan, P. J., Snell, P. C., Conway, D. J., & Lindsay, S. W. (2009). Effect of two different house screening interventions on exposure to malaria vectors and on anaemia in children in The Gambia: A randomised controlled trial. *The Lancet*, *374*, 998–1009. https://doi.org/10.1016/S0140-6736(09)60871-0

Kisia, J., Nelima, F., Otieno, D. O., Kiilu, K., Emmanuel, W., Sohani, S., Siekmans, K., Nyandigisi, A., & Akhwale, W. (2012). Factors associated with utilization of community health workers in improving access to malaria treatment among children in Kenya. *Malaria Journal*, *11*, 248. https://doi.org/10.1186/1475-2875-11-248

Koduri, V. N., & Kusneniwar, G. N. (2018). Awareness about mosquito borne diseases and practice about preventive methods against mosquito bite in rural field practice area of a tertiary care teaching institute, Telangana state. *Journal of Medical Science and Clinical Research, 6*(2), 512–518. https://dx.doi.org/10.18535/jmscr/v6i2.81

Lindsay, S. W., Thomas, M. B., & Kleinschmidt, I. (2021). Threats to the effectiveness of insecticide-treated bednets for malaria control: Thinking beyond insecticide resistance. *The Lancet Global Health, 9*(9), e1325-e1331. https://doi.org/10.1016/S2214-109X(21)00216-3

Lobo, M., Guntur, R. D., Kusumaningrum, D., & Bria, Y. P. (2024). The declined trend of malaria over a ten-year period in the rural East Nusa Tenggara Province, Indonesia: A medical record analysis. *Open Access Macedonian Journal of Medical Sciences*, *12*(1), 107–115. https://doi.org/10.3889/oamjms.2024.11829

Lwin, M. O., Vijaykumar, S., Lim, G., Theng, Y. L., & Foo, S. (2014). “It’s effective but should I bother?”A study of personal protection measures against malaria in urban India. *Public Health*, *128*(7), 654–664. https://doi.org/10.1016/j.puhe.2014.03.008

Maia, M. F., Kliner, M., Richardson, M., Lengeler, C., & Moore, S. J. (2018). Mosquito repellents for malaria prevention. *Cochrane Database of Systematic Reviews*, *2*(2), CD011595. https://doi.org/10.1002/14651858.CD011595.pub2

Mathanga, D. P., Mwandama, D. A., Bauleni, A., Chisaka, J., Shah, M. P., Landman, K. Z., Lindblade, K. A., & Steinhardt, L. C. (2015). The effectiveness of long-lasting, insecticide-treated nets in a setting of pyrethroid resistance: A case-control study among febrile children 6 to 59 months of age in Machinga District, Malawi. *Malaria Journal*, *14*, 457. https://doi.org/10.1186/s12936-015-0961-3

Mbewe, R. B., Keven, J. B., Mzilahowa, T., Mathanga, D., Wilson, M., Cohee, L., Laufer, M. K., & Walker, E. D. (2022). Blood-feeding patterns of Anopheles vectors of human malaria in Malawi: Implications for malaria transmission and effectiveness of LLIN interventions. *Malaria Journal, 21*, 67. https://doi.org/10.1186/s12936-022-04089-7

Meyer, D., & Riechert, M. (2019). Open source QGIS toolkit for the advanced research WRF modelling system. *Environmental Modelling & Software*, *112*, 166–178. https://doi.org/10.1016/j.envsoft.2018.10.018

Ministry of Health Republic of Indonesia. (2018). *Key results of the 2018 basic health research*. Indonesian Health Research and Development Agency. https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/

Ministry of Health Republic of Indonesia. (2019). *Laporan nasional Riskesdas 2018 [2018 national basic health research report]*. Health Research and Development Agency Publisher. https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/1/LaporanRiskesdas 2018 Nasional.pdf

Ministry of Health Republic of Indonesia. (2020). *National action plan for acceleration of malaria elimination 2020-2024*. Directorate General of Disease and Prevention Ministry of Health, Republic of Indonesia. https://malaria.kemkes.go.id/sites/default/files/2024-08/National%20Strategic%20Plan%20Revision_Malaria_29%20Mei%202023.pdf

Molina Gómez, K., Caicedo, M. A., Gaitán, A., Herrera-Varela, M., Arce, M. I., Vallejo, A. F., Padilla, J., Chaparro, P., Pacheco, M. A., Escalante, A. A., Arevalo-Herrera, M., & Herrera, S. (2017). Characterizing the malaria rural-to-urban transmission interface: The importance of reactive case detection. *PLoS Neglected Tropical Diseases, 11*, e0005780. https://doi.org/10.1371/journal.pntd.0005780

Morakinyo, O. M., Balogun, F. M., & Fagbamigbe, A. F. (2018). Housing type and risk of malaria among under-five children in Nigeria: Evidence from the malaria indicator survey. *Malaria Journal*, *17*, 311. https://doi.org/10.1186/s12936-018-2463-6

Mosha, J. F., Kulkarni, M. A., Lukole, E., Matowo, N. S., Pitt, C., Messenger, L. A., Mallya, E., Jumanne, M., Aziz, T., Kaaya, R., Shirima, B. A., Isaya, G., Taljaard, M., Martin, J., Hashim, R., Thickstun, C., Manjurano, A., Kleinschmidt, I., Mosha, F. W., ... Protopopoff, N. (2022).

Effectiveness and cost-effectiveness against malaria of three types of dual-active-ingredient long-lasting insecticidal nets (LLINs) compared with pyrethroid-only LLINs in Tanzania: A four-arm, cluster-randomised trial. *The Lancet*, *399*(10331), 1227–1241. https://doi.org/10.1016/S0140-6736(21)02499-5

Mpimbaza, A., Ndeezi, G., Katahoire, A., Rosenthal, P. J., & Karamagi, C. (2017). Demographic, socioeconomic, and geographic factors leading to severe malaria and delayed care seeking in Ugandan children: A case-control study. *The American Journal of Tropical Medicine and Hygiene*, *97*(5), 1513. http://doi.org/10.4269/ajtmh.17-0056

Mponzi, W. P., Swai, J. K., Kaindoa, E. W., Kifungo, K., Eiras, A. E., Batista, E. P. A., Matowo, N. S., Sangoro, P. O., Finda, M. F., Mmbando, A. S., Gavana, T., Ngowo, H. S., & Okumu, F. O. (2022). Observing the distribution of mosquito bites on humans to inform personal protection measures against malaria and dengue vectors. *PLoS One, 17*(7), e0271833. https://doi.org/10.1371/journal.pone.0271833

Obala, A. A., Mangeni, J. N., Platt, A., Aswa, D., Abel, L., Namae, J., & O'Meara, W. P. (2015). What is threatening the effectiveness of insecticide-treated bednets? A case-control study of environmental, behavioral, and physical factors associated with prevention failure. *PloS One, 10*(7), e0132778. https://doi.org/10.1371/journal.pone.0132778

Olowookere, S. A., Adeleke, N. A., Abioye-Kuteyi, E. A., & Mbakwe, I. S. (2013). Use of insecticide treated net and malaria preventive education: Effect on malaria parasitemia among people living with AIDS in Nigeria, a cross-sectional study. *Asia Pacific Family Medicine*, *12*, 2. https://doi.org/10.1186/1447-056X-12-2

Ramdzan, A. R., Ismail, A., & Zanib, Z. S. M. (2020). Prevalence of malaria and its risk factors in Sabah, Malaysia. *International Journal of Infectious Diseases*, *91*, 68–72. https://doi.org/10.1186/s12936-016-1405-4

Rassi, C., Graham, K., Mufubenga, P., King, R., Meier, J., & Gudoi, S. S. (2016). Assessing supply-side barriers to uptake of intermittent preventive treatment for malaria in pregnancy: A qualitative study and document and record review in two regions of Uganda. *Malaria Journal*, *15*, 341. https://doi.org/10.1186/s12936-016-1405-4

Ridha, M. R., Fakhrizal, D., Hidayat, S., & Liani, E. (2021). An overview of malaria elimination efforts in South Kalimantan from 2010 to 2018. *International Journal of Public Health*, *10*(1), 97–102. https://doi.org/10.11591/ijphs.v10i1.20617

Sugiarto, S. R., Baird, J. K., Singh, B., Elyazar, I., & Davis, T. M. E. (2022). The history and current epidemiology of malaria in Kalimantan, Indonesia. *Malaria Journal, 21*, 327. https://doi.org/10.1186/s12936-022-04366-5

Swai, J. K., Finda, M. F., Madumla, E. P., Godfrey F. L., Moshi, I. R., Rafiq, M.Y., Majambere, S., Okumu, F.O. (2016). Studies on mosquito biting risk among migratory rice farmers in rural south-eastern Tanzania and development of a portable mosquito-proof hut. *Malaria Journal, 15*, 564. https://doi.org/10.1186/s12936-016-1616-8

Tadesse, F., Fogarty, A. W., & Deressa, W. (2018). Prevalence and associated risk factors of malaria among adults in East Shewa Zone of Oromia Regional State, Ethiopia: A cross-sectional study. *BMC Public Health*, *18*, 25. https://doi.org/10.1186/s12889-017-4577-0

Tusting, L. S., Bottomley, C., Gibson, H., Kleinschmidt, I., Tatem, A. J., Lindsay, S. W., & Gething, P. W. (2017). Housing improvements and malaria risk in Sub-Saharan Africa: A multi-country analysis of survey data. *PLoS Medicine, 14*(2), e1002234. https://doi.org/10.1371/journal.pmed.1002234

Quaresima, V., Agbenyega, T., Oppong, B., Awunyo, J. A. D. A., Adu Adomah, P., Enty, E., Donato, F., & Castelli, F. (2021). Are malaria risk factors based on gender? A mixed-methods survey in an Urban setting in Ghana. *Tropical Medicine and Infectious Disease, 6*(3), 161. https://doi.org/10.3390/tropicalmed6030161

Van Eijk, A. M., Ramanathapuram, L., Sutton, P. L., Peddy, N., Choubey, S., Mohanty, S., Asokan, A., Ravishankaran, S., Priya, G., Johnson, J. A., Velayutham, S., Kanagaraj, D., Patel, A., Desai, N., Tandel, N., Sullivan, S. A., Wassmer, S. C., Singh, R., Pradhan, K., ... Sharma, S. K. (2016). The use of mosquito repellents at three sites in India with declining malaria transmission: Surveys in the community and clinic. *Parasites & Vectors*, *9*(1), 418. https://doi.org/10.1186/s13071-016-1709-9

Wanzirah, H., Tusting, L. S., Arinaitwe, E., Katureebe, A., Maxwell, K., Rek, J., Bottomley, C., Staedke, S. G., Kamya, M., Dorsey, G., & others. (2015). Mind the gap: House structure and the risk of malaria in Uganda. *PLoS One*, *10*(1), e0117396. https://doi.org/10.1371/journal.pone.0117396

World Health Organization. (2024). *WHO malaria policy advisory group (MPAG) meeting report*. World Health Organization. https://www.who.int/publications/i/item/9789240089648

Yimer, F., Animut, A., Erko, B., & Mamo, H. (2015). Past five-year trend, current prevalence and household knowledge, attitude and practice of malaria in Abeshge, South-Central Ethiopia. *Malaria Journal*, *14*, 230. https://doi.org/10.1186/s12936-015-0749-5

Appendix 1

Table 3. Multivariate analysis of preventive factors affecting self-reported malaria

Characteristics	Self-reported malaria		Multivariate Analysis											
			Logistic Regression Step 1		Logistic Regression Step 2		Logistic Regression Step 3		Logistic Regression Step 4		Logistic Regression Step 5		Logistic Regression Step 6	
	Yes	No	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)
West Kalimantan														
Age														
15 – 24	19	3495	1.143	0.680 (0.406-1.140)	0.142	0.679 (0.405-1.138)								
25 and above	64	15595												
Gender														
Male	45	9299	0.279	0.787 (0.510-1.214)										
Female	38	9791												
Used bed nets														
No	39	11079	0.006	1.869 (1.195-2.923)	0.006	1.865 (1.192-2.919)	0.008	1.824 (1.166-2.852)						
Yes	44	8011												
Used ITNs > 3 years														
No	61	16188	0.000	2.464 (1.484-4.092)	0.001	2.451 (1.475-4.073)	0.001	2.375 (1.432-3.939)						
Yes	22	2902												
Central Kalimantan														
Used ITNs ≤ 3 years														
No	33	14173	0.011	3.422 (1.331-8.623)	0.012	3.355 (1.306-8.623)								
Yes	5	640												
South Kalimantan														
Age														
15 – 24	8	3108	0.090	0.481 (0.206-1.122)	0.106	0.498 (0.214-1.159)	0.105	0.497 (0.24-1.157)	0.106	0.499 (0.214-1.160)	0.102	0.494 (0.212-1.149)		
25 and above	17	13568												
Gender														
Male	22	7947	0.001	0.120 (0.036-0.402)	0.001	0.122 (0.036-0.409)	0.001		0.001	0.124 (0.037-0.415)	0.001	0.124 (0.037-0.413)	0.001	0.122 (0.036-0.407)
Female	3	8729												
Used bed nets														
No	10	7141	0.296	1.572 (0.673-3.672)										
Yes	15	9535												
Used ITNs ≤ 3 years														
No	20	16289	0.000	12.192 (4.346-34.200)	0.000	10.535 (3.901-28.453)	0.000	10.507 (3.893-28.354)	0.000	10.434 (3.869-28.143)	0.000	11.337 (4.210-30.534)	0.000	11.034 (4.104-29.664)
Yes	5	387												
Used mosquito repellent														
No	9	8010	0.205	1.701 (0.749-3.867)	0.220	1.670 (0.735-3.795)								
Yes	16	8666												
Used mosquito electric rackets														
No	21	14810	0.147	2.251 (0.752-6.735)	0.191	2.058 (0.697-6.077)	0.214	1.986 (0.674-5.856)						
Yes	4	1866												
Installed anti-mosquito window screen														
No	24	13569	0.121	0.202 (0.027-1.525)	0.100	0.185 (0.025-1.385)	0.098	0.183 (0.024-1.370)	0.119	0.204 (0.027-1.510)				
Yes	1	3107												

Table 3. Continued

Characteristics	Self-reported malaria		Multivariate Analysis											
			Logistic Regression Step 1		Logistic Regression Step 2		Logistic Regression Step 3		Logistic Regression Step 4		Logistic Regression Step 5		Logistic Regression Step 6	
	Yes	No	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)	p	aOR (95%CI)
East Kalimantan														
Age														
15 – 24	7	2183	0.098	0.460 (0.183-1.155)	0.089	0.449 (0.178-1.131)	0.084	0.442 (0.175-1.116)	0.094	0.454 (0.180-1.143)				
25 and above	30	9373												
Used ITNs ≤ 3 years														
No	31	11064	0.031	2.691 (1.096-6.608)	0.036	2.620 (1.064-6.452)	0.029	2.729 (1.108-6.720)	0.022	2.859 (1.165-7.013)				
Yes	6	492												
Used ITNs > 3 years														
No	33	11182	0.123	2.306 (0.799-6.658)	0.113	2.353 (0.816-6.787)	0.104	2.410 (0.833-6.966)						
Yes	4	374												
Used mosquito repellent														
No	19	4473	0.048	0.509 (0.261-0.995)	0.120	0.597 (0.312-1.145)								
Yes	18	7083												
Used coils/electric mats														
No	4	2173	0.148	2.213 (0.754-6.490)										
Yes	33	9383												
North Kalimantan														
Age														
15 – 24	2	1039	0.867	1.148 (0.288-5.783)										
25 and above	9	3787												
Occupation														
Not working	4	1844	0.152	0.772 (0.193-3.090)	0.148	0.334 (0.074-1.483)								
Farmer	3	593												
Non-farmer	4	2389												