Determinants of malaria infections among children in refugee settlements in Uganda. Analysis of data from Uganda malaria indicator survey, 2018-19

Henry Semakula Musoke (henry.semakula@mak.ac.ug)
Makerere University College of Agricultural and Environmental Sciences https://orcid.org/0000-0002-9120-2235
Song Liang
University of Florida College of Public Health and Health Professions
Paul Isolo Mukwaya
Makerere University College of Agricultural and Environmental Sciences
Frank Mugagga
Makerere University College of Agricultural and Environmental Sciences
Monica Swahn
Kennesaw State University WellStar College of Health and Human Services
Denis Nseka
Makerere University College of Agricultural and Environmental Sciences
Hannington Wasswa
Makerere University College of Agricultural and Environmental Sciences
Patrick Kayima
Makerere University College of Agricultural and Environmental Sciences

Research Article

Keywords: Children, Household, Malaria, Logistic regression, Risk factors, Refugees, Settlements, Uganda

Posted Date: January 26th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-2497041/v1

Abstract

Background

Globally, 5% of 247 million global malaria cases are reported Uganda which is also one of the top refugee hosting countries in Africa, with 1.36 million refugees currently. Although malaria is an emerging challenge for humanitarian response in refugee settlements, little is known about its risk factors. The study analysed data from the 2018-19 Uganda Malaria Indicator Survey (UMIS) to determine the factors associated with malaria infections among refugee children under five years of age.

Methods

The analysis was run using the 'Individual dataset' of UMIS. The independent variables related to the demographic, social-economic and environmental information on 3,481 refugees spreading across the country. The rapid diagnostics test results was the outcome variable. Multivariate logistic regression was performed to identify predictors of the malaria infections.

Results

Overall, the prevalence of malaria infections in all refugee settlements across the nine hosting districts was 36.6%. Malaria infections were higher in refugee settlements located in Isingiro (98.7%), Kyegegwa (58.6%) and Arua (57.4%) districts. The odds of contracting malaria were higher in refugee households whose children were aged 31–45 months (AOR = 2.14, 95% CI = 1.32–3.47) and above 45 months (AOR = 2.01, 95% CI = 1.22–3.32). Households whose main sources of domestic water were open water sources, boreholes and water tanks, were 1.22 (AOR = 1.22, 95% CI = 0.08–0.59), 2.11(AOR = 2.11, 95% CI = 0.91–4.89) and 4.47(AOR = 4.47, 95% CI = 1.67–11.9) times more likely to have their children contracting malaria. Households which used pit latrines and those without any toilet facility or used open defecation methods were 1.48 (AOR = 1.48, 95% CI = 1.03–2.13) and 3.29 (AOR = 3.29, 95% CI = 1.54–7.05) times more likely to have their children contracting malaria. Households which did not have insecticide treated bed nets or sprayed their households were 1.15 (AOD = 1.15, 95% CI = 0.43–3.13) and 8.04 (AOD = 8.04, 95% CI = 2.47–26.2) times more likely to have their children contracting malaria. Households which did not know that mosquito bites caused malaria, were 1.09 (AOD = 1.09, 95%=0.79–1.51) times more likely to have their children getting malaria.

Conclusions

These findings suggest that humanitarian responses and investments that reduce survival, biting, feeding, parasite development and breeding of mosquitoes will provide malaria health benefits in refugee settlements in Uganda.

Background

Malaria is among the major global life threatening diseases which is spread to humans by bites from infected female *Anopheles* mosquitoes (1). Although six *Plasmodium* (p) parasite species (i.e. *P. falciparum*, *P. vivax, P. malariae*, *P. ovale curtisi*, *P. ovale wallikeri* and *P. knowlesi)* are known to cause malaria in humans, *P. falciparum* is the most prevalent malaria parasite in sub-Saharan Africa (SSA), contributing to most of the malaria cases and deaths (2). By 2021, there was an estimated 234 million malaria cases and 593,000 deaths within the WHO African Region (1). The malaria burden was further amplified by the COVID-19 disruptions which constrained malaria chemoprevention, distribution of insecticide-treated bed nets (ITNs), indoor residual spraying (IRS), malaria testing and treatment (3). By 2021, an estimated additional 13.4 million cases were attributed to the disruptions during the COVID-19 pandemic (1). In addition, climate change is adding another layer of complication to the burden considering that the transmission frontiers and the risk for malaria have shifted further to the eastern and southern parts of the African continent especially in highland and densely populated regions (4, 5).

As the world strives to eliminate malaria (1), the plight of refugees, displaced people, and asylum seekers must not be forgotten. It is widely recognised that human mobility influences the spread of infectious diseases including influenza, cholera, malaria, dengue, schistosomiasis and Ebola among others (6–8). Human mobility is one of determinants of many infectious disease transmission dynamics by either introducing pathogens into susceptible populations or changing the frequency of contacts between infected and susceptible individuals or both (9). As of late 2021, the United Nations Refugee Agency estimated that globally, there were 89.3 million forcibly displaced people (10), with almost two-thirds of the people affected by humanitarian emergencies inhabiting malaria endemic regions (11).

The high prevalence of malaria among the displaced populations in Africa constitutes an emerging challenge for humanitarian response (12). Vector borne and other infectious diseases present many challenges in refugee settlements due to inequalities, limited access to healthcare services, and crowded environments which enable rapid disease spread (13). The risk for malaria infections can increase among refugees especially when immunologically naive individuals with little to no prior malaria exposure move to areas of more intense transmission (11). Besides, the influx of refugees from endemic countries can be associated with imported malaria (6) which can contribute to secondary transmission and the spread of drug resistance while threatening long-term elimination goals (14).

The population subgroups considered to be at higher risk of contracting malaria include children under 5 years of age (15, 16), pregnant women (17), and patients with HIV/AIDS (18). Refugees are rendered vulnerable to malaria infections by their lack of protective immunity, increased concentration of people in exposed settings, limited distribution of ITNs, inadequate IRS, insufficient rapid clinical diagnostic and treatment responses (19, 20). Other risk factors include outdoor night activities, wearing short clothes, residing in unfinished houses, poor drainage (21) and acute malnutrition among children (22).

While 5% of the 247 million global malaria cases are from Uganda (1), the country is also one of the top refugee hosting countries in Africa (23). Refugee settlements in Uganda are predominantly located in rural areas of hosting districts usually with active malaria transmission. Such areas are typically characterised by overcrowding, inadequate and temporary shelters, limited vector control efforts and poor access to water and sanitation (24). These conditions make refugee settlements susceptible to high risks of malaria transmission. Elsewhere, it has been documented that malaria is among the leading causes of morbidity and mortality among children under five years of age in refugee settlements (16, 21, 25). Despite these potential risks and challenges, studies on refugees in Uganda have concentrated much on adolescent sexual behaviour (26), psychosocial impact of COVID-19 (27), impact of COVID-19 on food security (28), access to education (29), agroforestry (30), environmental degradation (31) among others, with limited focus on malaria risk factors, treatment and prevention measures (25).

Understanding the key risk factors for malaria infections among children in refugee settlements is crucial for (re)designing humanitarian responses and selecting appropriate intervention strategies for malaria prevention, control, even elimination. This is only possible with adequate research and evidence to support the development of effective and sustainable management strategies. To bridge this knowledge gap, this study utilised data from the 2018-19 Uganda Malaria Indicator Survey (UMIS) which is the first national wide malaria survey in Uganda to include households and people in refugee settlements (32). This study aimed at providing an overview the prevalence of malaria infections and local context risk factors for malaria infections among children under five years of age in refugee settlements of Uganda.

Methods

Study area

Uganda is the third largest refugee-hosting country in the world after Turkey and Pakistan with 1.36 million refugees (24). By 2018, South Sudanese made up the largest refugee population in Uganda (985,512), followed by DRC (271,967) and Burundi (36,677) (24). About 70,988 refugees from Ethiopia, Eritrea, Rwanda, Somalia and Sudan have lived in protracted exile in Uganda for the past three decades (33). The majority of the refugee population are women and children (82%), with 56% below the age of 15, while 25% are younger than 5 years (34). This study focused on all refugee settlements located in nine districts including Yumbe, Arua, Adjumani, Moyo, Lamwo, Kiryadongo, Kyegegwa, Kamwenge and Isingiro, as shown in Fig. 1.

Review of existing knowledge on malaria risk factors

To link the demographic and social-economic variables captured in the 2018-19 UMIS to malaria infections, a literature review was necessary. In this study, a comprehensive survey of relevant literature on household level malaria risk factors was conducted. The search for literature focused on review papers and scientific research articles. The search was done in four databases namely MEDLINE (Pubmed®), EMBASE®, Scopus®, and Web of Science®. Google scholar and Mendeley search engines were also used to obtain relevant literature. In both the databases and search engines, keywords and combination of key words [i.e. malaria and social economic factors, malaria and demographic characteristics, malaria risk factors etc.] were used to guide the literature search. The search was limited to literature published between 2018 and 2022. Ten publications, mainly review articles, were identified and reviewed for the documented risk factors associated with malaria infections among children at the household level. Explanatory variables identified from the review and deemed relevant for the refugee settlements are summarized in Table 1.

Table 1
Household level risk factors associated with malaria infections among children

Explanatory variables	Description	Relationships with malaria infections	Sources
Sex of household head	Determines the ability to obtain malaria treatment and prevention measures	±	(6,35,36)
Mother's education	Determines acquisition and usage of malaria prevention methods and treatment	±	(6,36–38)
Number of household members	Provides adequate source of blood meal for mosquitos. Larger households are at a higher risk	±	(6,36,37)
Household wealth status	Influences housing quality, ownership and payment for malaria prevention and treatment	±	(6,36–38)
Insecticide treated nets (ITNs)	Prevents night mosquito bites around the beds	±	(6,35–37,39,40)
Indoor residual spraying (IRS)	Kills or repels mosquitoes which feed and rest indoors	±	(6,35–37,39,40)
Wall materials	Influences the level at which mosquitoes enter households	±	(6,36–38,40–42)
Roof materials	Determines the suitability of indoor resting sites for mosquitoes	±	(6,36–38,40–42)
Floor materials	Influences indoor mosquito density	±	(6,36–38,40–42)
Sanitation	Determines the nature of breeding sites for mosquitoes around households	±	(6,36,37,41)
Drinking water sources	Influences the nature of ovi-position sites and the time required by vectors to locate them.	±	(6,36,37,41)
Distance to water sources	Determines the time taken by mosquitoes to find a suitable breeding site.	±	(6,36,41)
Type of cooking fuel	Influences indoor mosquito density, survival and biting rates	±	(36,41)
Knowledge of the cause and prevention of malaria	Influences the likelihood of ITN use and malaria treatment	±	(43)

Data source

Data for this study was from the 2018-19 Uganda's malaria indicator survey (UMIS). The dataset was downloaded from the Demographic and Health Surveys (DHS) program. The 2018-19 UMIS was the third malaria survey to be conducted in Uganda (after the 2009 UMIS and 2014-15 UMIS) focusing on refugee settlements and their hosting districts and included information on malaria parasite prevalence, anemia, and status of key malaria indicators (32). The 2018-19 UMIS used a nationally representative sample of 320 clusters. In this survey, representative samples were obtained using probability sampling techniques consisting of a two-stage cluster sampling method. Standardised questionnaires were designed to collect the demographic, social, economic and environmental information of the surveyed households. Both Rapid Diagnostic Test (RDT) and the Blood Smear Test (BST) were used to test malaria parasitemia among children under five years of age with consent from household heads. Detailed explanations on the sampling framework, sample allocation, sampling procedures, sample probabilities, sampling weights, estimates of sampling errors, data collection and coding are well documented in the Malaria Indicator Survey report for Uganda 2018–2019 (32).

Study population, sample size and variable selection

A total of 45,767 respondents were included in the dataset among whom, 3,481 individuals resided in refugee settlements. From the 3,481 refugees, only 675 respondents who had malaria test results (i.e. positive or negative) from the RDT (i.e. outcome variable) were extracted. The BST results were not used due to significant missing values. The explanatory or independent variables extracted from the survey dataset were those factors which had the ability to potentially influence mosquito survival, biting, feeding, parasite development and breeding as captured in Table 1. These were grouped into demographic and social-economic risk factors, water, sanitation and housing, malaria prevention practices, knowledge on the causes and prevention of malaria. Variables extracted from the dataset were categorized as shown in Table 2.

Table 2
Selected explanatory variables that were used to predict malaria infections

Independent/ explanatory variables	**Categories**
Socio- Demographic risk factors	
Age of child	1) 0–15 2) 16–30 3) 31–45 4) Above 45
Age of head of household	1) 15–24 years 2) 25–34 years 3) 35–44 years 4) 45 and above
Sex of household head	1) Male 2) Female
Mother's educational level	1) No education 2) Primary 3) "O" level 4) "A" level 5) Tertiary 6) University
Number of Household members	1) 1–5 members 2) 6–10 members 3) Above 10 members
Household wealth	1) Poor 2) Medium 3) Rich
Owns livestock, herds	1) No 2) Yes
Type of cooking fuel used	1) Charcoal 2) Firewood 3) Straw/grass
Sources of drinking water	1) Open water sources 2) Boreholes 3) Public water taps 4) Tank water
Environmental related risk factors	
Time to get to water source (minutes)	1) 0–15 minutes 2) 16–30 minutes 3) Above 30 minutes
Type of toilet facility	1) Flush toilets 2) Ventilated improved pit latrines 3) Pit latrines with slabs 4) Open pit latrines 5) No toilet facility/Bushes

Independent/ explanatory variables	Categories
Socio- Demographic risk factors	
Main floor material	1) Earth floors 2) Dung floors 3) Cement floors
Main wall material	1) Thatch walls 2) Cardboard walls 3) Bricks with cement walls 4) Bricks with mud walls 5) Poles with mud walls
Main roof material	1) Thatch roofs 2) Tarpaulin roofs 3) Iron sheet roofs
Malaria prevention risk factors	
Has mosquito bed net for sleeping	1) No 2) Yes
Has dwelling been sprayed against mosquitoes in last 12 months	1) No 2) Yes
Has access to malaria medicine	1) Yes 2) No
Child slept in ITN	1) No 2) All children 3) Some children
Knowledge on the causes of malaria	
Mosquitoes bites	1) No 2) Yes
Eating maize	1) No 2) Yes
Eating mangoes	1) No 2) Yes
Poor hygiene	1) No 2) Yes
Standing water	1) No 2) Yes
Not sleeping under nets	1) Yes 2) No
Knowledge on avoiding malaria	
Sleeping under ITNs	1) Yes 2) No
Taking preventative medicines	1) Yes 2) No
Using mosquito repellent	1) Yes 2) No

Independent/ explanatory variables	Categories
Socio- Demographic risk factors	
Spraying with insecticide	1) Yes 2) No
Destroying breeding sites	1) Yes 2) No

Data analysis

Descriptive analysis was used to all study variables. Univariate logistic regression was used to estimate the Unadjusted Odds Ratio (UOR) of each independent variable. Those having p-value < 0.05 were included in the multivariate logistic regression using a backward stepwise strategy to estimate the Adjusted Odds Ratios (AOR) of the household variables in association with malaria infections. The analysis was conducted by JMP 13.

Results

Prevalence of malaria infections among children in refugee settlements

A total of 675 children below the age of five was used in this study, of which 29.6% were aged 0–15 months, 21.3% aged 16–30 months, 24.9% aged 31–45 months and 24.1% age 46–60 months. Figure 2 shows the prevalence of malaria infections among children in refugee settlements located in the nine hosting districts of Uganda.

Overall, the prevalence of malaria infections in all refugee settlements across the nine hosting districts was 36.6%. Malaria infections were higher in refugee settlements located in Isingiro (98.7%), Kyegegwa (58.6%) and Arua (57.4%) districts. The prevalence of malaria was low in refugee settlements located in Adjumani (19.2%) and Kiryandongo (7.7%) districts.

Determinants of malaria infections among children in refugee settlements

Table 3 presents the results from both univariate and multivariate analyses and highlights the significant risk factors (p-value < 0.05) associated with malaria infections among children in refugee settlements.

Table 3
Household level predictors of malaria infections among children in refugee settlements

Predictors (*n* = 675)	Total *n* (%)	Negative *n* (%)	Positive *n* (%)	UOR (95%CI)	*p*-value	AOR (95%CI)	*p*-value
Socio-demographic risk factors							
Age of child (months)							
1) 0–15	200 (29.6)	151 (75.5)	49 (24.5)	0.46 (0.29–0.73)	0.0008*	0.49 (0.30–0.82)	0.0061*
2) 16–30	144 (21.3)	104 (72.2)	40 (27.8)	0.55 (0.34–0.89)	0.0150*	0.59 (0.34–1.01)	0.0462*
3) 31–45	168 (24.9)	97 (57.7)	71 (42.3)	2.26 (1.45–5.52)	0.0003*	2.14 (1.32–3.47)	0.0021*
4) Above 45	163 (24.1)	96 (58.9)	67 (41.1)	2.15 (1.37–3.37)	0.0008*	2.01 (1.22–3.32)	0.0061*
Age of household head (years)							
1) 15–24 years	90 (13.3)	62 (68.9)	28 (31.1)	2.06 (1.63–2.61)	< .0001**	1.74 (1.08–2.79)	0.0219*
2) 25–34 years	312 (46.2)	210 (67.3)	102 (32.7)	0.49 (0.38–0.62)	< .0001**	0.57 (0.36–0.92)	0.0219*
3) 35–44 years	157 (23.3)	97 (61.8)	60 (38.2)	0.62 (0.45–0.85)	0.0003*	0.68 (0.39–1.17)	0.1660
4) 45 and above	116 (17.2)	79 (68.1))	37 (31.9)	0.76 (0.46–1.26)	0.2813	-	-
Sex of household head							
1) Male	268 (39.7)	166 (61.9)	102 (38.1)	1.7 (1.28–2.36)	< .0001**	1.45 (0.98–2.12)	0.0571
2) Female	407 (60.3)	282 (69.3)	125 (30.7)	0.57 (042–078)	< .0001**	0.69 (0.47–1.01)	0.0571
Mother's educational level							
1) No education	355 (52.6)	230 (64.8)	125 (35.2)	2.75 (1.42–5.32)	0.0003*	1.35 (0.92–1.96)	0.0205*
2) Primary	264 (39.1)	178(67.4)	86 (32.6)	0.48 (0.37–0.62)	< .0001**	0.74 (0.51–1.08)	0.1116
3) "O" level	45 (6.7)	33 (73.3)	12 (26.7)	0.36 (0.19–0.70)	0.0002*	0.49 (0.65–3.43)	0.3483
4) "A" level	11 (1.6)	7 (63.6)	4 (36.4)	0.20 (0.18–22.1)	0.5714	-	-
No. of Household members							
1) 1–5 Members	197 (29.2)	133 (67.5)	64 (32.5)	1.9 (1.53–2.34)	< .0001**	1.04 (0.68–1.60)	0.8297
2) 6–10 Members	382 (56.6)	250 (65.4)	132 (34.6)	0.53 (0.43–0.65)	< .0001**	0.72 (0.40–1.30)	0.2802
3) Above 10 Members	96 (14.2)	65 (67.7)	31 (32.3)	0.48 (0.31–0.73)	< .0001**	1.38 (0.77–2.49)	0.3949
Household wealth status							
1) Poor	639 (94.7)	418 (65.4)	221 (34.6)	3.33 (1.34–8.30)	0.0097*	4.23 (1.19–14.9)	0.0251*
2) Rich	36 (5.3)	30 (83.3)	6 (16.7)	0.3 (0.12–0.75)	0.0097*	0.24 (0.06–0.83)	0.0251*
Owns livestock, herds							
1) No	443 (65.6)	294 (66.4)	149 (33.6)	0.66 (0.49–0.89)	0.0008*	0.72 (0.49–1.07)	0.1128
2) Yes	232 (34.4)	154 (66.4)	78 (33.6)	1.51 (1.11–2.04)	0.0008*	1.38 (0.93–2.05)	0.1128
Type of cooking fuel used							
1) Charcoal	97 (14.4)	79 (81.4)	18 (18.6)	0.54 (0.33–0.88)	0.0127*	0.18 (0.04–0.81)	0.0250*
2) Firewood	571 (84.6)	362 (63.4)	209 (36.6)	1.85 (1.14-3.00)	0.0113*	2.20 (1.17–4.15)	0.0143*
3) Straw/grass	7 (1.0)	3 (42.9)	4 (57.1)	8.43 (4.83–14.7)	< .0001**	2.51 (0.68–9.25)	0.0250*
Environmental related risk factors							
Sources of drinking water							
1) Open water sources	37 (5.5)	29 (78.4)	8 (21.6)	1.86 (1.01–3.22)	0.0044*	1.22 (0.08–0.59)	0.0029*
2) Boreholes	293 (43.4)	199 (66.8)	99 (33.2)	0.55 (0.31–0.98)	0.0046*	2.11 (0.91–4.89)	0.0189*
3) Public water taps	290 (43.0)	196 (67.6)	94 (32.4)	0.19 (0.11–0.35)	< .0001**	0.36 (1.01–5.53)	0.0482*
4) Water tanks	55 (8.1)	24 (48.0)	26 (52.0)	5.03 (2.83–8.92)	< .0001**	4.47 (1.67–11.9)	0.0029*
Walk time distance to water sources							
1) 0–15 minutes	337 (49.9)	232 (68.8)	105 (31.2)	2.10 (1.54–2.88)	< .0001**	1.68 (1.11–2.56)	0.0149*

Predictors (*n* = 675)	Total *n* (%)	Negative *n* (%)	Positive *n* (%)	UOR (95%CI)	*p*-value	AOR (95%CI)	*p*-value
Socio-demographic risk factors							
Age of child (months)							
2) 16–30 minutes	180 (26.7)	122 (67.8)	58 (32.2)	0.47 (0.35–0.650	< .0001**	0.77 (0.48–1.23)	0.0817*
3) Above 30 minutes	158 (23.4)	94 (59.5)	64 (40.5)	0.68 (0.49–0.94)	0.0018*	0.59 (0.39–0.90)	0.0149*
Type of toilet facility used							
1) Pit latrines with slabs	372 (55.1)	236 (63.4)	136 (36.6)	1.44 (1.03–2.01)	0.0305*	1.48 (1.03–2.13)	0.0332*
2) Open pits	270 (40.0)	196 (67.6)	94 (32.4)	8.03 (4.77–13.5)	< .0001**	6.67 (0.47–0.97)	0.0332*
3) No toilet/Bushes	33 (4.9)	16 (48.5)	17 (51.5)	5.58 (3.52–8.83)	< .0001**	3.29 (1.54–7.05)	0.0021*
Nature of main floor material							
1) Earth floors	533 (79.0)	345 (64.7)	188 35.3)	0.30 (0.19–0.47)	< .0001**	0.65 (0.33–1.29)	0.2197
2) Dung floors	110 (16.3)	77 (70.0)	33 (30.0)	0.38 (0.19–0.76)	0.0057*	0.86 (0.19–3.75)	0.8367
3) Cement floors	32 (4.7)	26 (81.3)	6 (18.8)	3.32 (2.11–5.23)	< .0001**	1.79 (0.48–6.68)	0.3873
Nature of main wall material							
1) Thatch walls	243 (36.0)	153 (63.50	88 (36.5)	9.21 (2.44–34.7)	< .0001**	4.50 (0.11-56.0)	0.0109*
2) Cardboard walls	16 (2.4)	7 (43.8)	9 (56.3)	3.09 (1.13–8.42)	0.0024*	2.30 (1.39–13.2)	0.0386*
3) Bricks with cement	16 (2.4)	12 (75.0)	4 (25.0)	0.11 (0.02–0.88)	0.0029*	0.39 (0.07–8.93)	0.5626
4) Bricks with mud walls	400 (59.3)	274 (68.5)	126 (31.5)	0.26 (0.09-.070)	0.0017*	0.64 (0.10–7.83)	0.6374
Nature of main roof material							
1) Thatch roofs	420 (62.2)	264 (62.9)	156 (37.1)	1.47 (1.03–2.09)	0.0033*	2.12 (0.94–4.79)	0.0007*
2) Tarpaulin roofs	147 (21.8)	99 (67.3)	48 (32.70	0.68 (0.48–0.97)	0.0037*	0.47 (0.21–1.07)	0.0007*
3) Iron sheet roofs	108 (16.0)	85 (78.7)	23 (21.3)	0.87 (0.53–1.42)	0.5756		
Malaria prevention risk factors							
Using mosquito bed-nets							
1) No	103 (15.3)	63 (61.2)	40 (38.8)	2.89 (2.11–3.95)	< .0001**	1.15 (0.43–3.13)	0.0031*
2) Yes	572 (84.7)	385 (67.3)	187 (32.7)	0.35 (0.25–0.47)	< .0001**	0.86 (0.32–2.35)	0.0031*
Sprayed against mosquitoes							
1) No	673 (99.7)	446 (66.3)	227 (33.7)	3.79 (2.76–5.23)	< .0001**	8.04 (2.47–26.2)	0.0005*
2) Yes	2 (0.3)	2 (100)	0 (0.0)	0.26 (0.19–0.36)	< .0001**	0.12 (0.04–0.40)	0.0005*
Child sleeping under ITN							
1) No	169 (25.0)	108 (63.9)	61 (36.1)	1.76 (1.24–2.50)	0.0017*	1.30 (0.58–2.49)	0.0451*
2) All children	376 (55.7)	257 (68.4)	119 (31.6)	0.57 (0.39–0.81)	0.0017*	0.77 (0.34–1.73)	0.0421*
3) Some children	127 (18.8)	82 (64.6)	45 (35.4)	2.12 (1.46–3.09)	< .0001**	1.33 (0.69–2.57)	0.3855
Has access to malaria medicine							
1) No	635 (94.1)	412 (64.9)	223 (35.1)	5.88 (2.03-17.0)	0.0011*	4.84 (1.82–12.8)	0.0016*
2) Yes	40 (5.9)	36 (90.0)	4 (10.0)	0.17 (0.06–0.49)	0.0011*	0.21 (0.08–0.55)	0.0016*
Knowledge on the causes of malaria							
Mosquito bites							
1) No	520 (77.0)	347 (66.7)	173 (33.3)	1.45 (1.07–1.97)	0.0155*	1.09 (0.79–1.51)	0.0051*
2) Yes	155 (23.0)	101 (65.2)	54 (34.8)	0.69 (0.51–0.93)	0.0155*	0.91 (0.66–1.26)	0.0051*
Eating maize							
1) No	666 (98.7)	441 (66.2)	225 (33.80	0.27 (0.19–0.38)	< .0001**	0.34 (0.13–0.89)	0.0276*
2) Yes	9 (1.3)	7 (77.8)	2 (22.2)	3.65(2.65-5.00)	< .0001**	2.96 (1.13–7.75)	0.0276*

Predictors (*n* = 675)	Total *n* (%)	Negative *n* (%)	Positive *n* (%)	UOR (95%CI)	*p*-value	AOR (95%CI)	*p*-value
Socio-demographic risk factors							
Age of child (months)							
Eating mangoes							
1) No	660 (97.8)	436 (66.1)	224 (33.9)	0.29 (0.21–0.39)	< .0001**	0.82 (0.31–2.14)	0.0483*
2) Yes	15 (2.2)	12 (80.0)	3 (20.0)	3.46 (2.52–4.75)	< .0001**	1.22 (0.47–3.19)	0.0438*
Standing water							
1) No	639 (94.7)	422 (66.0)	217 (34.0)	1.33 (0.63–2.82)	0.4464	-	-
2) Yes	36 (5.3)	26 (72.2)	10 (27.8)	0.75 (0.35–1.58)	0.4464	-	-
Poor hygiene						-	-
1) No	613 (90.8)	405 (66.1)	208 (33.9)	1.16 (0.66–2.04)	0.6020	-	-
2) Yes	62 (9.2)	43 (69.4)	19 (30.6)	0.86 (0.48–1.51)	0.6020	-	-
Not sleeping under nets						-	-
1) No	639 (94.7)	424 (66.4)	215 (33.6)	1.01 (0.49–2.07)	0.9691	-	-
2) Yes	36 (5.3)	24 (66.7)	12 (33.3)	0.99 (0.48-2.00)	0.9691	-	-
Knowledge on ways to avoid malaria							
Malaria can be avoided							
1) No	99 (14.7)	64 (64.6)	35 (35.4)	2.68 (1.96–3.66)	< .0001**	2.14 (1.29–3.55)	0.0031*
2) Yes	576 (85.3)	384 (66.7)	192 (33.3)	0.37 (0.27–0.51)	< .0001**	0.47 (0.28–0.77)	0.0031*
Sleeping under the net							
1) No	619 (91.7)	412 (66.6)	207 (33.4)	1.99 (1.47–2.70)	< .0001**	1.61 (1.16–2.23)	0.0038*
2) Yes	56 (8.3)	36 (64.3)	20 (35.7)	0.50 (0.37–0.68)	< .0001**	0.62 (0.45–0.86)	0.0038*
Using mosquito repellents							
1) No	672 (99.6)	446 (66.4)	226 (33.6)	1.01 (0.09–11.2)	0.9913	-	-
2) Yes	3 (0.4)	2 (66.7)	1 (33.3)	0.99 (0.08–10.9)	0.9913	-	-
Spraying with insecticides							
1) No	665 (98.5)	439 9 (66.0)	226 (34.0)	4.63 (0.59–36.8)	0.1470	-	-
2) Yes	10 (1.5)	9 (90.0)	1 (10.0)	0.22 (0.02–1.71)	0.1470	-	-
Destroying breeding sites							
1) No	610 (90.4)	395 (64.8)	215 (35.2)	2.40 (1.26–4.59)	0.0080*	1.99 (1.44–2.76)	< .0001*
2) Yes	65 (9.6)	53 (81.50	12 (18.5)	0.42 (0.22–0.79)	0.0080*	0.50 (0.36–0.69)	< .0001*

UOR = Unadjusted Odd ratio, AOR = Adjusted Odd ratio. *statistical significance at *P*-value < 0.05; ** high statistical significance at *P*-value < 0.01. Dashes indicate that the predictors were excluded from the multivariate regressions. All *p*-values are within the limits of 95% confidence interval (CI).

Demographic and social-economic risk factors

Significant factors associated with malaria infection risk among children in the refugee households were children's age, age of household head, household wealth status, mother's level of education, and type of cooking fuel. The results suggest that the odds of contracting malaria were significantly higher in refugee households whose children were aged 31–45 months (AOR = 2.14, 95% CI = 1.32–3.47) and above 45 months (AOR = 2.01, 95% CI = 1.22–3.32) compared to those households whose children were under 31 months. Households whose heads were aged between 15–24 years were 1.74 times (AOR = 1.74, 95% CI = 1.08–2.79) more likely to have their children getting malaria infections than those whose heads were 25 years and above. Refugee households with mothers with no education were 1.35 times (AOR = 1.35, 95% CI = 0.92–1.96) more likely to have their children contracting malaria compared to households with educated mothers. Poor households were 4.23 times (AOR = 4.23, 95% CI = 1.19–14.9) more likely to have their children at risk of malaria infections compared to rich households. Households which used firewood and straw for cooking were 2.20 (AOR = 2.20, 95% CI = 1.17–4.15) and 2.51 (AOR = 2.51, 95% CI = 0.68–9.25) times more likely to have their children contracting malaria respectively compared to households which used charcoal for cooking ($p < 0.05$).

Environmental malaria risk factors

Households whose main sources of domestic water were open water sources, boreholes and water tanks, were 1.22 (AOR = 1.22, 95% CI = 0.08–0.59), 2.11 (AOR = 2.11, 95% CI = 0.91–4.89) and 4.47 (AOR = 4.47, 95% CI = 1.67–11.9) times more likely to have their children contracting malaria respectively, compared to households which fetched water from public water taps ($p < 0.05$). Walk time distance to water sources of 0–15 minutes was associated with significantly higher odds of getting malaria among children (AOR = 1.68, 95% CI = 1.11–2.56) compared to walk time distance above 15 minutes. Households which used pit latrines with slabs and those without any toilet facility or used bushes were 1.48 (AOR = 1.48, 95% CI = 1.03–2.13) and 3.29 (AOR = 3.29, 95% CI = 1.54–7.05) times more likely to have their children obtaining malaria ($p < 0.05$). Using open pits also increased the risk for malaria infections (AOR = 6.67, 95% CI = 0.47–0.97). From Table 3, it is further indicated that households whose walls were constructed using thatch and cardboard were 4.50 (AOR = 2.50, 95% CI = 0.11-56.0) and 2.30 (AOR = 2.30, 95%=1.39–13.2) times more likely to have their children contracting malaria compared to households whose walls were built with brick and cement or mud ($p < 0.05$). Additionally, households with thatch roofs were 2.12 (AOR = 2.12, 95% CI = 0.94–4.79) times more likely to have their children contracting malaria compared households with roofs constructed of tarpaulins and iron sheets.

Malaria prevention risk factors

From Table 3, it is clearly indicated that households which did not have ITNs or sprayed their households with insecticides, were 1.15 (AOD = 1.15, 95% CI = 0.43–3.13) and 8.04 (AOD = 8.04, 95% CI = 2.47–26.2) times more likely to have their children contracting malaria compared to households which had implemented these preventive interventions. Further, households whose children did not sleep under ITNs were associated with significantly higher risk of malaria infection in children (AOD = 1.30, 955 CI = 0.58–2.49) compared to those households whose children slept under ITNs. Households which did not have access to malaria preventive medicine were 4.84 (AOD = 4.84, 95%=1.82–12.8) more likely to have their children getting malaria compared to those households which had access.

Risk factors associated with knowledge on malaria transmission and prevention

Households which did not know that mosquito bites caused malaria were 1.09 (AOD = 1.09, 95%=0.79–1.51) times more likely to have their children contracting malaria compared to those which knew. Households which indicated that eating maize and mangoes as the causes of malaria were 2.96 (AOD = 2.96, 95% CI = 1.13–7.75) and 1.22 AOD = 1.22, 95% CI = 0.47–3.19) times more likely to have their children contracting malaria respectively compared to those households which knew the actual causes ($p < 0.05$). Households which indicated that malaria could not be avoided were 2.14 (AOD = 2.14, 95%=1.29–3.55) times more likely to have their children contracting malaria. The odds of children contracting malaria were high in households which did not know that sleeping under the net (AOD = 1.61, 95% CI = 1.16–2.23) and destroying breeding sites (AOD = 1.99, 95% CI = 1.44–2.76) were the ways of avoiding malaria

Discussion

Uganda is located in an unstable region where conflicts continue to generate significant number refugees into the country. The concentration and crowding of refugees in settlement camps in Uganda is a fertile ground for malaria transmission within these settings and hosting communities. Despite their refugee status, malaria prevention and elimination programs in Uganda should embrace the principle of 'leaving no one behind' which is promoted by the United Nations. This study aimed at providing an overview of the determinants for malaria risk among children in refugee settlements using the nationally representative malaria data. The strength of this study is therefore largely premised on the generalisations arising from the use of this type of dataset. One implication of the study findings is that the national malaria control programs that do not consider refugee settlements are unlikely to have major impacts in eliminating malaria in Uganda by 2030.

Although other studies indicated that infants less than 12 months of age were the most vulnerable groups to be affected by malaria (44–46), the results of this study suggested that households with children aged 31 months and above were more likely to have their children contracting malaria in refugee settlements. There are several potential reasons for the difference. Refugee settlements are distinct and complex with people coming from diverse social-cultural and economic backgrounds. Thus, little is known of the neonatal and infant care practices, social norms, and behavioral patterns adopted by refugees to reduce malaria infections and other diseases. The high risk of malaria infection in children aged 31 months and older could, however, be attributed to the fact that at this age, the children were more active (i.e. crawling, walking, removing clothes, uncovering during sleep etc.), making them more susceptible to mosquito bites. Moreover, during this age, most of children are weaned when they have not yet acquired natural immunity to manage or fight high parasite density (47). Other studies have linked malaria risk among children between 24 to 60 months to malnutrition, although the evidence remains inconclusive (48). The shift in age groups at high risk of malaria as observed from children aged 31 months and above in this study, suggests the need to expand prevention and free treatment strategies for older children in order to cover the peak transmission months in refugee settlements.

The odds for contracting malaria among children were significantly higher among households headed by refugees aged 15–24 years. This is due to in part that refugees aged 15–24 years are within the category of 'child and young migrants' and may not have adequate knowledge about child care, malaria transmission and prevention and at the same time, may lack financial resources and support for malaria prevention measures and treatment. This study further revealed that increase in the age of household head reduced the odds of malaria infections in children. This result is contrary to other studies conducted in Nigeria (49) and SSA which indicate that increase in ages of both male and female head of household increased the odds of malaria prevalence among children under five years of age (37, 38). This contradiction can be explained by the population variations and age dynamics between refugee and non-refugee settlements. Moreover, such studies never considered refugee settlements yet context specific behavioural and social cultural information are key to understanding the interactions that propel the risks for malaria within these local dynamic settings.

The result of this study shows that lack of education among mothers was significantly associated with a risk of malaria among children compared to those households with educated mothers. This result is consistent with findings from other studies (21, 37, 38, 49). Since mothers are at the core of family welfare and wellbeing, their level of education is an essential social determinant of health and influences their ability to make better decisions about the health of children. Since adult literacy programmes for mothers in refugee settlements are rare, larger scale health promotional campaigns focusing on malaria diagnosis, prevention, and treatment are required. Such health education campaigns have worked well in endemic communities where knowledge about malaria and newer interventions are often lacking (43). For example, a study conducted in Ethiopia indicated that children whose parents received training and awareness about use of ITNs were found to be at a lower risk of malaria infection compared to those who did not have any training (38). The findings of this study further suggest that poor households were more likely to have their children contracting malaria. This result is in line with other study findings (43, 45). The cost of malaria diagnosis, treatment and prevention may seem high for the poor households who face other constraints and daily expenses. Distribution of ITN, conducting IRS and destruction of mosquito breeding sites are options that need to be explored in refugee settlements.

Although smoke from biomass cooking is often associated with reduced mosquito abundance and malaria transmission (50), the results of this study indicated that households which used firewood and straw for cooking were more likely to have their children contracting malaria compared to households which used charcoal. This result is consistent with other studies (51). There are potential reasons to this finding. Women and children in refugee settlements gather much of the firewood used in their households and this exposes them to frequent mosquito bites in the forests and bushes where firewood is obtained. Besides, firewood piles near households serve as daytime hiding place for mosquitoes. Additionally, the shift in mosquito behavior from indoor late-night biting to outdoor early-evening biting (52, 53) coincides well with the major outdoor cooking activities in most refugee homesteads. Some studies in non-refugee settlements, however, indicate no association between outdoor cooking practices and malaria infections among children (54). Nevertheless, epidemiological modelling (13) is required to better understand the relationships between cooking practices, cooking fuel emissions, mosquito activity and risk of malaria acquisition among children in refugee settlements. Such modelling can be vital in supporting appropriate malaria prevention messaging and evidence based decision making in this context. Although charcoal use was associated with reduced malaria risk, it is one of the fundamental drivers of deforestation in refugee hosting districts and beyond, thus, its use in malaria control programs is not advisable in both short and long run.

This study found out that households which obtained water from open water sources and water tanks were more likely to have their children contracting malaria. This result is consistent with other studies (37, 38, 43). This is likely due to several reasons. First, open water sources like rivers, ponds, lakes, swamps, dams, wells and springs serve as meeting places for humans and mosquitoes. Given the fact that mothers and children fetch most of the water from these sources, the chances of mosquito bites are high. Second, these water sources are potential oviposition sites which are crucial for reproductive success and population dynamics of mosquitoes (55). Third, these open water sources shorten the gonotrophic cycle (56) especially when located near refugee households. Water tanks as a key malaria risk factor is not surprising because they act as breeding sites for mosquitoes. Households which obtained water from boreholes and public water taps were less likely to have their children contracting malaria, although other studies indicated the opposite (15, 57). This study also revealed short walk time distance (0–15 minutes) to water sources was one of the risk factors for malaria among children. This result is in line with other studies focusing on malaria infections and distance to water sources (58, 59). Although distant water sources were associated with reduced malaria risk, this result should not hamper efforts geared to improve water access in refugee settlements. This is because reducing the time to fetch water has been observed to improve child health (60). Thus, given the land use and land cover changes within refugee settlements, environmental management practices such as draining stagnant water, dredging water channels, clearing vegetation among others, should be applied to water sources to reduce mosquitoes breeding and survival.

Regarding sanitation, households which had pit-latrines and those without any toilet facility were more likely to have their children contracting malaria. This result not surprising because mosquitoes have overtime started changing their breeding preference to contaminated surroundings (61). Similar findings have been observed in other studies (21, 37, 57, 59). Based on this finding, interventions need to be strengthened so that pit-latrines which are commonly used within refugee settlements are vector borne free. For example, mosquitoes in pit-latrines can suppressed when expanded polystyrene beads are used.

Regarding housing structure, this study revealed that the odds of malaria infections increased among children living in houses with grass thatch roofs, thatch and cardboard walls. This result is consistent with a systematic review meta-analysis study on socioeconomic determinants of malaria burden in SSA (38). Walls made up with thatch and cardboards allow mosquitoes to enter into households with ease (42). Additionally, thatch provides conducive indoor resting grounds for mosquitoes since there are associated with cool temperatures which can sustain survival of mosquitoes indoors (62). Thus, the choice of building materials for house construction in refugee settlements should be carefully selected to minimize malaria risk. For example, this study revealed that households with brick walls and iron sheet roofs were less likely to have their children contracting malaria, although the odds were not significant. However, a recent study conducted in SSA (63) revealed that metal-roofed houses contributed to the decline in malaria burden, since they were associated with higher temperatures and lower humidity which reduced survivorship of indoor-resting mosquitoes.

The odds of contracting malaria among children were significantly higher in households which did not have ITNs, spray against mosquitoes or lacked access to malaria prevention medicines. Some studies reported similar results (21, 38, 49). Although our study indicated that ITNs and IRS were effective in reducing the risk for malaria, there are limited in scope and efficacy. For example, IRS intervention apply to mosquitoes which feed and rest indoors, while ITNs prevent night mosquito bites just around the beds. This limitation provides opportunities for outdoor active mosquitoes to multiply while sustaining some level of transmission beyond the reach of ITNs and IRS. Additionally, in some cases, mosquitoes have developed resistance to pyrethroids used in ITNs and IRS (64). Moreover, their continued use has led to an apparent shift in mosquito behavioural traits (i.e. insecticide avoidance and early-exit behaviours among indoor-feeding vectors) (65). Despite these protection gaps, promotion of ITNs and IRS should continue in refugee settlements. Moreover, since mothers in refugee settlements engage in various outdoor activities at night (21), provision of nets for outdoor spaces in combination with IRS may be an additional strategy to effectively reduce the incidence of malaria among children. The effectiveness and efficacy of ITNs and IRS can be improved and strengthened by promoting environmentally based interventions which reduce mosquito survival and human-vector contact. However, there is a need for continued formative research and strong collaboration between the scientific community and other stakeholders to coordinate malaria elimination strategies that are adapted to the local social context of refugee settlements.

The results of this study suggest that households which did not know the causes and prevention of malaria were more likely to have their children contracting malaria. This result is consistent with a systematic review on studies conducted in Southeast Asia where it was observed that poor knowledge and awareness about malaria transmission was related to some families using nets for reasons other than malaria prevention, such as fishing and for warmth (43). Similar results are reported from SSA especially among the rural and uneducated individuals (38, 39, 66). The finding of our study underscores the need for more education, training and communication initiatives to complement delivery of integrated malaria programmes that include mass malaria drug administration in refugee settlements.

Conclusions

Malaria infections among children continue to circulate in many refugee settlements in Uganda. Based on the 2018-19 UMIS dataset, this study identified the risk factors for malaria infections among children which need special attention within the framework of humanitarian assistance. Refugee households which used firewood and straw for cooking, fetched water from open water sources and water tanks were more likely to have their children contracting malaria. In addition, households which used pit latrines and those without any toilet facility were more likely to have their children getting malaria infections. The odds of contracting malaria among children also increased in households with thatch walls and roofs, those without preventive measures and those which had limited knowledge on the causes and prevention of malaria. This study highlights potential research gaps about ITNs and IRS protection inadequacies, malaria disease and intervention knowledge among others which require further investigation. On the basis of the results the following recommendations are made. Since ITN and IRS have potential protection gaps, their combination with environmental management interventions should be the focus of special attention in refugee settlements. We further recommend the distribution of mosquito repellents and outdoor mosquito nets for use during out-door activities at night. There is need to focus on the sociocultural differences of refugee and how these translate into social norms and behavioural patterns that could affect access and behaviours towards malaria diagnosis, treatment, and prevention measures. Large scale health promotion campaigns focusing on the causes of malaria, symptoms, and treatment and prevention measures are required. Strategies to reduce inequities and poverty among refugees may help to reduce the burden of malaria in settlements. Promotion of renewable indoor cooking fuels such as gas, solar and electricity can be promoted in refugee settlements to reduce on the risk of malaria. Future studies can examine the impact of additional factors on the risk for malaria that have not been studied here.

Abbreviations

AOR: Adjusted Odds Ratio; BST: Blood Smear Test; Cl: Confidence interval; COVID-19: Coronavirus disease; DHS: Demographic and Health Surveys; IRS: Indoor Residual Spraying; ITNs: Insecticide-Treated Bed-nets; UOR: RDT: Rapid Diagnostic Test; Unadjusted Odds Ratio; UMIS: Uganda Malaria Indicator Survey, WHO: World Health Organization.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles stated in the Helsinki Declaration. The launch of MIS (phase DHS-VII) data collection was conditional on the authorisation of the National Statistical Council and the approval of the National Committee on Health Research Ethics. During data collection, the informed consent of eligible respondents was sought before starting the interviews. The dataset used was fully anonymised.

Consent for publication

Not applicable.

Availability of data and materials

The data used in this study can be obtained by sending a request via the DHS Program website and upon approval data can be obtained from https://dhsprogram.com/data/dataset/Uganda_MIS_2018.cfm?flag=1

Competing interests

Neither of the authors discloses any potential or actual conflict of interest. No financial or nonfinancial benefits have been or will be received from any party related directly or indirectly to the subject of this article.

Funding

This research received no external funding.

Authors' contributions

H.M.S. contributed to conceptualisation, methodology, data acquisition, formal analysis, visualisation, validation, preparation, revision and editing of the original draft. S.L. participated in conceptualisation, methodology, validation, revision of the original draft and supervision. P.I.M, F.M, M.S, D.N, H.W and P.K helped with the conceptualisation, revision of the original draft. All authors approved the final manuscript. All authors read and approved this version of the manuscript.

Acknowledgements

We would like to thank the DHS program for authorising us to use the data used in this study.

References

1. WHO. World Malaria Report [Internet]. Vol. WHO/HTM/GM, World Health., 2022. Available from: https://www.who.int/publications/i/item/9789240064898
2. Ngotho P, Soares AB, Hentzschel F, Achcar F, Bertuccini L, Marti M. Revisiting gametocyte biology in malaria parasites. FEMS Microbiol Rev. 2019;43(4):401–14.
3. Hussein MIH, Albashir AAD, Elawad OAMA, Homeida A, Malaria. and COVID-19: unmasking their ties. Malar J [Internet]. 2020;19(1):1–10. Available from: https://doi.org/10.1186/s12936-020-03541-w
4. Semakula HM, Song G, Achuu SP, Shen M, Chen J, Mukwaya PI et al. Prediction of future malaria hotspots under climate change in sub-Saharan Africa.Clim Change. 2017
5. Ryan SJ, Lippi CA, Zermoglio F. Shifting transmission risk for malaria in Africa with climate change: A framework for planning and intervention. Malar J [Internet]. 2020;19(1):1–14. Available from: https://doi.org/10.1186/s12936-020-03224-6
6. Ahmed S, Reithinger R, Kaptoge SK, Ngondi JM. Travel is a key risk factor for malaria transmission in pre-elimination settings in Sub-Saharan Africa: A review of the literature and meta-analysis. Am J Trop Med Hyg. 2020;103(4):1380–7.
7. Ciddio M, Mari L, Sokolow SH, De Leo GA, Casagrandi R, Gatto M. The spatial spread of schistosomiasis: A multidimensional network model applied to Saint-Louis region, Senegal. Adv Water Resour. 2017 Oct;1:108:406–15.
8. Mari L, Gatto M, Ciddio M, DIa ED, Sokolow SH, De Leo GA et al. Big-data-driven modeling unveils country-wide drivers of endemic schistosomiasis. Sci Rep [Internet]. 2017;7(1):1–11. Available from: http://dx.doi.org/10.1038/s41598-017-00493-1
9. Wesolowski A, Buckee CO, Engø-Monsen K, Metcalf CJE. Connecting mobility to infectious diseases: The promise and limits of mobile phone data. J Infect Dis. 2016;214(Suppl 4):414–20.
10. UNHCR. Global Trends Forced Displacement In 2021 [Internet]. 2021. Available from: https://www.unhcr.org/62a9d1494/global-trends-report-2021
11. Messenger LA, Furnival-Adams J, Pelloquin B, Rowland M. Vector control for malaria prevention during humanitarian emergencies: Protocol for a systematic review and meta-analysis. BMJ Open. 2021;11(7):1–10.
12. Eshag HA, Elnzer E, Nahied E, Talib M, Mussa A, Muhajir AEMA, et al. Molecular epidemiology of malaria parasite amongst patients in a displaced people's camp in Sudan. Trop Med Health. 2020;48(1):1–7.
13. Aylett-Bullock J, Gilman RT, Hall I, Kennedy D, Evers ES, Katta A, et al. Epidemiological modelling in refugee and internally displaced people settlements: Challenges and ways forward. BMJ Glob Heal. 2022;7(3):1–10.
14. Tatem AJ, Jia P, Ordanovich D, Falkner M, Huang Z, Howes R et al. The geography of imported malaria to non-endemic countries: a meta-analysis of nationally reported statistics. Lancet Infect Dis [Internet]. 2017;17(1):98–107. Available from: http://dx.doi.org/10.1016/S1473-3099(16)30326-7
15. Semakula HM, Song G, Achuu SP, Zhang S. A Bayesian belief network modelling of household factors influencing the risk of malaria: A study of parasitaemia in children under five years of age in sub-Saharan Africa.Environ Model Softw. 2016;75.
16. Hershey CL, Doocy S, Anderson J, Haskew C, Spiegel P, Moss WJ. Incidence and risk factors for Malaria, pneumonia and diarrhea in children under 5 in UNHCR refugee camps: A retrospective study. Confl Health. 2011;5(1):1–11.
17. Tegegne Y, Asmelash D, Ambachew S, Eshetie S, Addisu A, Jejaw Zeleke A. The Prevalence of Malaria among Pregnant Women in Ethiopia: A Systematic Review and Meta-Analysis. J Parasitol Res. 2019;2019.
18. Obebe OO, Falohun OO. Epidemiology of malaria among HIV/AIDS patients in sub-Saharan Africa: A systematic review and meta-analysis of observational studies. Acta Trop [Internet]. 2021;215:105798. Available from: https://doi.org/10.1016/j.actatropica.2020.105798
19. Sherrard-Smith E, Griffin JT, Winskill P, Corbel V, Pennetier C, Djénontin A et al. Systematic review of indoor residual spray efficacy and effectiveness against Plasmodium falciparum in Africa.Nat Commun. 2018;9(1).
20. Pryce J, Medley N, Choi L. Indoor residual spraying for preventing malaria in communities using insecticide-treated nets.Cochrane Database Syst Rev. 2022;2022(1).
21. Takarinda KP, Nyadundu S, Govha E, Gombe NT, Chadambuka A, Juru T et al. Factors associated with a malaria outbreak at Tongogara refugee camp in Chipinge District, Zimbabwe, 2021: a case–control study. Malar J [Internet]. 2022;21(1):1–12. Available from: https://doi.org/10.1186/s12936-022-04106-9
22. Tepa A, Abame I, Makamta V, Fongang B, Donkeu J, Ayong L et al. Nutritional Status and Humoral Immune Response to Plasmodium falciparum in Children Aged 6–59 Months. J Trop Med. 2020;2020.
23. Ahimbisibwe F. Uganda and the refugee problem: challenges and opportunities. Afr J Polit Sci Int Relations. 2019;13(5):62–72.
24. UNHCR. Uganda Country Refugee Response Plan. UNHCR, Reg Refug Coord Off. 2018;(December):49.
25. Oboth P, Gavamukulya Y, Barugahare BJ. Prevalence and clinical outcomes of Plasmodium falciparum and intestinal parasitic infections among children in Kiryandongo refugee camp, mid-Western Uganda: A cross sectional study. BMC Infect Dis. 2019;19(1):1–8.
26. Bukuluki P, Kisaakye P, Mwenyango H, Palattiyil G. Adolescent sexual behaviour in a refugee setting in Uganda. Reprod Health [Internet]. 2021;18(1):1–11. Available from: https://doi.org/10.1186/s12978-021-01181-0
27. Bukuluki P, Mwenyango H, Katongole SP, Sidhva D, Palattiyil G. The socio-economic and psychosocial impact of Covid-19 pandemic on urban refugees in Uganda. Soc Sci Humanit Open [Internet]. 2020;2(1):100045. Available from: https://doi.org/10.1016/j.ssaho.2020.100045

28. Brigham AM, Mukwaya PI, Khasalamwa-Mwandha S. The Corona Pandemic's Impact on the Food and Nutrition Security of Refugees in. RuralisNo [Internet]. 2021;(1). Available from: https://ruralis.no/wp-content/uploads/2021/05/ny-rapport-1_21-refugee-fsn-corona-pandemic-1.pdf
29. Mugerwa-Sekawabe M. Increasing access to education for refugees in Uganda. Law Democr Dev. 2021;25:1–29.
30. Grosrenaud E, Okia CA, Adam-Bradford A, Trenchard L, Agroforestry. Challenges and opportunities in rhino camp and imvepi refugee settlements of arua district, northern uganda. Sustain. 2021;13(4):1–18.
31. Mwangu AR. An assessment of economic and environmental impacts of refugees in Nakivale, Uganda. Migr Dev [Internet]. 2022;11(3):433–49. Available from: https://doi.org/10.1080/21632324.2020.1787105
32. NMCD U and, Uganda Malaria D. Indicator Survey 2018-19. Kampala, Uganda, [Internet]. 2020. Available from: https://www.dhsprogram.com/pubs/pdf/MIS34/MIS34.pdf
33. World Bank. An Assessment of Uganda ' s Progressive Approach to Refugee Management [Internet]. Washington. ; 2016. Available from: https://openknowledge.worldbank.org/bitstream/handle/10986/24736/An0assessment00o0refugee0management.pdf?sequence=1&isAllowed=y
34. World Bank. Informing the Refugee Policy Response in Uganda; Informing the Refugee Policy Response in Uganda: Results from the Uganda Refugee and Host Communities 2018 Household Survey [Internet]. 2019. Available from: http://hdl.handle.net/10986/32511
35. Björkman A, Shakely D, Ali AS, Morris U, Mkali H, Abbas AK, et al. From high to low malaria transmission in Zanzibar - Challenges and opportunities to achieve elimination. BMC Med. 2019;17(1):1–15.
36. Obasohan PE, Walters SJ, Jacques R, Khatab K. A scoping review of the risk factors associated with anaemia among children under five years in sub-Saharan African countries. Int J Environ Res Public Health. 2020;17(23):1–20.
37. Boyce MR, Katz R, Standley CJ. Risk factors for infectious diseases in urban environments of sub-Saharan Africa: A systematic review and critical appraisal of evidence.Trop Med Infect Dis. 2019;4(4).
38. Degarege A, Fennie K, Degarege D, Chennupati S, Madhivanan P. Improving socioeconomic status may reduce the burden of malaria in sub Saharan Africa: A systematic review and meta-analysis. PLoS ONE. 2019;14(1):1–26.
39. Okumu F, Gyapong M, Casamitjana N, Castro MC, Itoe MA, Okonofua F, et al. What Africa can do to accelerate and sustain progress against malaria. PLOS Glob Public Heal. 2022;2(6):e0000262.
40. Furnival-Adams J, Olanga EA, Napier M, Garner P. House modifications for preventing malaria.Cochrane Database Syst Rev. 2021;2021(1).
41. Vilcins D, Sly PD, Jagals P. Environmental Risk Factors Associated with Child Stunting: A Systematic Review of the Literature. Ann Glob Heal [Internet]. 2018;84(4):551–62. Available from: https://www.researchgate.net/publication/328753452_Environmental_Risk_Factors_Associated_with_Child_Stunting_A_Systematic_Review_of_the_Literat
42. Furnival-Adams J, Olanga EA, Napier M, Garner P. Housing interventions for preventing malaria. Cochrane Database Syst Rev. 2019;2019:8.
43. Cheng B, Htoo SN, Mhote NPP, Davison CM. A systematic review of factors influencing participation in two types of malaria prevention intervention in Southeast Asia. Malar J [Internet]. 2021;20(1):1–9. Available from: https://doi.org/10.1186/s12936-021-03733-y
44. Kamau A, Mtanje G, Mataza C, Mwambingu G, Mturi N, Mohammed S et al. Malaria infection, disease and mortality among children and adults on the coast of Kenya. Malar J [Internet]. 2020;19(1):1–12. Available from: https://doi.org/10.1186/s12936-020-03286-6
45. Kwambai TK, Mori AT, Nevitt S, van Eijk AM, Samuels AM, Robberstad B et al. Post-discharge morbidity and mortality in children admitted with severe anaemia and other health conditions in malaria-endemic settings in Africa: a systematic review and meta-analysis. Lancet Child Adolesc Heal. 2022 Jul 1;6(7):474–83.
46. Ngari MM, Berkley JA. Severe anaemia and paediatric mortality after hospital discharge in Africa. Lancet Child Adolesc Heal. 2022 Jul;1(7):447–9.
47. Tabue RN, Njeambosay BA, Zeukeng F, Esemu LF, Fodjo BAY, Nyonglema P et al. Case Definitions of Clinical Malaria in Children from Three Health Districts in the North Region of Cameroon. 2019; Available from: https://doi.org/10.1155/2019/9709013
48. Das D, Grais RF, Okiro EA, Stepniewska K, Mansoor R, Van Der Kam S, et al. Complex interactions between malaria and malnutrition: A systematic literature review. BMC Med. 2018;16(1):1–14.
49. Ugwu CLJ, Zewotir TT. Improving socioeconomic status may reduce the burden of malaria in sub Saharan Africa: A systematic review and meta-analysis. Malar J [Internet]. 2018;17(1):1–10. Available from: https://doi.org/10.1186/s12936-018-2604-y
50. Tamire M, Addissie A, Skovbjerg S, Andersson R, Lärstad M. Socio-cultural reasons and community perceptions regarding indoor cooking using biomass fuel and traditional stoves in rural ethiopia: A qualitative study.Int J Environ Res Public Health. 2018;15(9).
51. Mohan I, Kumar Kodali N, Chellappan S, Karuppusamy B, Kumar Behera S, Natarajan G et al. Socio-economic and household determinants of malaria in adults aged 45 and above: analysis of longitudinal ageing survey in India, 2017–2018. Malar J [Internet]. 2021;20:306. Available from: https://doi.org/10.1186/s12936-021-03840-w
52. Gryseels C, Durnez L, Gerrets R, Uk S, Suon S, Set S et al. Re-imagining malaria: heterogeneity of human and mosquito behaviour in relation to residual malaria transmission in Cambodia.Malar J. 2015;14.
53. Degefa T, Githeko AK, Lee MC, Yan G, Yewhalaw D. Patterns of human exposure to early evening and outdoor biting mosquitoes and residual malaria transmission in Ethiopia. Acta Trop. 2021 Apr 1;216:105837.
54. Woolley KE, Bartington SE, Pope FD, Greenfield SM, Tusting LS, Price MJ et al. Cooking outdoors or with cleaner fuels does not increase malarial risk in children under 5 years: a cross-sectional study of 17 sub-Saharan African countries. Malar J [Internet]. 2022;21(1):1–15. Available from: https://doi.org/10.1186/s12936-022-04152-3
55. Ignell R, Hill SR. Malaria mosquito chemical ecology. Curr Opin Insect Sci [Internet]. 2020;40:6–10. Available from: https://doi.org/10.1016/j.cois.2020.03.008

56. Shaw WR, Marcenac P, Catteruccia F. Plasmodium development in Anopheles: a tale of shared resources.Trends Parasitol. 2022 Feb1;38(2):124–35.
57. Yang D, He Y, Wu B, Deng Y, Li M, Yang Q et al. Drinking water and sanitation conditions are associated with the risk of malaria among children under five years old in sub-Saharan Africa: A logistic regression model analysis of national survey data.J Adv Res. 2020 Jan1;21:1–13.
58. Mangani C, Frake AN, Chipula G, Mkwaila W, Kakota T, Mambo I, et al. Proximity of Residence to Irrigation Determines Malaria Risk and Anopheles Abundance at an Irrigated Agroecosystem in Malawi. Am J Trop Med Hyg. 2022;106(1):283–92.
59. Obasohan PE, Walters SJ, Jacques R, Khatab K. A scoping review of selected studies on predictor variables associated with the malaria status among children under five years in sub-Saharan Africa. Int J Environ Res Public Health. 2021;18(4):1–21.
60. Pickering AJ, Davis J. Freshwater Availability and Water Fetching Distance Affect Child Health in Sub-Saharan Africa. Environ Sci Technol. 2012;46(4):2391–7.
61. De Silva PM, Marshall JM, Silva PM, De, Marshall JM, De Silva PM, Marshall JM. Factors contributing to urban malaria transmission in sub-saharan Africa: A systematic review. J Trop Med [Internet]. 2012 Jan [cited 2014 Aug 11];2012:819563. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3483782&tool=pmcentrez&rendertype=abstract
62. Paaijmans KP, Thomas MB. The influence of mosquito resting behaviour and associated microclimate for malaria risk. Malar J [Internet]. 2011;10(1):183. Available from: http://www.malariajournal.com/content/10/1/183
63. Lindsay SW, Jawara M, Mwesigwa J, Achan J, Bayoh N, Bradley J, et al. Reduced mosquito survival in metal-roof houses may contribute to a decline in malaria transmission in sub-Saharan Africa. Sci Rep. 2019;9(1):1–10.
64. Richards SL, Byrd BD, Reiskind MH, White AV. Assessing Insecticide Resistance in Adult Mosquitoes: Perspectives on Current Methods.Environ Health Insights. 2020;14.
65. Carrasco D, Lefèvre T, Moiroux N, Pennetier C, Chandre F, Cohuet A. Behavioural adaptations of mosquito vectors to insecticide control.Curr Opin Insect Sci. 2019 Aug1;34:48–54.
66. Orok AB, Ajibaye O, Aina OO, Iboma G, Adagyo Oboshi S, Iwalokun B. Malaria interventions and control programes in Sub-Saharan Africa: A narrative review. Cogent Med [Internet]. 2021;8(1). Available from: https://doi.org/10.1080/2331205X.2021.1940639

Figures

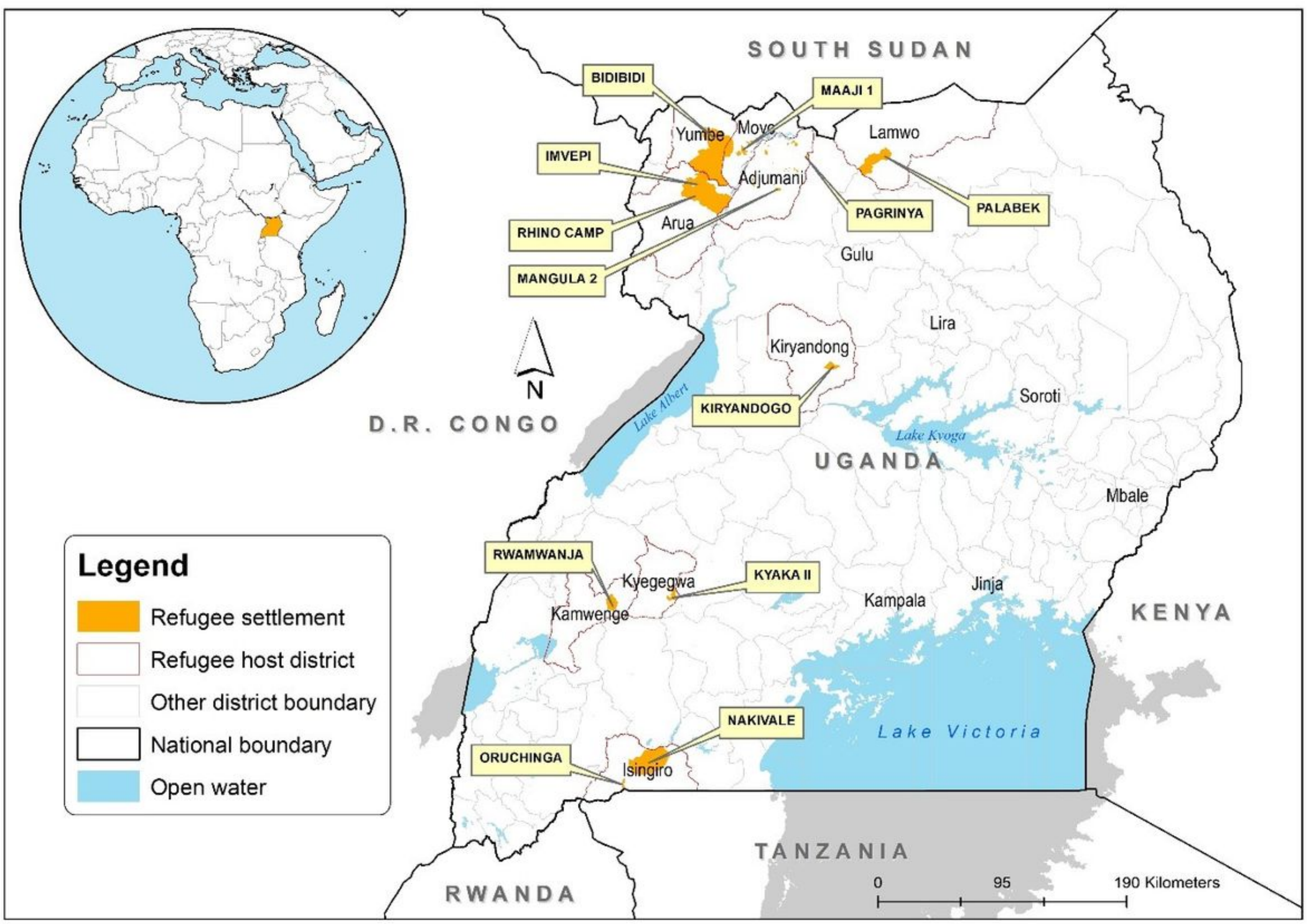

Figure 1

Refugee hosting districts in Uganda

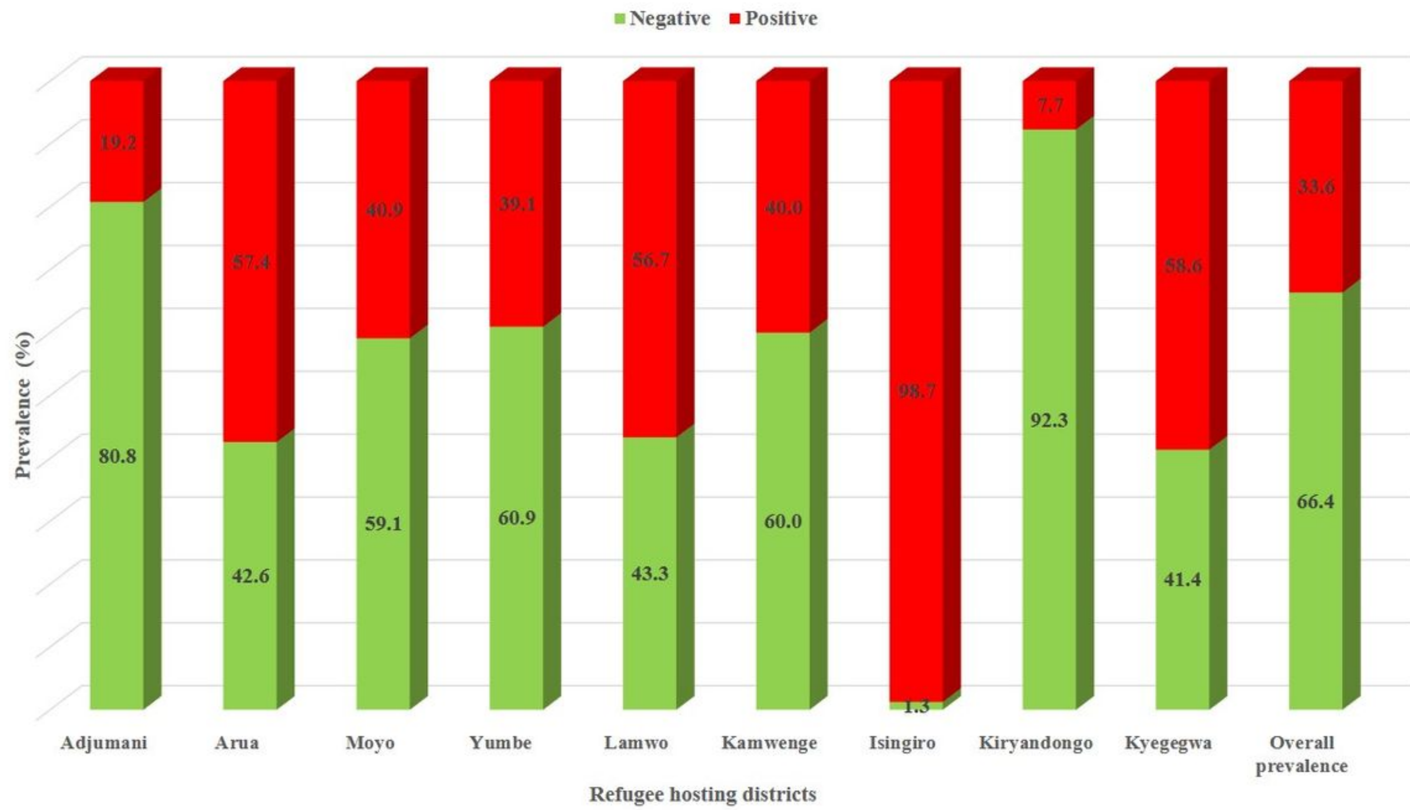

Figure 2

Prevalence of malaria infections among the screened children in refugee settlements