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Prevalence and factors associated with childhood malaria and anaemia in Osun state, Nigeria: a baseline household malariometric study

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Abstract

Background Under-5 children have been known to bear a significant burden of malaria in endemic countries. Though significant progress has been made towards malaria prevention and control in Nigeria, it is expected that the addition of new malaria prevention strategy, such as perennial malaria chemoprevention (PMC) can contribute to a more rapid decline in malaria cases. This study aimed to determine the prevalence and factors associated with malaria and anaemia among children aged 2–18 months in Osun State.

Methods A cross-sectional household malariometric study was conducted in 80 communities across eight Local Government areas (LGAs) in Osun State. Ethical approval was obtained from Osun State Health Research Ethical Committee (OSHREC/PRS/569T312/ on the 22nd of May 2023. Malaria test positivity was determined by rapid diagnostic test (RDT) and microscopy. In addition, haemoglobin levels were measured using Haemocue® Hb 201. Caregivers were interviewed on malaria management practices using tools adapted from Nigeria Malaria Indicator Survey.

Results A total of four hundred children aged 2–18 months were assessed in this study, which was conducted in July 2023. The caregivers were mostly the biological mothers of the children (n = 387, 96.8%). Female children were 51.8% and their male counterparts 48.2% respectively. Malaria positivity rate by RDT was 36.8% and this was higher in children aged 13–18 months (48.0%) and followed by those aged 7–12 months (44.0%). By microscopy, the positivity rate was 12.5% overall, with 15.0% positivity rate among children aged 7–12 months, about 13.5% among those 13–18 months and those aged 2–6 months had the least positivity rate whether by microscopy (8.5%) or RDT (18.5%). Overall, the prevalence of severe anaemia was 4.0%, moderate was 37.3%, mild was 18.3% and the normal was 40.4% respectively. However, higher proportion of moderate anaemia (7.0–9.9 haemoglobin (g/dL)) was reported in older children. Children from medium wealth households (aOR = 0.549; 95% CI 0.306–0.986) and those from rich households (aOR = 0.543; 95% CI 0.283–1.042) had 45.0% reduction in the odds of having malaria, when compared with their

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counterparts from poor households. In addition, children aged 7–12 months (aOR = 2.856; 95% CI 1.524–5.354) and those aged 13–18 months (aOR = 4.269; 95% CI 2.422–7.526) had higher odds of malaria infection, respectively, when compared with children aged 2–6 months.

Conclusion Malaria infection and anaemia were found to be higher in older children. Household wealth and child's age were significantly associated with malaria infection. These findings would inform the positioning of PMC intervention touch-points to reduce malaria burden in young children.

Keywords Malariometric, Prevalence, Malaria, Children, Anaemia, PMC, IPTi, Osun State, Nigeria

Background

Malaria remains a significant public health problem in Nigeria. With Nigeria contributing 27% of global malaria burden, it is the highest malaria burden country and one of four countries accounting for nearly half of the global malaria cases, followed by the Democratic Republic of the Congo (12%), Uganda (5%) and Mozambique (4%) [1]. In Nigeria, malaria disproportionately affects under-5 children. It is the primary cause of morbidity and mortality for this age group, with over 95,000 deaths from malaria annually [2].

Nigeria faces persistent challenges in controlling and eliminating malaria because several factors contribute to the high burden, including widespread poverty, inadequate access to healthcare, and insufficient use of preventive measures such as insecticide-treated nets (ITNs) and indoor residual spraying (IRS) [3]. The substantial rise in Nigeria's population is causing a double burden of infectious diseases such as malaria, leading to higher morbidity, and mortality rates, increased healthcare costs, decreased productivity, and health inequalities, posing significant challenges to the country's healthcare system [4]. Additionally, drug resistance by parasites, insecticide resistance by vectors and climatic conditions that favour mosquito breeding could be contributing to malaria persistence in endemic countries. Efforts to combat malaria in Nigeria have involved the implementation of various strategies, such as the distribution of ITNs, provision of intermittent preventive treatment in pregnancy (IPTp), and ensuring prompt diagnosis and effective treatment of malaria cases. In addition, there are ongoing efforts to provide evidence for the implementation of perennial malaria chemoprevention (PMC) [5].

The World Health Organization (WHO) has recommended the use of PMC in areas of moderate-to-high transmission to prevent malaria among young children. The children at high-risk of malaria infection can be given antimalarial medicines at predefined intervals to prevent transmission. National malaria programmes can now tailor the strategy, specifically, the age, number and timing of drug doses uptake based on evidence of the local context. The strategy recommends using expanded programme on immunization (EPI) as the platform for delivering PMC. This recommendation is made even in places where the marker of SP resistance *dihydropteroate synthase* (*dhps*) K540E is greater than the threshold of 50% that was previously used as criteria not to implement PMC intervention. To support decision-making at the country level, PMC recommendation must be accompanied by available research evidence. The WHO encourages acquisition of evidence in the local context, before national malaria programmes' adoption, adaptation and scale-up [6].

This study was conducted to provide baseline data prior to the commencement of the implementation of PMC which would ultimately determine the scalability of deploying PMC as a malaria prevention measure in Nigeria. Women of reproductive age (15–49 years) were interviewed and their children aged 2–18 months recruited for biomarker testing. Parasitaemia and anaemia biomarkers collected at baseline would be compared with endline measures after PMC implementation to measure PMC effectiveness for policy decision-making and scale-up.

Methods

Study design

This was a cross-sectional malariometric household survey conducted in July 2023 in Osun state, Nigeria that included children aged 2–18 months from randomly selected communities across 80 political wards from eight local government areas (LGAs).

Exclusion criteria

1. Children with signs of severe or complicated malaria or other ailments
2. Patients that were currently on antimalarials
3. Children with other febrile conditions that are similar to malaria infection.

Inclusion criteria

1. Children with no signs of clinical malaria

2. Children aged 2–18 months
3. Usual residents of the study communities
4. Children with no recent antimalarial treatment (within 14 days of the study)

Target age group

The baseline survey conducted biomarker tests on children aged 2–18 months. Four hundred (400) children were randomly selected across 80 clusters/communities (five (5) from each cluster/community) in eight LGAs. The data collectors mobilized the eligible children from selected households, to a designated centre within the community. At this centre, a team of laboratory scientists collected blood samples from the children. The laboratory scientist ensured that the children from whom blood samples were collected were the same for whom sociodemographic data had been obtained, and whose caregivers had been interviewed in their respective households. This approach helped maintain the consistency and integrity of the data gathered throughout the survey, ensuring a comprehensive and reliable understanding of the targeted population's health and other characteristics.

Sampling technique

A two-stage sampling approach was used, where at least one settlement was selected in each of the 80 wards across eight LGAs and 5 households were randomly selected in each cluster/community from the list of eligible households. One child was randomly selected per household. The five (5) children sampled from each cluster/community were tested for malaria and anaemia.

Study population(s) questionnaire

Three questionnaires were utilized based on the study objectives. Moreover, a household roster was developed to elicit basic information about the entire members of the household including visitors who spent the night before the survey. These include name, sex, age, residency status, and line number.

- Household questionnaire covered various aspects, such as household characteristics, information about the women or caregivers and children in the household. The respondent to this questionnaire was usually the head of the household. The questions included demographic information about the respondent and household members, including their age, sex, occupation, education level as well as household characteristics (wall, floor, roof, and number of rooms amongst others) to determine the wealth tertile. In addition, the household questionnaire collected information on ownership and use of bed nets.
- Woman questionnaire was used to collect information related to women living in the households such as information about children born in the last five years. All women aged 15–49 years identified in the household were interviewed. This also contained information on the woman's background characteristics such as age, educational level, pregnancy and birth, health-seeking behaviour, and malaria prevention knowledge in relation to antenatal health care.
- Child questionnaire captured basic information about every child selected for the study. Information such as age, sex, history of fever, malaria, hospital admission due to malaria amongst others were captured.

Training of research assistants and laboratory scientists

A 3-day training was conducted for the laboratory scientists, facilitated by Nigerian Institute of Medical Research (NIMR) who supported the sample collection. The training consisted of didactic lectures and hands-on sessions for aseptic and optimum collection of blood samples for rapid diagnostic tests (RDT), microscopy, haemoglobin concentration (Hb) and dry blood spot (DBS). The scope of the training included the survey and its objectives, contextual overview of malaria disease burden, malaria diagnostic techniques, preparation of thick and thin blood films for malaria microscopy, RDT, good clinical or laboratory practice, human subject research, malaria sample collection on DBS, hands-on demonstration, practical challenges in RDT and test quality assessment. A pre-and post-test was conducted to analyse the training impact.

Sample size estimation

To determine the sample size for the prevalence of malaria among children aged 2–18 months, the following formula was used:

$$\mathrm{n} = \frac{Z^2 * P * (1 - P)}{d^2}$$

where:

n = required sample size.

Z = Z-score (the number of standard deviations corresponding to the desired confidence level): For a 95% confidence level, Z = 1.96.

p = estimated prevalence (0.5 was used as there was no literature for the prevalence of malaria among children 2–18 months in Osun State).

d = margin of error (0.05)

$$n = \frac{1.96^2 * 0.5 * (1 - 0.5)}{0.05^2}$$

Using a 5% non-response rate, sample size of about 400 was obtained.

Data collection

The data collection was conducted July 2023. The malariometric survey team assigned a unique identifier to each interviewee according to each LGA, cluster/community and household number using the standard operating procedure (SOP). In addition, sociodemographic and clinical information were captured for all children that were randomly selected. This included their age, sex, height, weight, temperature, haemoglobin concentration, positive or negative malaria test results by RDT.

Blood sample collection and processing

A sample size of four hundred (400) children aged 2–18 months was determined for the malaria and anaemia testing. Blood samples were collected from all eligible children whose caregivers gave written informed consent. Blood from finger prick made with lancet was collected from the middle finger that was cleaned with alcohol swabs according to the WHO approved best practices [7]. Drops of blood taken from the same heel or finger prick was used to test for the presence of malaria parasite by RDT, measure haemoglobin concentration with a HemoCue analyzer, prepare two copies of thick and thin blood films for microscopy[8], and make three blood spots on Whatmann 3MM filter papers (DBS).

Plasmodium RDT cassettes, microscopy slides, cuvettes for HemoCue and filter paper for DBS were labelled with participants' unique identifier and date of sampling before samples were taken. Histidine-Rich Protein 2 (HRP2) RDT was conducted according to manufacturer's manual and blood spotted on the filter paper according to the SOP. The filter papers were air dried and stored individually in plastic sleeves with seal-locks with desiccant sachets. These blood spot samples are currently stored at room temperature away from extreme light and heat for future parasite genotyping assays (NGS). Haemoglobin concentration assessed with concentration < 7.0 g/dl and those with malaria infection were referred to the nearest health facility for treatment [9]. Thin films of duplicate blood slides for microscopy were fixed and the films stained with 3% Giemsa for 1 h.

Data management and statistical analysis

The household wealth tertile was computed using the principal components analysis (PCA) technique. Scores were assigned and the wealth indicator variable was standardized using household assets such as floor type, wall type, roof type, water source, sanitation facilities, radio, electricity, television, refrigerator, cooking fuel, furniture, and number of persons per room. Then, the factor loadings and z-scores were calculated. For each household, the indicator values were multiplied by the loadings and summed to produce the household's wealth index value. The standardized z-score was used to classify the overall scores to wealth tertile (poor, medium, rich). Data was collected and entered into Microsoft Excel and exported to Stata Version 16 (StataCorp; College Station, TX, USA) for further analysis. Counts, percentage and descriptive statistics were used for univariate estimates. The prevalence of malaria parasites was expressed in percentage. For bivariate analysis, Chi-square test was used. The variable(s) statistically significant at $p < 0.05$ were included in the multivariable logistic regression. A multivariable logistic regression analysis was used to examine the factors associated with malaria infection among children aged 2–18 months.

Laboratory analysis

Malaria microscopy slides were stained in the field and later read in the NIMR laboratory. The microscopy results such as detection, species, stage, gametocyte detection, asexual parasite count, gametocyte count were included. During data analysis, the children household data were linked by the unique identifier to the samples collected for malariometric assessment. The slides were examined at a magnification of a 1000 X binocular light microscope and the parasites counted [10]. Parasite densities were determined by reading the thick blood smears and counting the number of asexual parasites and the number of leukocytes for 200 high-powered fields. Slides were considered negative if no parasite was detected after reading 200 high-powered fields. The presence of gametocytes was also recorded. Thin blood smears were reviewed for non *P. falciparum* infections. Two microscopists read all slides independently, and parasite densities were calculated by averaging the two counts. In case of ≥ 20% variance in counts between primary and secondary microscopists, a third microscopist read the slide, and the average of the two closest parasite densities was retained [11].

Definition of anaemia

Haemoglobin levels were calculated to determine the anaemia status. A Hb reading of Hb < 7.0 g/dL (severe anaemia); Hb 7.0–9.9 g/dL (moderate anaemia); Hb

10.0–10.9 g/dL (mild anaemia); Hb ≥ 11.0.0 g/dL (non-anaemic) among children below five years was considered [12].

Ethical consideration

Ethical approval for this survey was obtained from Osun State Health Research Ethical Committee (OSHREC/PRS/569T312) on the 22nd of May 2023 as sub-study (baseline) formative research of a bigger project" PMC Effect Study: Nigerian Operational Feasibility and Effectiveness", from NHREC and the Osun State Health Research Ethics Committee. The study is also registered as a trial with clinicaltrial.gov registration number NCT06155448. The caregivers provided written informed consent for malaria and Haemoglobin concentration testing. Participation was at no cost to the participants and all participants that tested positive to malaria and children with haemoglobin concentration (HbC) < 7.0 g/dl and/or malaria infection were referred to the nearest health facility for treatment. All work was performed according to the guidelines for human experimentation in clinical research and Helsinki declaration.

Results

Table 1 showed the distribution of respondents' characteristics. The majority of household heads were artisans (46.0%), had secondary education (50.3%) and literate (72.8%). Furthermore, about 75.0% of the respondents have 2–4 family members, 88.25% from families having one child. See Table 1 below for the details.

Overall, malaria positivity rate with RDT was 36.8% and 12.5% with microscopy. Figure 1 shows that malaria prevalence by RDT was higher in children aged 13–18 months (48.0%), followed by those aged 7–12 months (44.0%). By microscopy, there was 15.0% positivity rate among children aged 7–12 months. Those aged 2–6 months had the least positivity rate whether by microscopy (8.5%) or RDT (18.5%).

Overall, the prevalence of children with severe anaemia was 4.0%, moderate was 37.3%, mild was 18.3% and the normal was 40.4%, respectively. Figure 2 showed the proportion of anaemia among children aged 2–18 months by mild moderate and severe anaemia in Osun state, Nigeria. Higher proportion of moderate anaemia (7.0–9.9 haemoglobin (g/dL)) was reported in older children 7–12 months (43.6%) and children 13–18 months (38.9%).

Table 2 showed the cross-tabulation between children's characteristics and malaria positivity status using RDT. Based on bivariate analysis results, the household head occupation, household head educational attainment, household wealth quintile, household head literacy,

Table 1 Descriptive characteristics of the study participants

Characteristics of respondents	Frequency (n)	Percent (%)
Occupation of the household head		
Farmer	115	28.8
Artisan	184	46.0
Business	74	18.5
Civil servant	17	4.3
Unemployed	10	2.5
Household head education		
No formal education	36	9.0
Primary	100	25.0
Secondary	201	50.3
Tertiary	63	15.8
Household head literacy (read and write)		
No	109	27.3
Yes	291	72.8
Household wealth tertile		
Poor	134	33.5
Medium	134	33.5
Rich	132	33.0
Household size		
2–4 members	300	75.0
5 members +	100	25.0
Number of Under 5yrs in the household		
1 child	353	88.3
2–4 children	47	11.8
Possession of child's vaccination card		
No	85	21.3
Yes	315	78.8
Caregivers' age group		
15–24yrs	137	34.3
25–34yrs	209	52.3
35yrs +	54	13.5
Caregivers' education		
No formal education	87	21.8
Primary	69	17.3
Secondary	200	50.0
Higher education	44	11.0
Relationship of the caregiver to the child		
Mother	387	96.8
Father	5	1.3
Another family member	8	2.0
Children age in month		
2–6 months	125	31.3
7–12 months	102	25.5
13–18 months	173	43.3
Child slept under a bed net the night before the survey		
No	345	86.3
Yes	55	13.8
Sex of child		
Female	207	51.8

Table 1 (continued)

Characteristics of respondents	Frequency (n)	Percent (%)
Male	193	48.2

caregivers' education and children age in month were significantly associated with malaria among children. The significant variables were then entered to the multivariable model for logit analysis.

Table 3 showed the cross-tabulation between children's characteristics and anaemia status by HemoCue results. Based on bivariate analysis results, household head occupation, household head education, household wealth quintile, household size, number of under 5yrs in the household, possession of child's vaccination card, household head literacy caregivers' age group, caregivers' education, relationship of the caregiver to the child, children age in month, child slept under a bed net the night before

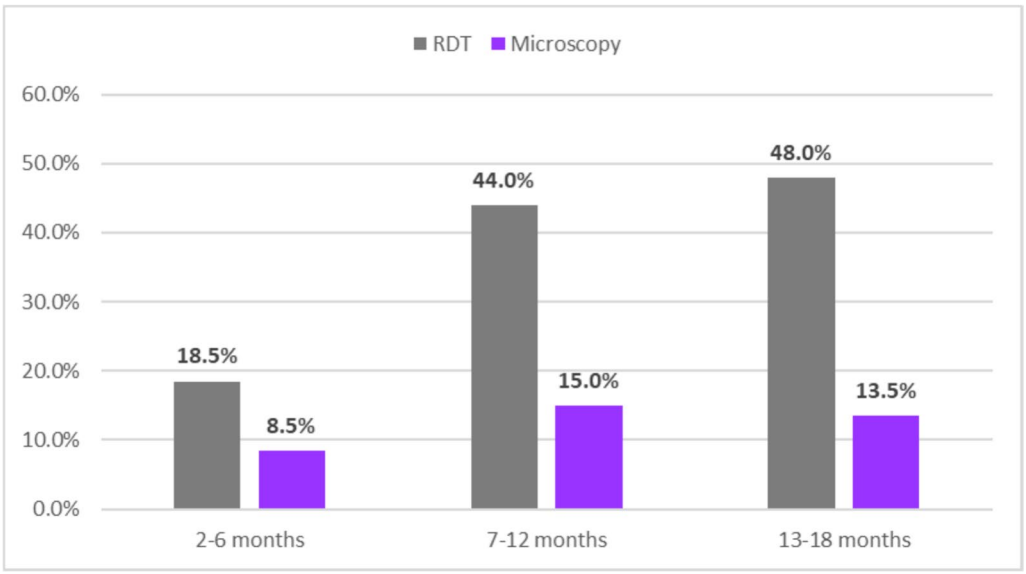

Fig. 1 Prevalence of malaria among children aged 2–18 months in Osun state, Nigeria

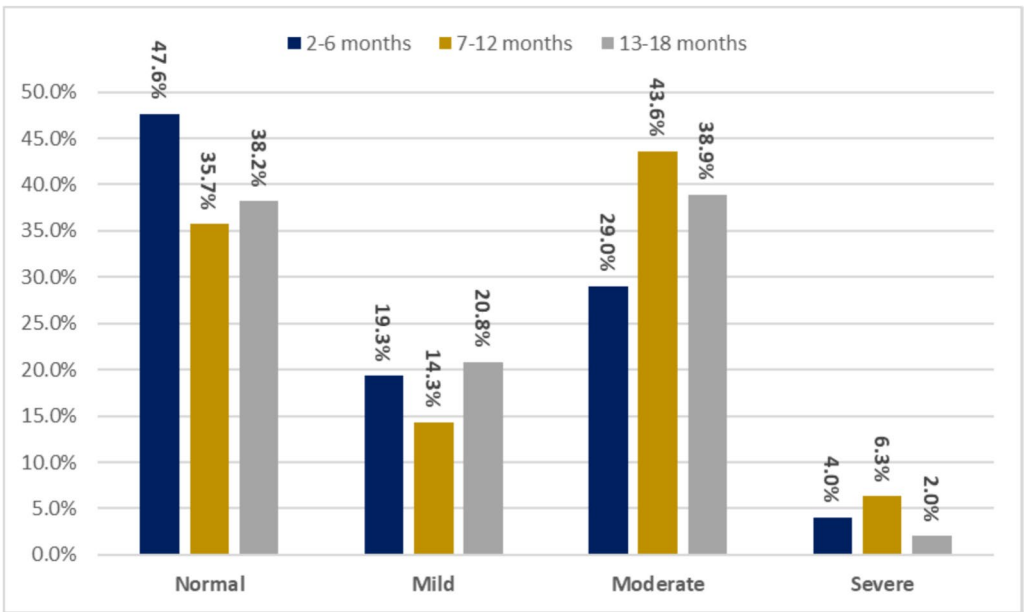

Fig. 2 Prevalence of anaemia among children aged 2–18 months in Osun state, Nigeria

Table 2 Association between participants' characteristics and malaria rapid diagnostic test (RDT) results

Participants' characteristics	RDT results			
	Negative (%)	Positive (%)	Total (%)	p-value
Household head occupation				
Farmer	56 (48.7)	59 (51.3)	115 (100)	0.004*
Artisan	121 (65.8)	63 (34.2)	184 (100)	
Business	53 (71.6)	21 (28.4)	74 (100)	
Civil servant	14 (82.4)	3 (17.6)	17 (100)	
Unemployed	6 (60.0)	4 (40.0)	10 (100)	
Household head education				
No formal education	17 (47.2)	19 (52.8)	36 (100)	0.001*
Primary	53 (53.0)	47 (47.0)	100 (100)	
Secondary	129 (64.2)	72 (35.8)	201 (100)	
Tertiary	51 (80.9)	12 (19.1)	63 (100)	
Household wealth tertile				
Poor	62 (46.3)	72 (53.7)	134 (100)	< 0.001*
Medium	90 (67.2)	44 (32.8)	134 (100)	
Rich	98 (74.2)	34 (25.8)	132 (100)	
Household size				
2–4 members	185 (61.7)	115 (38.3)	300 (100)	0.551
5 members +	65 (65.0)	35 (35.0)	100 (100)	
Number of Under 5yrs in the household				
1 child	217 (61.5)	136 (38.5)	353 (100)	0.245
2–4 Children	33 (70.2)	14 (29.8)	47 (100)	
Possession of child's vaccination card				
No	50 (58.8)	35 (41.2)	85 (100)	0.430
Yes	200 (63.5)	115 (36.5)	315 (100)	
Household head literacy (read and write)				
No	55 (50.5)	54 (49.5)	109 (100)	0.002*
Yes	195 (67.0)	96 (33.0)	291 (100)	
Caregivers' age group				
15–24yrs	81 (59.1)	56 (40.9)	137 (100)	0.522
25–34yrs	136 (65.1)	73 (34.9)	209 (100)	
35yrs +	33 (61.1)	21 (38.9)	54 (100)	
Caregivers' education				
No formal education	43 (49.43)	44 (50.57)	87 (100)	< 0.001*
Primary	35 (50.7)	34 (49.3)	69 (100)	
Secondary	135 (67.5)	65 (32.5)	200 (100)	
Higher education	37 (84.1)	7 (15.9)	44 (100)	
Relationship of the caregiver to the child				
Mother	243 (62.8)	144 (37.2)	387 (100)	0.756
Father	3 (60.0)	2 (40.0)	5 (100)	
Another family member	4 (50.0)	4 (50.0)	8 (100)	
Children age in month				
2–6 months	102 (81.6)	23 (18.4)	125 (100)	< 0.001*
7–12 months	61 (59.8)	41 (40.2)	102 (100)	
13–18 months	87 (50.3)	86 (49.7)	173 (100)	
Child slept under a bed net the night before the survey				
No	219 (63.5)	126 (36.5)	345 (100)	0.312
Yes	31 (56.4)	24 (43.6)	55 (100)	
Sex of child				
Female	136 (65.7)	71 (34.3)	207 (100)	0.171
Male	114 (59.1)	79 (40.9)	193 (100)	

Table 2 (continued)

Note: * at 5% level of significance

the survey and sex of child were statistically not significant with being anaemic.

Table 4 showed the factors associated with malaria test positivity among children aged 2–18 months. Children from households with medium wealth, had about 45% reduction in the odds of having malaria, when compared with children from poor households (aOR = 0.549; 95% CI 0.306–0.986). Similarly, though not statistically significant, children from rich households (aOR = 0.543; 95% CI 0.283–1.042) had 45.0% reduction in the odds of having malaria, when compared with their counterparts from poor households. Children aged 7–12 months (aOR = 2.856; 95% CI 1.524–5.354) and those aged 13–18 months (aOR = 4.269; 95% CI 2.422–7.526) had higher odds of malaria infection respectively, when compared with children aged 2–6 months.

Discussion

The findings from this study showed malaria prevalence by microscopy was highest (15.0%) among children 7–12 months, while by RDT, it was highest (48.0%) among children 13–18 months. The prevalence of malaria by RDT is similar to the report observed amongst febrile patients in Iwo, a community also in Osun State [13]. It was however higher than the result obtained for Osun state in the 2021 NMIS [14]. Though malaria prevalence dropped from 42% in 2010 to 21.5% in 2021 MIS [15], a higher prevalence observed in this study, compared to the earlier report in Osun state, could be explained by the latent effect of disruption in malaria control activities from the COVID-19 pandemic era. There was a shift of medical resources from malaria control to emergency COVID-19 response during the pandemic. This caused disruptions, reductions, and delays in malaria prevention and control interventions. The Garki study [10] and more recently, of 49 discontinued programmes during global malaria elimination programme (GMEP), resurgence was reported in 36 programmes following their cessation [16]. By implication, malaria prevention and control interventions must be sustained to prevent resurgence.

Other prevalence surveys reported in the South West region of Nigeria among under-5 using microscopy was 79.1% [17], and 47% by RDT in adolescent school age children [18]. Pooled prevalence of malaria among children aged 6–59 months in MIS of 13 sub-Saharan Africa (SSA) countries was 27.41%, ranging from 5.04% in Senegal to 62.57% in Sierra Leone [19]. Another pooled estimate from seven high malaria burdened SSA countries spanning from 2010 to 2023 was 26.2%, with substantial country-specific variations observed [20]. These differences are in consonance with the fact that malaria burden is heterogeneous across geographical space. It is however important to compare results from similar periods using similar methods of malaria detection and from similar climatic and geographic conditions and the indices used as measures vary from season to season in the same region.

With the higher odds of malaria among children aged 13–18 months, than in children 2–6 months in this study, this showed that the proportion of those infected with malaria increases with age has been observed from several other studies including pooled studies in 13 African countries of children 6–59 months [19, 21] and in the survey data from nine countries in SSA countries [22]. Lower prevalence of malaria has also been reported amongst children under one year in Mozambique [23], However children aged 2 years and below are significantly associated with a high risk of malaria (50.85%), compared to those who are at least 3 years of age (32.07%) in the Nigerian 2021 MIS [24] and prevalence significantly reduced with increasing age in the Akure study [17]. Maternally derived antibodies are commonly believed to provide protection against many infectious diseases, including malaria, for periods of up to 6–9 months [25]. Mothers who have developed stronger immunity due to repeated exposure to malaria are more likely to transfer higher levels of protective antibodies to their infants [26, 27]. When immunity wanes as the children grow older, they also become more independent, engage in more outdoor activities independent of protective eyes and reach of their caregivers. They grow in body surface area with a resultant increased exposure to infected vectors [28].

PMC could play a transformative role in reducing malaria incidence among older children (13–18 months), a group increasingly vulnerable to infection in endemic areas. Unlike the younger children (2–6 months), older children may have less access to preventive measures, even as exposure to malaria increases with age and mobility. In a previous study conducted in Nigeria, the prevalence of malaria was higher among older children with those aged 6–11 months 21.9%, aged 12–17 months was 32.1% and those aged 18–24 months was 31.7% respectively [29]. EPI platform could be an equitable approach to include the majority of eligible children in PMC service access, particularly because those in poor households have high odds of malaria parasitaemia. PMC could bridge the immunity gap, especially in

Table 3 Association between participants' characteristics and anaemia status by HemoCue results

Participants' characteristics	Anaemia status			
	Anaemic (%)	Normal (%)	Total (%)	p-value
Household head occupation				
Farmer	69 (60.5)	45 (39.5)	114 (100)	0.746
Artisan	107 (58.2)	77 (41.8)	184 (100)	
Business	44 (60.3)	29 (39.7)	73 (100)	
Civil servant	10 (58.8)	7 (41.2)	17 (100)	
Unemployed	8 (80.0)	2 (20.0)	10 (100)	
Household head education				
No formal education	25 (69.4)	11 (30.6)	36 (100)	0.544
Primary	61 (61.6)	38 (35.4)	99 (100)	
Secondary	117 (58.5)	83 (41.5)	200 (100)	
Tertiary	35 (55.6)	28 (44.4)	63 (100)	
Household wealth quintile				
Poor	77 (58.3)	55 (41.7)	132 (100)	0.540
Medium	77 (57.5)	57 (42.5)	134 (100)	
Rich	84 (63.6)	48 (36.4)	132 (100)	
Household size				
2–4 members	178 (59.3)	122 (40.7)	300 (100)	0.740
5 members +	60 (61.2)	38 (38.8)	98 (100)	
Number of Under 5yrs in the household				
1 child	208 (59.3)	143 (40.7)	351 (100)	0.548
2–4 Children	30 (63.8)	17 (36.2)	47 (100)	
Possession of child's vaccination card				
No	51 (60.7)	33 (39.3)	84 (100)	0.847
Yes	187 (59.5)	127 (40.5)	314 (100)	
Household head literacy (read and write)				
No	71 (65.7)	37 (34.3)	108 (100)	0.140
Yes	167 (57.6)	123 (42.4)	290 (100)	
Caregivers' age group				
15-24yrs	80 (58.4)	57 (41.6)	137 (100)	0.766
25-34yrs	124 (59.6)	84 (40.4)	208 (100)	
35yrs +	34 (64.2)	19 (35.8)	53 (100)	
Caregivers' education				
No formal education	52 (59.8)	35 (40.2)	87 (100)	0.773
Primary	38 (55.9)	30 (44.1)	68 (100)	
Secondary	119 (59.80)	80 (40.20)	199 (100)	
Higher education	29 (65.9)	15 (34.1)	44 (100)	
Relationship of the caregiver to the child				
Mother	231 (60.0)	154 (40.0)	385 (100)	0.655
Father	2 (40.0)	3 (60.0)	5 (100)	
Another family member	5 (62.5)	3 (37.5)	8 (100)	
Children age in month				
2–6 months	65 (52.4)	59 (47.6)	124 (100)	0.122
7–12 months	63 (61.8)	39 (38.2)	102 (100)	
13–18 months	110 (63.9)	62 (36.1)	172 (100)	
Child slept under a bed net the night before the survey				
No	201 (58.6)	142 (41.4)	343 (100)	0.223
Yes	37 (67.3)	18 (32.7)	55 (100)	

Table 3 (continued)

Participants' characteristics	Anaemia status			
	Anaemic (%)	Normal (%)	Total (%)	p-value
Sex of child				
Female	123 (60.0)	82 (40.0)	205 (100)	0.933
Male	115 (59.8)	78 (40.4)	193 (100)	

high-transmission settings, where older children frequently experience clinical malaria and can act as a reservoir for further transmission. By extending PMC to this age group, health systems may improve child health outcomes, and decrease community transmission levels. Additionally, implementing PMC as part of broader malaria control efforts could complement insecticide-treated bed nets and indoor residual spraying, enhancing community-wide malaria prevention.

Table 4 Multivariable analysis of factors associated with malaria among children

Participants' characteristics	Odds ratio	95% CI	p-value
Household head occupation			
Farmer	ref		
Artisan	0.785	[0.450–1.368]	0.393
Business	0.621	[0.306–1.260]	0.187
Civil servant	0.795	[0.166–3.792]	0.773
Unemployed	1.253	[0.261–6.003]	0.778
Household head education			
No formal education	ref		
Primary	1.042	[0.430–2.526]	0.927
Secondary	1.235	[0.424–3.599]	0.699
Tertiary	0.629	[0.157–2.515]	0.512
Household wealth tertile			
Poor	ref		
Medium	0.549	[0.306–0.986]	0.045*
Rich	0.543	[0.283–1.042]	0.066
Household head literacy (read and write)			
No	ref		
Yes	0.942	[0.450–1.970]	0.874
Caregivers' education			
No formal education	ref		
Primary	1.136	[0.536–2.411]	0.739
Secondary	0.663	[0.321–1.370]	0.267
Higher education	0.451	[0.125–1.632]	0.225
Children age in month			
2–6 months	ref		
7–12 months	2.856	[1.524–5.354]	0.001*
13–18 months	4.269	[2.422–7.526]	0.001*

Note: ref: reference category; * significant at 5%; CI confidence interval

Of the factors that associated with malaria significantly, multivariate analysis showed that the odds of each of the medium wealth tertile having malaria is 45%, less than in the poor household wealth tertile. Poverty is associated with hunger, lack of education, shelter and clothing, as well as illness and illiteracy [30, 31]. Wealthier households are likely to be more educated, possess superior knowledge of malaria prevention measures, and have improved access to healthcare services [20]. Eradicating poverty in all its forms will address the public health effect of not only malaria but other disease as indicated by the Millennium Sustainable Goals [32].

Anaemia prevalence of approximately 60% (< 11 g/dl) as observed in this study, is comparable to 71% of the children categorized as anaemic in 2018 Nigerian Demographic and Health Survey [33]. The finding is also comparable with what was recorded in a baseline survey of malaria and anaemia prevalence prior to mass net distributions in Abia and Plateau States also in Nigeria. Anaemia prevalence in children < 5 years was 64.7% in children in Abia and 73.1% in Plateau [34]. It is however lower than 85.2% that was recorded amongst children < 5 years in Osun State [35]. Only the severe measure of anaemia which ranged from 1.2% in Nasarawa State to 22% in Sokoto State, was presented in the 2021 MIS [15] and the prevalence recorded for Osun in the survey was 2.7%. Supporting the lack of association of anaemia in this study with any factor in particular is the lack of a significant difference in anaemia between implementing and non-implementing of IRS communities of Lagos [36]. The prevalence of anaemia has been shown to be influenced by a complex interplay of nutritional deficiencies, infections, genetic disorders, socio-economic conditions, and healthcare access [37].

Study implications, direction of future research and limitations

This study has critical implications for public health. The high malaria prevalence suggests gaps in vector control and preventive measures, highlighting the need to strengthen insecticide-treated net distribution, community education, and access to prompt treatment. The strong link between malaria and anaemia in terms of

high prevalence underscores the dual burden of parasitic infections and nutritional deficiencies, necessitating integrated interventions addressing both. Identifying associated factors, such as socioeconomic status, environmental conditions, and healthcare access, can inform targeted strategies. These findings can guide policymakers in optimizing resource allocation and designing evidence-based programmes to reduce child morbidity and mortality.

Future malariometric research among young children in Osun State, Nigeria, should prioritize understanding the interplay of environmental, socioeconomic, and behavioural factors influencing malaria transmission. Studies should explore spatial–temporal patterns of malaria prevalence to identify hotspots and guide targeted interventions. Investigating insecticide resistance in *Anopheles* vectors and the efficacy of current vector control measures, such as insecticide-treated nets and indoor residual spraying, is crucial. Additionally, research should assess the effectiveness of PMC and explore innovative approaches to strengthen early diagnosis and treatment in underserved areas. Evaluating community-based interventions and integrating malaria control with other child health programs is essential for sustainable progress.

This study was household-based and gives a broad overview of the malariometric situation across selected LGAs in Osun State. The randomly selection of clusters or communities, households and children, gives a balance to the endogenous and exogenous factors. The survey results can however be affected by respondent social desirability, availability and recall bias, thereby limiting the scope and depth of information provided, which could result in response error. A key limitation is that cross-sectional study cannot be used to established causality. There was a wide disparity between the RDT and microscopy test positivity results and this could be due to Histidine-Rich Protein 2 (HRP2) RDT that was used in this study.

Conclusion

This study provided the baseline malaria prevalence data, against which, comparison can be made to assess the effectiveness of PMC intervention in Osun State, Nigeria. The prevalence of malaria and anaemia among children aged 7–18 months were higher compared to younger children in their first 6 months of life. Malaria was also associated with child's age and household wealth tertile. These findings would inform the positioning of PMC intervention touch points to reduce malaria burden in young children.

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Availability of data and materials
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study involves human participants and was approved by National Health Research Ethics Committee (NHREC) and Osun State Health Research Ethics Committee. Participants gave informed consent to participate in the study before taking part.

Consent for publication
Not applicable.

Patient and public involvement
Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Competing interests
The authors declare no competing interests.

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