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Prevalence and factors associated with malaria among children aged 6 months to 10 years in the Greater Accra Region of Ghana: a community-based cross-sectional survey

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Abstract

Background Malaria remains a major public health problem, especially among children in sub-Saharan Africa. Knowledge of malaria parasite prevalence informs targeted interventions and helps to monitor the effectiveness of those interventions. This study aimed to determine prevalence and factors associated with malaria in children aged 6 months to 10 years in the Greater Accra Region of Ghana.

Methods A community-based cross-sectional study was conducted among 8,741 children aged 6–59 months and 8,292 children aged 5–10 years in all 29 districts of the Greater Accra Region of Ghana in October 2020. Systematic random sampling was used to select communities, households and study participants. A structured questionnaire was used to collect data from caregivers. Rapid diagnostic test kits were used to determine the presence of malaria parasites in blood samples collected by fingerprick. Factors associated with malaria RDT-positivity were determined using multivariate logistic regression analysis.

Results Of 8727 children aged 6–59 months and 8279 aged 5–10 years from whom blood samples were obtained, positive results were obtained for 289 (3.3%; 95% CI 3.0–3.7) and 406 (4.9%; 95% CI 4.5–5.4) respectively. Malaria parasite prevalence in the districts ranged from 0.9 to 10.7% and 1.4–15.0% in children aged 6–59 months and 5–10 years respectively. Factors associated with increased odds of malaria included higher age (AOR = 1.43; 95% CI 1.14–1.71), and living in households without nets on the windows (AOR 1.64; 95% CI 1.10–2.45). On the other hand, living in households located in urban communities was associated with a lower risk of malaria (AOR 0.56; 95% CI 0.40–0.78).

Conclusion The average prevalence of malaria in the Greater Accra Region is low compared with other regions. However, there are potential hotspots that need to be targeted with appropriate interventions to accelerate the drive towards malaria elimination.

Keywords Malaria, Prevalence, Children, Ghana

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Background

Despite several efforts aimed at controlling and eliminating malaria, the disease continues to be a major public health problem, especially in sub-Saharan Africa. It is estimated that malaria cases increased by 5 million to 249 million in 2022 compared with 2021. However, deaths attributable to malaria decreased from 610,000 to 608,000 over the same period. Globally, the Africa region accounted for about 94% of cases and 95% of deaths, with children under 5 years accounting for about 78% of deaths in the region [1].

According to the World Health Organization (WHO), Ghana was among 11 highest burden countries that accounted for 70% of the global estimated case burden and 71% of global estimated deaths as at 2018 [2]. The 2019 Ghana Malaria Indicator Survey (GMIS) showed that the prevalence of malaria among children aged 6–59 months (by microscopy) was 14%, a decrease from 21% in the 2016 survey. There was a marked regional variation of malaria parasite prevalence in the country, ranging from 2% in the Greater Accra Region to 27% in the Western Region, with prevalence increasing with age (6% in children aged 6–8 months versus 19% in those aged 48–59 months) and decreasing with increasing household wealth [3].

Methods for measuring malaria transmission intensity include the entomological inoculation rate (EIR), malaria incidence, sporozoite rate and slide positivity rate [4–7]. Accurate measurement of incidence requires strong health systems for adequate reporting of malaria cases, which is most often not the case [8]. Additionally, health facilities do not capture asymptomatic infections which contribute significantly to malaria transmission. Measuring EIR can be time consuming, expensive, and less precise, especially in settings of low malaria transmission [9].

Malaria parasite prevalence (MPP) is a widely accepted measure of malaria risk in a community. However, available data on malaria risk in Ghana are often national and regional estimates, making it difficult to interpret for effective planning at sub regional levels. Accurate district and sub-district malaria estimates will complement national and regional estimates for effective planning and design of targeted intervention by local stakeholders and the National Malaria Elimination Programme (NMEP). Although a low overall malaria parasite prevalence has been reported in the Greater Accra Region, there is the likelihood of hotspots with high prevalence of asymptomatic malaria parasitaemia which could serve as a reservoir for the transmission of malaria in communities. It is, therefore, important to identify hotspots for malaria transmission for targeted interventions to be deployed in the quest for malaria elimination.

This study sought to determine district- and sub-district-level malaria parasite prevalence during the high malaria transmission season for children aged 6–59 months aged 5–10 years old using rapid diagnostic test (RDT) kits to identify potential hotspots for targeted interventions, and the associated factors in the Greater Accra Region of Ghana.

Methods

Study design and area

A community-based cross-sectional household survey was conducted in October 2020 in all the 29 administrative districts of the Greater Accra Region of Ghana (Fig. 1). The study area is characterized by two distinct rainy seasons from April to June and September to November. The area has at least nine months of malaria transmission, with a low transmission from May to June and an intense transmission from October to November [10].

Study population, eligibility and exclusion criteria

The study population consisted of two cohorts of children, i.e., children aged 6–59 months and children aged 5–10 years who resided in communities within the Greater Accra Region for at least 3 months preceding the visit of the study team. Children who were severely ill requiring urgent medical attention/hospitalization or whose guardians did not give written informed consent were excluded from the study.

Media engagement and community sensitization

Prior to commencement of fieldwork, a 1-day meeting was held with directors of health services for each of the districts to discuss about the study. Permission was also sought from the political head of each district. Engagement with media practitioners were also organized through a press briefing and radio discussions to sensitize residents and household heads about the study. Community education on the study was also carried out, led by the District Health Promotion Officers.

Selection of subdistricts, communities and participants

All administrative districts within the Greater Accra region were eligible for inclusion in the study. At the district level, a maximum of 3 sub-districts were randomly selected if the district had more than 3 subdistricts, except Ledzokuku District which consisted of only 2 sub-districts. Within each sub-district, a list of communities was generated and assigned numbers. Communities were selected using systematic random sampling using the model by Bennet et al. [11].

In the selected communities, a central assembly point was determined by the opinion leaders in the

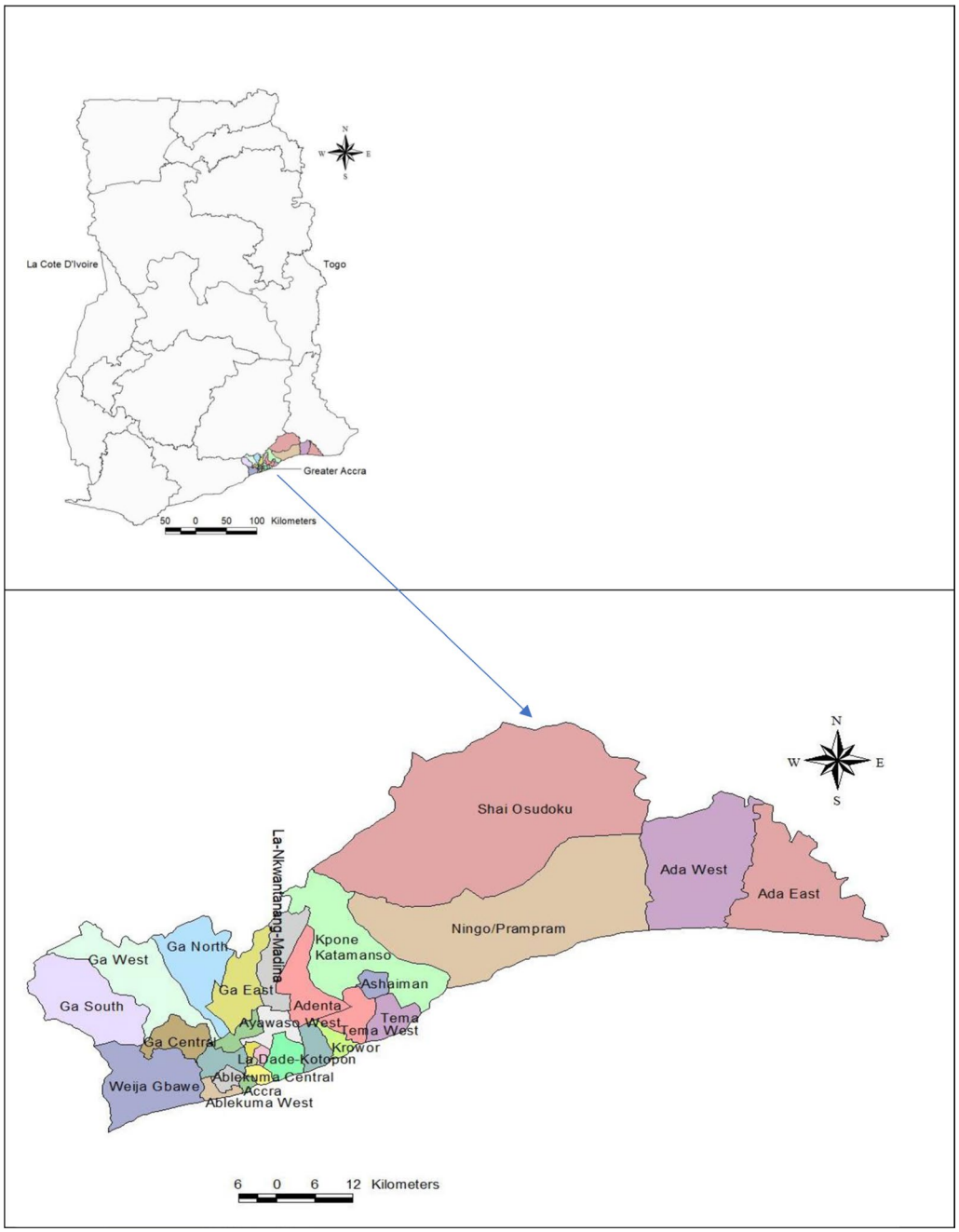

Fig. 1 A map of the study districts in the Greater Accra Region of Ghana

community. "Random directions" were selected by spinning a top at the community's central assembly point. Subsequently, households along the directional lines were selected by systematic random sampling and the study team moved from one household to the next, until the last household in the directional line for the community was reached. Within a selected household, a maximum of two children aged 6–59 months and two aged 5–10 years meeting the eligibility criteria were enrolled in the study. If there were more than two children in a particular age category, the study team assigned a number to each child and balloting was used to select a child for inclusion into the study. In the absence of a child in the selected household, the process of identifying households and children continued until the sample size was met.

Written informed consent was obtained for eligible children and a study questionnaire adapted from the Malaria Indicator Cluster Survey (MICS) was used by the trained field teams to collect data with the Open Data Kit (ODK) Application which had been installed on a smartphone or tablet, with the data server hosted at the Data Science Centre of the Kintampo Health Research Centre (KHRC). The questionnaire covered areas such as information on participants' characteristics such as age, sex, medical history, service utilization such as ITN use and access to artemisinin-based combination therapy (ACT), and the results of malaria RDTs. Members of the survey team observed for the presence or absence of nylon screens (nets) which are usually fixed on the windows to prevent the entry of mosquitoes and other insects.

Blood sample collection and testing

Malaria RDT testing was performed using the SD Bioline Malaria Ag Pf (05FK50) test kit. A sterile finger- or heel-prick blood sample (5 µL) was collected by a medical laboratory scientist and used to perform an on-the-spot malaria testing, following the kit manufacturer's instructions. Briefly, 5 µL of blood was added to the sample well, followed by 4 drops of buffer into the diluent well. The result was read between 15 and 30 min. The presence of one coloured band in the control line within the result window indicated a negative result. The presence of two coloured bands in the Test and Control lines within the results window indicated a positive result. Absence of a coloured band for the Control was interpreted as an Invalid result, to which the test was repeated with a new test kit. Children who tested positive for malaria and were not on treatment nor treated less than one month prior to testing were treated according to the standard treatment guidelines of the Ministry of Health, Ghana.

Sample size consideration

Assuming an average malaria prevalence of 5% for children aged 6 months to 10 years, a 95% level of confidence and a 2.5% margin of error, a sample size of 292 children in each age group per district was estimated.

Quality control

A total of eight workshops (1-day) were organized within the study region to train all the district teams. The District Malaria Focal Persons directly supervised and monitored data collection in each district. The Regional Malaria Focal Person and staff of the Regional Health Directorate, Kintampo Health Research Centre, Dodowa Health Research Centre and the National Malaria Control Programme monitored and supervised the training and data collection activities. Malaria RDT kits used for the study were embedded with controls in each test performed, and results were not accepted if the quality control test did not pass.

Outcome definitions

Malaria parasite prevalence in each district and sub-district was defined as the proportion of children in the age specific cohort who tested positive for malaria using malaria RDT. Percentage of insecticide treated bed-nets (ITN) use was defined as the proportion of children who were reported to have slept under an ITN the previous night.

Fever was defined as temperature ≥ 37.5 °C or history of fever in the past 14 days, whiles ACT use was defined as the proportion of children who received ACT within the past 14 days.

Data management and statistical analysis

Data collection from the field was conducted using the Open Data Kit (ODK) programme. Multiple automated validation procedures were implemented to guarantee the integrity of the data. The acquired data was remotely relayed to a central data server situated at KHRC, where it was regularly backed up and archived. Entered data was cleaned and analysed using STATA 14 (StataCorp, College Station, Texas). Basic descriptive statistics was used to describe all demographic and household characteristics of study participants. Overall and district level prevalence of malaria were presented as percentage with 95% confidence interval (CI). Factors associated with malaria RDT positivity were determined using the logistic regression analysis. Variables with a $p < 0.15$ in the univariable logistic regression analysis were included in the multivariable logistic regression analysis. In the final multivariate logistic regression model, a $p < 0.05$ was deemed as statistically significant. The adjusted odds ratios (AOR) with 95% CI were used to determine the strength of association of the variables.

Ethical considerations

The study protocol was approved by the Institutional Ethics Committee of the Kintampo Health Research Centre (KHRCIEC/2020-7). Written Informed consent was obtained from parents or guardians of all eligible children before commencement of study procedures. In the case of minor parents, consent was obtained from an adult parent or guardian. Participants who tested positive to malaria RDT were given antimalarial medications by a Community Health Nurse or Public Health Nurse in accordance with the malaria case-management guidelines of the NMEP and GHS. However, children suffering or suspected of severe malaria were referred to the nearest health facility for appropriate management. Data was anonymized and kept confidential.

Results

Demographic characteristics of study participants

A total of 17,033 children (8,741 aged 6–59 months and 8,292 aged 5–10 years) from 8,305 households were enrolled in the study. Majority (n = 9,004; 52.9%) were females, and about a quarter of the study population slept under an ITN on the night preceding the survey. The proportion of participants presenting fever as malaria symptoms was 1.8% (n = 309) and 0.7% (n = 119) of participants had used an artemisinin-based combination within the last 14 days before the survey (Table 1). Majority (n = 5,751; 63.9%) of the households were located in urban communities, 64% (n = 5,316) had floors made of cement, and 94.5% (n = 7,848) had roofs made of iron sheets. Nearly all the households (n = 8,136; 98%) had electricity and almost half (n = 3,892; 46.9%) had open windows/eaves (Table 2).

Prevalence of malaria

The overall prevalence of malaria among children aged 6–59 months and 5–10 years in the Greater Accra Region were 3.3% (289/8727; 95% CI 3.0–3.7) and 4.9% (406/8279; 95% CI 4.5–5.4), respectively. Among children aged 6–59 months, the lowest malaria prevalence (0.9%) was found in the Ablekuma North and Ayawaso Central districts and highest (10.7%) in the Ga West district (Fig. 2; Additional file 1). However, among children aged 5–10 years, the lowest malaria prevalence (1.4%) was found in Ablekuma West district, whiles the highest (15.0%) was found in Ada East district. Out of the 29 districts, 22 (75.9%) had overall malaria RDT positive tests below the < 5% regarded as pre-elimination prevalence, for both children 6–59 months and 5–10 years (Fig. 3; Additional file 2).

At the sub-district level, 76.7% (66/86) and 62.3% (54/86) sub-districts had malaria prevalence within

Table 2 Household characteristics of study participants

	Households N = 8,305 n	Percentage
Location of household		
Rural	1,289	15.5
Semi-rural	1,265	15.2
Urban	5,751	69.3
Material of floor		
Cement	5316	64.0
Natural (sand)	1751	21.1
Others	1238	14.9
Type of roof		
Iron sheet	7848	94.5
Others	457	5.5
Type of windows/eaves		
Open	3892	46.9
Closed	2440	29.4
Partially open	1973	23.7
Availability of electricity		
Yes	8136	98.0
No	169	2.0
Presence of nylon screens on windows		
On all windows	6,661	80.2
On some windows	1,181	14.2
Not present	463	5.6

Table 1 Demographic characteristics of study participants

	6–59 months N = 8,741		5–10 years N = 8,292		Combined N = 17,033	
	n	%	n	%	n	%
Sex						
Male	4,175	47.8	3,854	46.5	8,029	47.1
Female	4,566	52.2	4,438	53.5	9,004	52.9
ITN use						
Yes	2,595	29.7	2,133	25.7	4,728	27.8
No	6,146	70.3	6,159	74.3	12,305	72.2
Fever						
Yes	185	2.1	124	1.5	309	1.8
No	8,556	97.9	8,168	98.5	16,724	98.2
ACT use						
Yes	61	0.7	58	0.7	119	0.7
No	8,680	99.3	8234	99.3	16,914	99.3

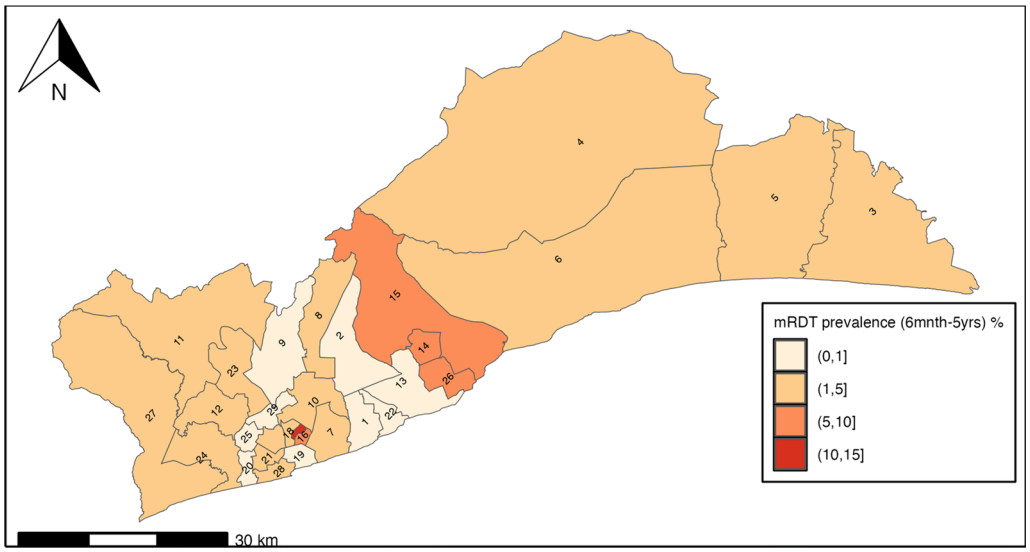

Fig. 2 Prevalence of malaria among children 6–59 months in the Greater Accra Region

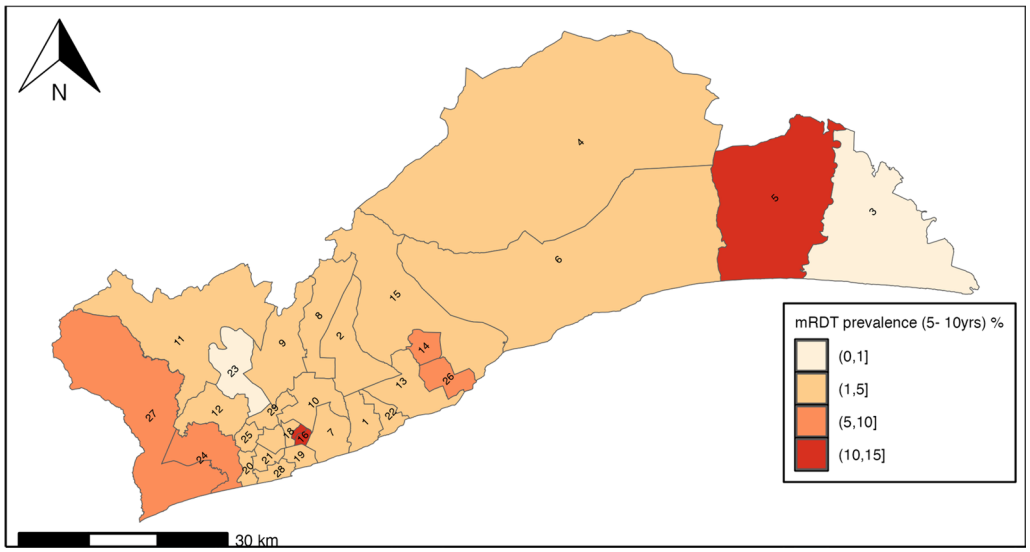

Fig. 3 Prevalence of malaria among children 5–10 years in the Greater Accra Region

pre-elimination levels for children aged 6–59 months and 5–10 years, respectively. The highest malaria prevalence among children aged 6–59 months, 14.3% (14/98) and those aged 5–10 years, 36.7% (36/98) were observed in the Agomeda sub-district of Shai-Osudoku district and Pediator sub-district of Ada East, respectively (Additional file 3).

Factors associated with malaria test positivity

In the univariate analysis, age of the child, location of residence, presence of net in windows of the house, main source of drinking water (open water source), presence of electricity and materials used for walls, floor and roof of the house were associated with malaria positivity ($p < 0.20$) whiles ITN use, gender and type of window were not (Table 3). In the multivariate analysis children aged 5–10 years were 1.4 times more likely to test positive than children aged 6–59 months (AOR = 1.43;

Table 3 Factors Associated with Malaria Test Positivity among Children 6 to 59 months and 5 to 10 years in the Greater Accra Region, 2020

Factors	Malaria RDT			Univariate analysis			Multivariate analysis		
	Total (N = 17,006)	Positive (N = 695) n (%)	Negative (N = 16,311) n (%)	COR	95% CI	p-value	AOR	95% CI	p-value
Age									
6–59 months	8,727 (51.3)	289 (1.7)	8,438 (49.6)	1					
5–10 years	8,279 (48.7)	406 (2.4)	7,873 (46.3)	1.51	1.29–1.76	< 0.001	1.43	1.14–1.79	0.002
Gender									
Male	8,016 (47.1)	342 (2.0)	7,674 (45.1)	1					
Female	8,990 (52.9)	353 (2.1)	8,637 (50.8)	0.92	0.78–1.07	0.264			
Location of residence									
Rural	1,284 (15.5)	92 (1.1)	1,192 (14.4)	1			1		
Semi-rural	1,263 (15.2)	79 (0.95)	1,184 (14.3)	0.86	0.63–1.18	0.36	1.01	0.71–1.43	0.948
Urban	5,742 (69.3)	158 (1.9)	5,584 (67.4)	0.37	0.28–0.48	< 0.001	0.56	0.40–0.78	< 0.001
ITN use									
No	12,287 (72.2)	503 (3.0)	11,784 (69.3)	1					
Yes	4,719 (27.7)	192 (1.1)	4,527 (26.6)	0.99	0.84–1.18	0.941			
Material for walls									
Mud	406 (4.9)	46 (0.6)	360 (4.3)	1					
Bricks	403 (4.9)	11 (0.1)	392 (4.7)	0.22	0.11–0.43	< 0.001	0.40	0.19–0.81	0.011
Cement/plaster	1,842 (22.2)	103 (1.2)	1,739 (21.0)	0.46	0.32–0.67	< 0.001	0.88	0.56–1.39	0.585
Cement/paint	4,945 (59.7)	134 (1.6)	4,811 (58.0)	0.22	0.15–0.31	< 0.001	0.53	0.33–0.85	0.009
Other	693 (8.4)	35 (0.4)	658 (7.9)	0.42	0.26–0.66	< 0.001	0.90	0.51–1.60	0.723
Material for floor									
Natural floor	1,746 (21.1)	86 (1.0)	1,660 (20.0)	1					
Rudiment floor	61 (0.7)	5 (0.1)	56 (0.7)	1.72	0.67–4.41	0.256	1.51	0.56–4.08	0.415
Parquet/polished wood	33 (0.4)	3 (0.04)	30 (0.4)	1.93	0.58–6.45	0.285	2.48	0.71–8.71	0.156
Vinyl/asphalt strips	14 (0.2)	0 (0.0)	14 (0.2)	–	–	–			
Ceramic tiles	512 (6.2)	6 (0.1)	506 (6.1)	0.23	0.10–0.53	0.001	0.47	0.20–1.10	0.080
Cement	5,309 (64.1)	206 (2.5)	5,103 (61.6)	0.78	0.60–1.01	0.058	1.24	0.93–1.66	0.139
Carpet	614 (7.4)	23 (0.3)	591 (7.1)	0.75	0.47–1.20	0.232	1.21	0.73–1.99	0.464
Material for roof									
Grass/palm	138 (1.7)	22 (0.3)	116 (1.4)	1					
Iron sheet	7,832 (94.5)	303 (3.7)	7,529 (90.8)	0.21	0.13–0.34	< 0.001	0.65	0.35–1.21	0.171
Tiles	150 (1.8)	2 (0.02)	148 (1.8)	0.71	0.02–0.31	< 0.001	0.24	0.05–1.11	0.068
Other	169 (2.0)	2 (0.0)	167 (2.0)	0.06	0.01–0.27	< 0.001	0.24	0.05–1.12	0.069
Type of window in house									
Open	3,881 (46.8)	139 (1.7)	3,742 (45.1)	1					
Closed	2,437 (29.4)	101 (1.2)	2,336 (28.2)	1.16	0.89–1.51	0.255			
Partially open	1,971 (23.8)	89 (1.1)	1,882 (22.7)	1.27	0.97–1.67	0.082			
Nylon screen on window of the house									
Nets on all windows	6,646 (80.2)	224 (2.7)	6,422 (77.5)	1					
Nets on some windows	1,180 (14.2)	49 (0.6)	1,131 (13.6)	1.24	0.91–1.70	0.18	0.97	0.70–1.35	0.869
Nets not present	463 (5.6)	56 (0.7)	407 (4.9)	3.94	2.89–5.38	0.001	1.64	1.10–2.45	0.015
Main source of water									
Close water source	5,281 (63.7)	194 (2.3)	5,087 (61.4)	1					
Open water source	581 (7.0)	63 (0.8)	518 (6.3)	3.19	2.37–4.30	0.001	1.80	1.25–2.59	0.002
Bottled/sachet water	2,427 (29.3)	72 (0.9)	2,355 (28.4)	0.80	0.61–1.06	0.115	0.94	0.71–1.24	0.655
Presence of electricity									
No	169 (2.0)	13 (0.2)	156 (1.9)	1					
Yes	8,120 (98.0)	316 (3.8)	7,804 (94.2)	0.49	0.27–0.87	0.01	1.24	0.66–2.32	0.504

Table 3 (continued)

COR Crude odds ratio, *AOR* Adjusted odds ratio, *CI* Confidence interval

95% CI 1.14–1.71). Compared to children who lived in households located in rural communities, children in households located in urban communities were 44% less likely to test positive for malaria (AOR 0.56; 95% CI 0.40–0.78). Children living in households without nets on the windows were 1.6 times more likely to test positive for malaria than children who were living in households with nets on the windows (AOR 1.64; 95% CI 1.10–2.45). Children in households with an open water source were nearly 2 times more likely to test positive for malaria compared to those in households that used closed water source (AOR 1.80; 95% CI 1.25–2.59).

Discussion

This study assessed the prevalence of malaria in both children aged 6–59 months and those aged 5–10 years as well as the factors associated with malaria positivity in all the administrative districts of the Greater Accra Region of Ghana using malaria rapid diagnostic test kits. The low prevalence of malaria reported by this study in children 6–59 months (3.3%) and 5–10 years (4.9%) living in the Greater Accra region is slightly higher than the 2% reported for the region among children under 5 years in the 2019 GMIS. These results, however confirm the overall low prevalence of malaria within the region compared to the other regions of Ghana. Disaggregation of the district prevalence data into subdistrict further showed subdistricts requiring intensified interventions to reduce the parasite prevalence to pre-elimination levels, and then to elimination.

Contrary to the finding of Kawaguchi et al. [12] which identified the Kpone-Katamanso, Ashiaman, Tema and La-Kwantanang Municipals as hotspots of malaria transmission in the Greater Accra Region, this study found Ga West, Ga South, Ada East and Shai-Osudoku districts as areas requiring actions to strengthen existing prevention tools for reducing malaria parasite prevalence. The difference, however, could be due to methods used (i.e. all age groups used in previous study whiles only children aged 6 months to 10 years were used in the current study. Also, while the current study used prevalence levels, Kawaguchi et al. used the annual parasite index from the District Health Information Management System for data collected from 2015 to 2019.

The increased risk of malaria infection in rural compared with urban areas is consistent with several published reports and reviews [13–15]. Practices and factors such as outdoor cooking in the evenings, rearing of livestock, farming near residential areas, poor housing such as mud and thatch houses, and absence of nets on windows are exposure risk factors of children to malaria [16]. This highlights the need for additional tools in rural communities to prevent and control malaria infection.

The higher risk of malaria infection in children aged 5–10 years compared to the age range of 6–59 months is supported by many other studies [17, 18]. This finding could be explained by the large range of malaria prevention tools deployed among children less than 5 years old, such as ITNs, malaria chemoprevention and vaccines [19–21].

This study has strengthened the capacity of health personnel at the sub-district level who can perform similar surveys at planned intervals to monitor trends in malaria parasite prevalence to determine the effectiveness or otherwise of targeted interventions to reduce the burden of malaria at shorter intervals than the 3-years interval of the MIS. This is particularly important as Ghana moves from malaria control to elimination phase. Whiles the MIS focuses only on children under 5 years and pregnant women, this study included the children under 5 years as well as those aged 5–10 years, thereby providing information on parasite prevalence in this older age group which also needs to be monitored. The study also covered all the districts of the Greater Accra Region, thereby providing baseline information for monitoring and also identifying hotspots within the region.

This study had a potential limitation. There is the possibility of false negative results due to HRP2 gene deletions [22–24]. However, a previous study in Ghana, found a low prevalence of false negative malaria, indicating RDTs remain effective in diagnosis of malaria [25].

Conclusion

This study sought to determine the prevalence and factors associated with malaria among children aged 6 months to 10 years in the Greater Accra Region of Ghana. A low prevalence of malaria was reported, compared with other regions in the country. There are, however, potential hotspots that need to be targeted with appropriate interventions to accelerate the drive towards malaria elimination. Factors such as absence of nets on the windows and being aged 5–10 years were associated with higher likelihood of malaria positivity.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12936-024-05109-4.

Supplementary material 1. Prevalence of malaria among children 6 to 59 months in the Greater Accra Region

Supplementary material 2. Prevalence of malaria among children 5 to 10 years in the Greater Accra Region

Supplementary material 3. Sub-district level prevalence of malaria among children in the Greater Accra Region

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Author contributions
K.P.A., K.M., D.K.D., N.Y.P., J.W. and G.A.A. conceived the study. D.K.D., G.A.A., K.K., L.A. and D.A.G. designed the laboratory studies. D.K.D., K.K., G.A.A., F.A., K.A., and D.A. coordinated participant enrolment & study coordination. A.R,N., E.O.L., D.K.D. and K.K. managed and cleaned data for analysis. S.G. performed statistical analysis of the data. D.K.D. wrote the first draft of the manuscript. All authors contributed to the interpretation of the results, and revision of the final manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
Data is provided within the manuscript or supplementary information files.

Declarations

Competing interests
The authors declare no competing interests.

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