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Unravelling factors associated with malaria parasitaemia among children 6–24 months to inform malaria interventions in Nigeria: evidence from 2021 Malaria Indicator Survey

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Abstract

Background As an additional two million malaria cases were reported in 2021 compared to the previous year, concerted efforts toward achieving a steady decline in malaria cases are needed to achieve malaria elimination goals. This work aimed at determining the factors associated with malaria parasitaemia among children 6–24 months for better targeting of malaria interventions.

Methods A cross-sectional study analysed 2021 Nigeria Malaria Indicator Survey dataset. Data from 3058 children 6–24 months were analyzed. The outcome variable was children 6–24 months whose parasitaemia was determined using a rapid diagnostic test (RDT). Independent variables include child age in months, mothers' age, mothers' education, region, place of residence, household ownership and child use of insecticide-treated net (ITN), exposure to malaria messages and knowledge of ways to prevent malaria. Logistic regression analysis was conducted to examine possible factors associated with malaria parasitaemia in children 6–24 months.

Results Findings revealed that 28.7% of the 3058 children aged 6–24 months tested positive for malaria by RDT. About 63% of children 12–17 months (aOR = 1.63, 95% CI 1.31–2.03) and 91% of children 18 to 24 months (aOR = 1.91, 95% CI 1.51–2.42) were more likely to have a positive malaria test result. Positive malaria test result was also more likely in rural areas (aOR = 1.79, 95% CI 2.02–24.46), northeast (aOR = 1.54, 95% CI 1.02–2.31) and northwest (aOR = 1.63, 95% CI 1.10–2.40) region. In addition, about 39% of children who slept under ITN had a positive malaria test result (aOR = 1.39, 95% CI 1.01–1.90). While children of mothers with secondary (aOR = 0.40, 95% CI 0.29–0.56) and higher (aOR = 0.26, 95% CI 0.16–0.43) levels of education and mothers who were aware of ways of avoiding malaria (aOR = 0.69, 95% CI 0.53–0.90) were less likely to have a malaria positive test result.

Conclusion As older children 12 to 24 months, children residing in the rural, northeast, and northwest region are more likely to have malaria, additional intervention should target them in an effort to end malaria.

Keywords Malaria, Nigeria, Children, Parasitaemia, Cross-sectional study

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Background

Despite advancements made globally through the implementation of international and national malaria control programmes, malaria still remains a global public health challenge with 247 million cases and 619,000 malaria-related deaths reported in the year 2021 [1]. With an additional two million malaria cases reported in 2021 compared to the previous year, concerted efforts toward achieving a steady decline in malaria cases are needed. Four countries account for 52% of all global malaria deaths with Nigeria accounting for 31% of the deaths [1]. Without accelerated action, the progress expected towards achieving malaria elimination according to the Global Technical Strategy for malaria may be unattained in 2030.

Over the years, pregnant women and children under five are most vulnerable to malaria, with severity and mortality higher among these vulnerable groups [2–5]. Although malaria control strategies target the general population, but intensive efforts focus on the most vulnerable population. In Nigeria, malaria control interventions include the use of insecticide-treated nets (ITN), prevention of malaria in pregnant women (IPTp), seasonal malaria chemoprevention (SMC) in children 6–59 months using sulfadoxine–pyrimethamine, and amodiaquine (SPAQ), prompt diagnosis of malaria cases and treatment with artemisinin-based combination therapy (ACT) [5]. These interventions have been effective in reducing morbidity and mortality due to malaria [6–8]. As such resulted in 45% decline in malaria prevalence from 42% to 2010 to 23% in 2018 [9]. However, the 2021 Nigeria Malaria Indicator Survey (NMIS) reported a slight decrease (4%) in malaria prevalence to 22% [10].

Without relenting in efforts to tackle the scourge of malaria, investments, innovations, new developments, and initiatives are being put in place to reduce the burden of malaria. In the Nigeria National Malaria Strategic Plan (2021–2025), Intermittent preventive treatment in infant (IPTi) now perennial malaria chemoprevention (PMC) evaluation pilot is proposed for states where seasonal malaria chemoprevention is not implemented. The World Health Organization (WHO) has recommended PMC be extended to children up to 24 months due to increased malaria prevalence among younger children [11]. In addition, WHO recommended RTS,S/AS01 malaria vaccine for the prevention of *Plasmodium falciparum* malaria in children living in regions with moderate to high malaria transmission will also be deployed to children in a four dose schedule starting from 5 months of age [11–13]. Deploying PMC and malaria vaccine in addition with existing interventions for malaria prevention would complement efforts

to save children in Nigeria. Re-investigating malaria risk factors prior to deployment of new interventions is vital to inform effective delivery of new innovations for malaria prevention in children and achieve the leave no one behind ambition [14].

Prevalence of malaria and associated factors have been explored in pregnant women and delivering mothers [15–17]. Similar study has also been conducted in children under five and children up to 14 years old including neonates [18–22], and the general population [23]. Some studies have also explored prevalence of malaria in young children less than 6 months old [24, 25] and the first year of life [26]. This paper aim to explore factors associated with malaria parasitaemia in children 6–24 months old. Understanding factors associated with malaria parasitaemia in children are essential for better targeting of malaria control efforts.

Methods

This study analysed cross-sectional survey data from 2021 NMIS. Survey was based on a nationally representative sample drawn from all states and local government area of the country. Analysis of NMIS dataset was conducted after adjusting for survey design cluster and non-response using the individual weight contained in the dataset. Population analysed was children 6–24 months. The outcome variable was children 6–24 months whose malaria parasitaemia was determined using rapid diagnostic test (RDT) during the survey. The independent variables included in the analysis include child's age in months, mothers' age, mothers' education, region, place of residence, mothers' exposure to malaria messages and her knowledge of malaria prevention. Protective factor against the parasite by using an insecticide-treated net (ITN) was explored by including household ownership, and child use of ITN as independent variables. These variables were chosen as previous studies have established their association with malaria parasitaemia [18, 20, 23, 27–31].

Both bivariate and multivariate statistical data analyses were performed using the statistical package Stata/SE 14.0. While bivariate analysis explored the malaria parasitaemia in comparison with the independent variables. The chi-squared test of independence was used to determine any significant associations between malaria parasitaemia and the independent variables. Variables with p-value < 0.2 at bivariate level were included into the logistic regression model and the unadjusted and adjusted odds ratio were derived to examine possible factors associated with malaria parasitaemia in children. Significant associations were measured at 5% alpha level ($p < 0.05$).

Ethical consideration

This study utilized a population based NMIS dataset obtained from The Demographic Health Survey (DHS) Program, which was available online. The survey was approved by National Health Research Ethical Committee of Nigeria (NHREC) and ICF institutional Review Board. Informed consent was obtained from the caregivers of the children to participate in the survey and for blood sample collected from the children. The DHS Program followed regulations for guarding respondents' privacy while gathering data. DHS also deleted all personally identifiable information from the online-accessible dataset. This study didn't need any further ethical approvals because the DHS Program already requested and gained approval before the survey. Authors were given permission by the DHS Program to utilize the dataset for this study.

Results

Descriptive analysis presents the sociodemographic characteristics of children 6–24 months and the prevalence of malaria parasitaemia. While bivariate and multivariate analysis determined the factors associated with malaria parasitaemia in children 6–24 months.

Sociodemographic characteristics

A total of 3058 children 6–24 months were included in the study. Table 1 shows the socio demographic characteristics of these children. About 974 (31.8%) were aged 6–11 months; 1031 (33.7%) were aged 12–17 months while 1053 (34.4%) were aged 18–24 months old. Findings revealed that a higher proportion (51.1%) of their mothers were aged 25–34 years. About 43.2% of mothers had no education, while one out of three mother (30.8%) had secondary level of education. A higher proportion of the children (71.6%) reside in rural areas. While 2048 (67.0%) children live in households that had insecticide-treated nets (ITNs) almost half of the children (47.7%) slept under ITN the night before the survey. About 43.4% of mothers of these children were exposed to malaria messages in the last 6 months while 79.4% were aware of ways of preventing malaria.

Prevalence of malaria parasitaemia

Data on 3058 children 6–24 months analysed revealed 878 (28.7%) of the children tested positive to malaria with RDT. Figure 1 shows prevalence of malaria by age in months. Results show an increase in the malaria cases from 6 months of age, which plateaus between 8 and 10 months and peaked at 13th months, 17th month and 20th months of age. Higher malaria cases were

seen in the second year of life compared to the first year of life.

Bivariate and multivariate analysis

Table 2 presents the bivariate analysis of the factors associated with malaria parasitaemia in children 6–24 months by sociodemographic characteristics. Findings show that malaria parasitaemia was associated with the age of child in months, age of mother, education of mother, region, place of residence, sleeping under ITN, mothers' exposure to malaria messages in the past 6 months and knowledge of ways of preventing malaria ($p < 0.05$). While malaria prevalence in children 6–11 months was 21.9%. Malaria prevalence in children 12–17 months (32.1%) and 18–24 months (31.7%) were significantly higher ($P < 0.000$). Malaria parasitaemia was also significantly associated with place of residence ($P < 0.000$). About 33.7% of children in the rural area had a positive malaria test result compared to 16.1% in the urban area. Geographic variation was also observed with Northeast (36.3%) and Northwest (37.2%) having higher prevalence compared to other regions. Children of mothers with secondary (17.3%) and higher level of education (9.4%) were significantly less likely to have a positive test result compared to children whose mother had primary (31.2%) and no education (40.8%). Interestingly, about 32.8% ($P < 0.001$) of children whose mother reported that they slept under an ITN the night before the survey had a positive test result. While children of mothers' who have seen or heard malaria messages (24.9%) and mothers' who know ways of avoiding malaria (26.1%) were significantly less likely ($p < 0.001$) to have a positive malaria test result.

Table 1 also presents result of the multivariable logistic regression analysis. Findings show that children 12–17 months were about 63% more likely to have a positive test result (aOR = 1.63, 95% CI 1.31–2.03) while children 18–24 months were 91% more likely to have a positive test result. (aOR = 1.91, 95% CI 1.51–2.42). Similarly, children whose mother have secondary (aOR = 0.40, 95% CI 0.29–0.56) and higher (aOR = 0.26, 95% CI 0.16–0.43) level of education were less likely to have a positive malaria test result. Children residing in rural area were about twice (aOR = 1.79, 95% CI 1.36–2.36) more likely to have a positive malaria test result compared to their counterparts in the urban areas. Similarly, children in the Northeast (aOR = 1.54, 95% CI 1.02–2.31) and Northwest (aOR = 1.63, 95% CI 1.10–2.40) regions were more likely to have a positive malaria test result compared to their counterparts in other regions. Children whose mother stated they slept under ITN the night before the survey were about 39% more likely to test positive to malaria (aOR = 1.39 95%

Table 1 Sociodemographic characteristics and factors associated with malaria parasitaemia in children 6 to 24 months in Nigeria (N = 3058)

Variables	n (%)	Malaria positive to RDT	
		Crude OR (95% CI)	Adjusted OR (95% CI)
Child age (months)			
6–11 months	974 (31.8)	1.00	1.00
12–17 months	1031 (33.7)	1.70 (1.38–2.08)	1.63 (1.31–2.03)
18–24 months	1053 (34.4)	1.66 (1.32–2.09)	1.91 (1.51–2.42)
Mothers age			
15–24 years	820 (26.8)	1.00	1.00
25–34 years	1562 (51.1)	0.73 (0.59–0.90)	0.91 (0.73–1.13)
35 years and above	677 (22.1)	0.76 (0.58–1.00)	0.86 (0.65–1.13)
Mothers educational level			
No education	1322 (43.2)	1.00	1.00
Primary	469 (15.3)	0.66 (0.48–0.88)	0.76 (0.55–1.04)
Secondary	942 (30.8)	0.30 (0.23–0.40)	0.40 (0.29–0.56)
Higher	326 (10.7)	0.15 (0.10–0.24)	0.26 (0.16–0.43)
Mother heard/seen malaria messages			
No	1732 (56.6)	1.00	1.00
Yes	1326 (43.4)	0.72 (0.58–0.87)	0.95 (0.76–1.18)
Mother know ways to avoid getting malaria			
No	630 (20.6)	1.00	1.00
Yes	2427 (79.4)	0.55 (0.44–0.70)	0.69 (0.53–0.90)
Sex of household head			
Male	2868 (93.8)		
Female	190 (6.2)		
Household own ITN			
No	1010 (33.0)	1.00	1.00
Yes	2048 (67.0)	1.20 (0.96–1.51)	0.78 (0.58–1.06)
Child slept under ITN			
No	1601 (52.3)	1.00	1.00
Yes	1457 (47.7)	1.46 (1.16–1.83)	1.39 (1.01–1.90)
Region			
Northcentral	554 (18.1)	1.00	1.00
Northeast	506 (16.6)	1.85 (1.24–2.78)	1.54 (1.02–2.31)
Northwest	1082 (35.4)	1.93 (1.33–2.79)	1.63 (1.10–2.40)
Southeast	232 (7.6)	0.78 (0.46–1.32)	1.26 (0.69–2.30)
Southsouth	318 (10.4)	0.96 (0.60–1.52)	1.46 (0.85–2.49)
Southwest	365 (11.9)	0.46 (0.28–0.76)	0.96 (0.56–1.67)
Place of residence			
Rural	2191 (71.6)	1.00	
Urban	867 (28.4)	2.65 (1.97–3.56)	1.79 (1.36–2.36)

CI 1.01–1.90) while children whose mother know ways to avoid malaria were less likely (aOR = 0.69, 95% CI 0.53–0.90) to have a positive malaria test result.

Discussion

This study examined factors associated with malaria parasitaemia in children 6–24 months by conducting a secondary data analysis of 2021 NMIS dataset. The true

prevalence of malaria in children has not been characterized and this is expedient with the epidemiological shift in population at risk to malaria [24, 32]. Findings highlight a malaria prevalence of 28.7% in children aged 6–24 months old using RDT, with prevalence higher in children more than 12 months compared to younger children. This finding confirmed increased malaria prevalence in children more than one year in Nigeria. Previous

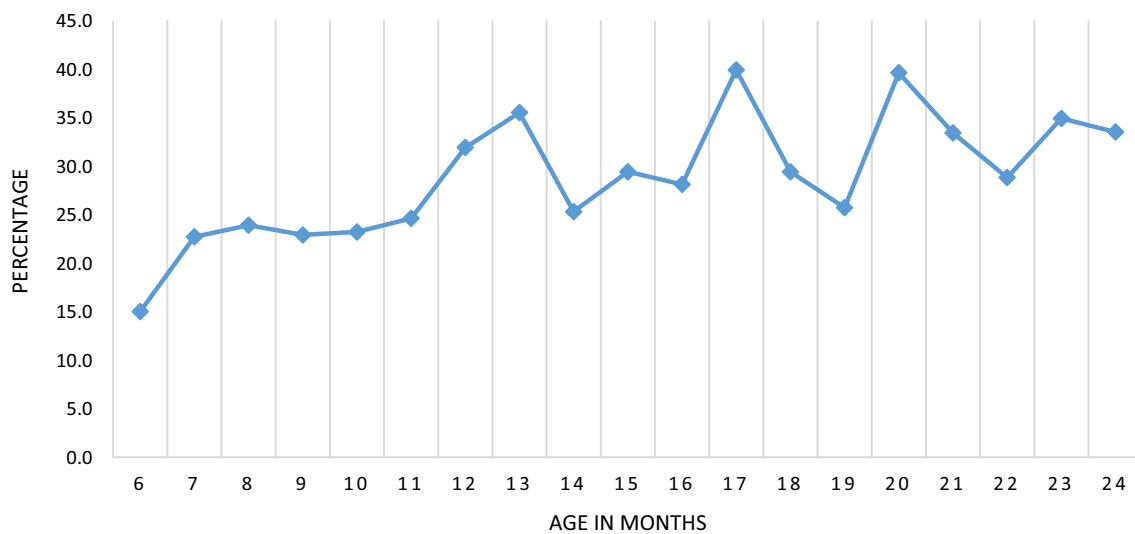


Fig. 1 Prevalence of malaria parasitaemia in children 6–24 months using RDT

studies have also reported increased prevalence of malaria with increased age of persons in the population [30, 33, 34]. As prevalence of malaria in these children is higher than 10%, targeted malaria prevention approach is required for this age group. The National Malaria Strategic Plan articulates the countries malaria prevention and control strategies towards a malaria free Nigeria. The newly introduced tool RTS,S malaria vaccine is reported to result in significant reduction in clinical malaria, severe malaria and severe malaria anaemia [35]. Positioning this intervention across the country should be based on evidence on malaria prevalence and possible factors associated with malaria. This study which enables understanding of the factors' association with malaria in children revealed child age, mother's education, region, knowledge of ways to prevent malaria and place of residence were associated with malaria parasitaemia in children 6–24 months old. This finding is similar to several other studies. For instance, some studies have documented children residing in rural areas have higher prevalence of malaria than children in urban areas [21, 36]. This is attributed to dirty environments common in rural areas, which increase the likelihood of contacting malaria. Another study also showed that malaria is well acknowledged as a disease of poor communities common in rural areas [17, 37]. As progress made in reducing malaria prevalence in children is a measure to assess the achievement of leave no one behind global ambition [14], additional interventions such as malaria vaccine which has a high potential of reducing inequality of accessing existing intervention should target underserved children to protect them from malaria [38].

Several studies have confirmed sleeping under ITN protects from malaria with reduced prevalence in children who slept under ITN [18, 27, 29]. This study agrees with these findings as majority of the children who slept under ITN were protected, while about 39% of children who slept under ITN had a positive test result. The likelihood of children who used ITN to have malaria has been reported elsewhere [39]. Those that had a positive result could have been exposed to mosquitoes at a time when net was not used [27, 34, 40]. As maternally acquired protection from malaria will have waned after 6 months and a steady increase in malaria cases seen with increase in child age, danger of morbidity and mortality due to malaria need to be averted in these children. Social behaviour change communication (SBCC) has increased the impact of health intervention in hygiene, HIV and nutrition and can improve malaria prevention and treatment behaviour [41–43]. This study has also demonstrated the effect of behaviour change communication (BCC) on malaria as knowledge of malaria was associated with lower prevalence of malaria parasitaemia. As BCC has notably improved behaviour in several interventions, interpersonal communication at community and health facilities should target women with lower level of education whose children have a higher prevalence of malaria to increase their knowledge about malaria prevention and treatment. The identified factors associated to malaria prevalence presented in this study should be considered for better targeting of interventions.

Strength and limitations

This study has a representative sample at regional and national level to guide malaria prevention strategy in

Table 2 Malaria parasitaemia in children 6 to 24 months by sociodemographic characteristics

Variables	Malaria parasitaemia in children 6–24 months		P value
	Negative n (%)	Positive n (%)	
Child age (months)			0.000
6–11 months	761 (78.1)	213 (21.9)	
12–17 months	700 (67.8)	332 (32.1)	
18–24 months	719 (71.3)	334 (31.7)	
Mothers age			0.01
15–24 years	545 (66.5)	274 (33.5)	
25–34 years	1144 (73.2)	418 (26.8)	
35 years and above	490 (72.5)	186 (27.5)	
Mothers educational level			0.000
No education	783 (59.2)	538 (40.8)	
Primary	322 (68.8)	146 (31.2)	
Secondary	779 (82.7)	163 (17.3)	
Higher	295 (90.6)	31 (9.4)	
Mother heard/seen malaria messages			0.001
No	1184 (68.3)	548 (31.7)	
Yes	995 (75.1)	330 (24.9)	
Mother know ways to avoid getting malaria			0.000
No	385 (61.1)	245 (38.9)	
Yes	1794 (73.9)	633 (26.1)	
Household own ITN			0.110
No	745 (73.8)	265 (26.2)	
Yes	1434 (70.0)	614 (30.0)	
Child slept under ITN			0.001
No	1200 (75.0)	401 (25.1)	
Yes	980 (67.2)	478 (32.8)	
Place of residence			0.000
Rural	1452 (66.3)	739 (33.7)	
Urban	727 (83.9)	140 (16.1)	
Region			0.000
Northcentral	424 (76.5)	130 (23.5)	
Northeast	323 (63.7)	184 (36.3)	
Northwest	680 (62.8)	402 (37.2)	
Southeast	188 (80.7)	45 (19.3)	
South south	246 (77.3)	72 (22.7)	
South west	320 (87.6)	45 (12.4)	
Total	2179 (71.3)	878 (28.7)	

children less than two years old and decision-making. Being a cross-sectional study, results captured point prevalence of malaria. As such seasonal trends in malaria transmission was not accounted for in this study.

Conclusion

Older children 12 to 24 months and children residing in the rural areas, northeast and northwest region were more likely to have a positive malaria test result while children whose mothers have a higher level of education

and know how to prevent malaria were less likely to have a positive malaria test result. Additional malaria intervention should target children under two years old at higher risk to malaria to attain malaria elimination goals.

Abbreviations

ACT	Artemisinin-based combination therapy
BCC	Behaviour change communication
DHS	Demographic Health Survey
IPTi	Intermittent preventive treatment in infant
ITN	Insecticide-treated net

NHREC	National Health Research Ethical Committee of Nigeria
NMIS	Nigeria Malaria Indicator Survey
PMC	Perennial malaria chemoprevention
RDT	Rapid diagnostic test
SMC	Seasonal malaria chemoprevention
SPAQ	Sulfadoxine–pyrimethamine and amodiaquine
WHO	World Health Organization

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Author contributions

CNU conceived the idea of the work, conducted statistical data analysis, and drafted the manuscript. OAM provided technical oversight to the manuscript development. All authors made valuable input to the concept, review of the manuscript, agreed on all aspects of the work and approved the final version.

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Availability of data and materials

The datasets used for this work are available with permission in the Demographic Health Survey Program repository, at <http://www.dhsprogram.com/data/dataset>.

Declarations

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

- WHO. World malaria report 2022. Geneva: World Health Organization; 2022. <https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report>. Accessed 28 Jan 2023.
- Schantz-Dunn J, Nour NM. Malaria and pregnancy: a global health perspective. *Rev Obstet Gynecol*. 2009;2:186–92.
- Lufele E, Umbers A, Ordi J, Ome-Kaius M, Wangnapi R, Unger H, et al. Risk factors and pregnancy outcomes associated with placental malaria in a prospective cohort of Papua New Guinean women. *Malar J*. 2017;16:427.
- Afoakwah C, Deng X, Onur I. Malaria infection among children under-five: the use of large-scale interventions in Ghana. *BMC Public Health*. 2018;18:536.
- WHO. First malaria vaccine in Africa: a potential new tool for child health and improved malaria control. Geneva: World Health Organization; 2019.
- Cairns M, Ceessay SJ, Sagara I, Zongo I, Kessely H, Gamougam K, et al. Effectiveness of seasonal malaria chemoprevention (SMC) treatments when SMC is implemented at scale: case–control studies in 5 countries. *PLoS Med*. 2021;18: e1003727.
- Baba E, Hamade P, Kivumbi H, Marasciulo M, Maxwell K, Moroso D, Roca-Feltrer A, Sanogo A, Johansson JS, Tibenderana J, Abdoulaye R. Effectiveness of seasonal malaria chemoprevention at scale in West and Central Africa: an observational study. *Lancet*. 2020;39:1829–40.
- Lindblade KA, Mwandama D, Mzilahowa T, Steinhardt L, Gimnig J, Shah M, et al. A cohort study of the effectiveness of insecticide-treated bed nets to prevent malaria in an area of moderate pyrethroid resistance, Malawi. *Malar J*. 2015;14:31.
- National Population Commission (NPC), [Nigeria], and ICF. 2019. Nigeria demographic health survey 2018. Abuja, Nigeria, Rockville, Maryland, USA: NPC/ICF. <https://dhsprogram.com/pubs/pdf/FR359/FR359.pdf>. Accessed 12 Jan 2022.
- National Malaria Elimination Programme (NMEP) [Nigeria], National Population Commission (NPC) [Nigeria], and ICF. 2022. Nigeria malaria indicator survey 2021 final report. Abuja, Nigeria, and Rockville, Maryland, USA: NMEP, NPC, and ICF. <https://dhsprogram.com/pubs/pdf/MIS41/MIS41.pdf>. Accessed 28 Jan 2023.
- WHO. Guidelines for malaria (3 June 2022). Geneva: World Health Organization, ReliefWeb. <https://reliefweb.int/report/world/who-guidelines-malaria-3-june-2022>. Accessed 14 June 2022.
- Baral R, Levin A, Odero C, Pecenka C, Tabu C, Mwendu E, et al. Costs of continuing RTS,S/AS01E malaria vaccination in the three malaria vaccine pilot implementation countries. *PLoS ONE*. 2021;16: e0244995.
- van den Berg M, Ogutu B, Sewankambo NK, Biller-Andorno N, Tanner M. RTS,S malaria vaccine pilot studies: addressing the human realities in large-scale clinical trials. *Trials*. 2019;20:316.
- Ren M. Greater political commitment needed to eliminate malaria. *Infect Dis Poverty*. 2019;8:28.
- Agomo CO, Oyibo WA. Factors associated with risk of malaria infection among pregnant women in Lagos, Nigeria. *Infect Dis Poverty*. 2013;2: 19.
- Gontie GB, Wolde HF, Baraki AG. Prevalence and associated factors of malaria among pregnant women in Sherko district, Benishangul Gumuz regional state, West Ethiopia. *BMC Infect Dis*. 2020;20:573.
- Limenh A, Gelaye W, Alemu G. Prevalence of malaria and associated factors among delivering mothers in Northwest Ethiopia. *BioMed Res Int*. 2021;2021:2754407.
- Workineh L, Lakew M, Dires S, Kiros T, Damtie S, Hailemichael W, et al. Prevalence of malaria and associated factors among children attending health institutions at South Gondar Zone, Northwest Ethiopia: a cross-sectional study. *Glob Pediatr Health*. 2021;8:2333794X211059107.
- Falade C, Mokuolu O, Okafor H, Orogade A, Falade A, Adedoyin O, et al. Epidemiology of congenital malaria in Nigeria: a multi-centre study. *Trop Med Int Health*. 2007;12:1279–87.
- Ajakaye OG, Ibukunoluwa MR. Prevalence and risk of malaria, anemia and malnutrition among children in IDPs camp in Edo State, Nigeria. *Parasite Epidemiol Control*. 2019;8:e00127.
- Beavogui AH, Delamou A, Camara BS, Camara D, Kourouma K, Camara R, et al. Prevalence of malaria and factors associated with infection in children aged 6 months to 9 years in Guinea: results from a national cross-sectional study. *Parasite Epidemiol Control*. 2020;11: e00162.
- Habyarimana F, Ramroop S. Prevalence and risk factors associated with malaria among children aged six months to years old in Rwanda: evidence from 2017 Rwanda malaria indicator survey. *Int J Environ Res Public Health*. 2020;17: 7975.
- Duguma T, Nuri A, Melaku Y. Prevalence of malaria and associated risk factors among the community of Mizan-Aman town and its catchment area in Southwest Ethiopia. *J Parasitol Res*. 2022;2022:1–8.
- Ceesay SJ, Koivogui L, Nahum A, Taal MA, Okebe J, Affara M, et al. Malaria prevalence among young infants in different transmission settings, Africa. *Emerg Infect Dis*. 2015;21:1114.
- Folarin OF, Kuti BP, Oyelami AO. Heavy malaria parasitaemia in young Nigerian infants: prevalence, determinants and implication for the health system. *West Afr J Med*. 2022;39:154–61.
- Natama HM, Rovira-Vallbona E, Somé MA, Zango SH, Sorgho H, Guetens P, et al. Malaria incidence and prevalence during the first year of life in Nanoro, Burkina Faso: a birth-cohort study. *Malar J*. 2018;17:163.
- Awosolu OB, Yahaya ZS, Haziqah MTF. Prevalence. Parasite density and determinants of falciparum malaria among febrile children in some peri-urban communities in Southwestern Nigeria: a cross-sectional study. *Infect Drug Resist*. 2021;14:3219–32.
- Abossie A, Yohanes T, Nedu A, Tafesse W, Damitie M. Prevalence of malaria and associated risk factors among febrile children under five years: a

- cross-sectional study in Arba Minch Zuria District, South Ethiopia. *Infect Drug Resist.* 2020;13:363–72.
29. Ahmed A, Mulatu K, Eflu B. Prevalence of malaria and associated factors among under-five children in Sherkole refugee camp, Benishangul-Gumuz region, Ethiopia. A cross-sectional study. *PLoS ONE.* 2021;16:e0246895.
 30. Sultana M, Sheikh N, Mahumud RA, Jahir T, Islam Z, Sarker AR. Prevalence and associated determinants of malaria parasites among Kenyan children. *Trop Med Health.* 2017;45:25.
 31. Morakinyo OM, Balogun FM, Fagbamigbe AF. Housing type and risk of malaria among under-five children in Nigeria: evidence from the malaria indicator survey. *Malar J.* 2018;17:311.
 32. D'Alessandro U, Ubben D, Hamed K, Ceesay SJ, Okebe J, Taal M, et al. Malaria in infants aged less than six months—is it an area of unmet medical need? *Malar J.* 2012;11:400.
 33. Dawaki S, Al-Mekhlafi HM, Ithoi I, Ibrahim J, Atroosh WM, Abdulsalam AM, et al. Is Nigeria winning the battle against malaria? Prevalence, risk factors and KAP assessment among Hausa communities in Kano State. *Malar J.* 2016;15:351.
 34. Roberts D, Matthews G. Risk factors of malaria in children under the age of five years old in Uganda. *Malar J.* 2016;15:246.
 35. RTS,S Clinical Trials Partnership. Efficacy and safety of, RTS,S/AS01 malaria vaccine with or without a booster dose in infants and children in Africa: final results of a phase 3, individually randomised, controlled trial. *Lancet.* 2015;386:31–45.
 36. Yankson R, Anto EA, Chipeta MG. Geostatistical analysis and mapping of malaria risk in children under 5 using point-referenced prevalence data in Ghana. *Malar J.* 2019;18:67.
 37. Yusuf OB, Adeoye BW, Oladepo OO, Peters DH, Bishai D. Poverty and fever vulnerability in Nigeria: a multilevel analysis. *Malar J.* 2010;9: 235.
 38. Unwin HJT, Mwandigha L, Winskill P, Ghani AC, Hogan AB. Analysis of the potential for a malaria vaccine to reduce gaps in malaria intervention coverage. *Malar J.* 2021;20:438.
 39. Wanzira H, Katamba H, Okullo AE, Agaba B, Kasule M, Rubahika D. Factors associated with malaria parasitaemia among children under 5 years in Uganda: a secondary data analysis of the 2014 malaria indicator survey dataset. *Malar J.* 2017;16:191.
 40. Tsegaye AT, Ayele A, Birhanu S. Prevalence and associated factors of malaria in children under the age of five years in Wogera district, north-west Ethiopia: a cross-sectional study. *PLoS ONE.* 2021;16: e0257944.
 41. Koenker H, Keating J, Allio M, Acosta A, Lynch M, Nafu-Traore F. Strategic roles for behaviour change communication in a changing malaria landscape. *Malar J.* 2014;13: 1.
 42. Wakefield MA, Loken B, Hornik RC. Use of mass media campaigns to change health behaviour. *Lancet.* 2010;376:1261–71.
 43. Curtis V, Kanki B, Cousens S, Diallo I, Kpozehouen A, Sangaré M, et al. Evidence of behaviour change following a hygiene promotion programme in Burkina Faso. *Bull World Health Organ.* 2001;79:518–27.

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