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High prevalence and risk factors associated with asymptomatic malaria among children in Nkwen village, Northwest Region, Cameroon

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Abstract

Background In endemic locations, asymptomatic malaria is a major contribution to the rise in clinical malaria. In order to achieve the goal of interrupting malaria transmission, control programmes should take into consideration carriers of asymptomatic malaria parasite. Hence, the purpose of this study was to look at the prevalence and risk factors of asymptomatic malaria in children in Nkwen village.

Methods Using a cross-sectional and community-based design, conducted between June and December 2022, a total of 246 children were enrolled after obtaining informed and signed consent from parents and/ or guardians. To collect data, pre-tested, closed-ended, structured questionnaires were used, ensuring the accuracy and reliability of the information gathered. A digital thermometer with infrared forehead capability was used to take participants' body temperature, providing precise measurements and respondents with temperature < 37.5 °C, and not presenting any symptoms or indicators of malaria were included in the study, ensuring the focus on asymptomatic cases. Blood samples were collected by venipuncture and screened for the presence of asymptomatic parasitaemia using blood smear microscopy and nested polymerase chain reaction (PCR). Data was entered into Microsoft Excel worksheet and analysed using SPSS version 23 software. Logistic regression models were carried out to explore the risk factors associated with asymptomatic malaria at household and individual levels and statistically significant association was considered at a p-value < 0.05.

Results A total of 246 healthy children were examined for asymptomatic malaria infection using microscopy and PCR. Of the examined children, 65.9% (162/246) were malaria positive by PCR while 59.3% (146/246) were malaria positive by microscopy. Considering both diagnostic methods, females had a greater prevalence of asymptomatic malaria than males. In logistic analysis, the risk of developing asymptomatic malaria was associated several factors: previous malaria episode (OR = 5.14; CI 2.94–9.01), family history of malaria (OR = 3.86; CI 2.21–6.74), homestead near swampy areas (OR = 3.56; CI 2.10–10.61), non-utilization of insecticide treated nets (OR = 4.36; CI 2.53–7.5), non-usage of indoor residual spray (IRS) (OR = 6.67; CI 3.75–11.86) and opened eaves (OR = 3.86; CI 2.21–6.74). No associations were established between asymptomatic malaria and the following factors: age group (p > 0.05), gender (p > 0.05) and type of wall construction (p > 0.05).

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Conclusion The high rate of asymptomatic malaria in this study is a significant problem and may jeopardize the current malaria control effort. Personal and house-level risk factors were linked with asymptomatic malaria. Therefore, it should be considered when evaluating and restructuring more successful malaria elimination tactics to accomplish the intended goals of malaria control.

Keywords Asymptomatic malaria, Risk factors, Children

Background

Malaria remains a global public health concern, that is responsible for the high mortality and morbidity in children and pregnant women [1, 2]. In 2022, global malaria cases was estimated at 249 million in 85 malaria endemic countries while the World Health Organization (WHO) African Region accounted for 94% of the global cases estimated at 233 million [3], compared to 247 million cases in 2021, 241 million cases in 2020 and 229 million cases recorded in 2019 with the most at risk being infants below 5 years [4–6]. *Plasmodium falciparum* is the primary cause of malaria deaths worldwide [4, 5]. Asymptomatic malaria which can be defined as the presence of parasites in a blood smear at any density with no clinical signs associated with malaria [7, 8]. Asymptomatic malaria poses a significant hurdle to the elimination of malaria [7] due to the fact that asymptomatic carriers do not seek medical assistance, they serve as reservoirs for parasites from which *Anopheles* mosquitoes get infected and transmit the infection to uninfected individuals enhancing transmission dynamics. In addition, malaria cases continue to remain under reported coupled with the absence of clinical signs and symptoms in asymptomatic carriers [7–10].

Long-term asymptomatic carriage is believed to be a type of resistance to the parasite in young children, strengthening their immune response and preventing either a moderate or a more severe malarial attack [10]. The transmission dynamics of asymptomatic malaria are influenced by geographical and other complex factors, such as hosts, environment and parasites [11] Previous studies revealed that the risk of asymptomatic malaria among school children was age-dependent with a higher risk occurring in male children, presence of standing water around homes [12, 13] and a study of these factors is, therefore, an important factor for the control of malaria. For several years, Cameroon has implemented a variety of strategies to combat and eradicate malaria. Known method of preventing and controlling malaria adopted by the Cameroonian Government, include large scale free distribution insecticide-treated nets (ITNs) to all households across the national territory [14–16]. Although the Northwest Region of Cameroon is noted for low endemicity to malaria, previous study by Payne et al. [17] reported malaria prevalence to drop from 14.5% in 2017 to 9.13% in 2020. This decline of malaria incidence and prevalence could be accounted for by the expansion of interventions including use of insecticide-treated bed nets (ITNs) and indoor residual spraying (IRS) which targets the vectors, and patient care with the use of efficient artemisinin-based combination drugs which targets the parasite [14, 18]. These gains in malaria incidence and prevalence especially in under five children made through a combination of interventions to control malaria, could result to new and significant reservoirs for malaria transmission, shifting the prevalence to school children who most often display malaria asymptomatically. Till date, no study has been carried out on asymptomatic malaria in the Northwest Region of Cameroon. In order to determine the degree of the infection reservoir and restructure any malaria control programme to be effective in this area, it is crucial to investigate the prevalence of asymptomatic malaria and its associated risk factors.

Methods

Ethical approval

Ethical clearance for this study was obtained from the Regional Ethical Committee for Human Health Research, North West, Cameroon, Ref No. 2024/01/001/CERSH-NW. After the objectives and benefits of the research were spelled out to the concerned authorities, verbal authorizations were granted from the Quarter heads of the selected Quarters, written informed consent was obtained from guardians and/or parents and interested children signed assent forms. Participant's data was kept confidential and only used for the study purpose.

Study area

Nkwen village is found in Bamenda III sub-Division, under the Mezam Division with head Quarter being the North West Region. It has a population of about 40,000 with 14, 248 households with 46 quarters [2, 15]. It has an elevation of roughly 1258 m above sea level. Nkwen is located between Latitude 5056″ N–5058″ N and between longitude 10,008″ E to 10,010″ E [19] *Anopheles* mosquitoes thrive there due to its temperate climate, with mean annual temperature between 21.1–22 °C, and average relative humidity of 97%–98%. Generally, North West Region in general is defined the dry and rainy seasons.

The Region receives about 1800–2500 mm as average rainfall per year, and the vegetation is primarily grassland [15, 19, 20] (Fig. 1).

Study design and period

This study was a cross-sectional, community-based investigation, involving children (5–14) years, permanently residing in Nkwen village and who had a temperature of 37.5 °C or below 37.5 °C with no noticeable signs or symptoms of malaria. The seven months duration of the study spanned from June 2022 to December 2022.

The sample size was determined using the Cochran formula

$$n = \frac{Z^2P(1-P)}{e^2}$$

where n is the required sample size, Z is the 1.96 (95%CI; Confidence interval), p is the prevalence of malaria in Bambili is the 9.13% [16], a nearby village close to the study location; e is the error rate = 0.05.

$$n = \frac{(1.96)^2 \times 0.0913(1-0.0913)}{0.05^2} = 127.48$$

Thus, 127 was considered as the minimum sample size; considering the loss of sample due to incomplete data entry and reduction in variability, a total of 246 children were recruited for this study. Convenient sampling was used to select consented participants.

Criteria for the selection of study participants

Children living in Nkwen between the ages of 5–14 years, and have permission from their parents or guardians to engage in the study were included. As a method of limiting bias from false negatives, children who had received anti-malarial medication or other recent treatments for fever within the preceding two weeks were not included in this study. Furthermore, excluded from this study were children with either haematological disorders, HIV positive status, or more serious medical illnesses such as sickle cell disease, diabetes and kidney diseases.

Study design

Data collection

Structured, closed-ended, pretested questionnaires written in English, were administered to interested participants to obtain several data including demographic data (sex, age, residence), known associated risk factors (type of wall construction, presence and use of insecticide-treated nets (ITNs), past episodes of malaria infection of family members in the last two weeks, use of IRS amongst others). These questionnaires were orally translated from English to Pidgin English and the Nkwen mother tongue for those who could not read and understand English. A digital thermometer was used to take the participant's facial skin temperature, and the results were entered on the data sheet in degrees Celsius to the nearest 0.1 °C.

Blood collection

About 3 mL of blood was drawn by venipuncture into a 5 mL sterile disposable syringe. A small portion of the blood was then placed on 3MM Whatmann filter paper and on a labelled glass slide for polymerase chain reaction and microscopy respectively following the method previously described by [20, 21]. The remaining blood in the syringe was dispensed into labelled dry tubes that were taken to the laboratory for additional assays. The blood spots were preserved and transported to the laboratory for molecular analysis in zip-locking plastic bags.

A thick film for microscopy was prepared from blood spotted on labelled, grease-free glass slide. To rupture all the red blood cells and remove any parasites present, a thick film in the shape of a coin was created by rubbing the blood drop over the edge of another glass slide. After allowing the slide to air dry over a light source, it was stained for ten minutes with 10% fresh Giemsa stain and examined under (X100) lens of the microscope [20]. After scanning through at least 100 high-power fields and failing to detect any malaria parasite the slide was deemed negative. Two seasoned independent laboratory technicians who are experts in microscopy at the Bambili Health Centre looked over the slides as a quality control measure for discrepancies. Parasitaemia was calculated using a technique from an earlier investigation [22, 23]. Four categories were used to categorize the parasite density as previously described [24].

Molecular analysis

For each sample, dry blood spots (DBS) that were created using approximately 100 µL of anticoagulated whole blood on Whatmann filter paper were used to extract DNA by the chelex method as previously described [21]. As previously described [21, 25, 26] the 18SrRNA gene of *P. falciparum* was amplified by nested PCR using a RoboCycler Gradient 96 thermal Cycler (Stratagene, Amsterdam). Stringent procedures were taken to avoid cross-contamination. The amplified products were visualized by electrophoresis on 2% agarose gel (Sigma, Fisher, USA) stained with ethidium bromide (Sigma-Aldrich, USA) for 45 min at 100 V. A 100-bp ladder (exACTGene Ladder, Fisher) was used a reference. The presence of a band at the expected size for each primer set was determined positive.

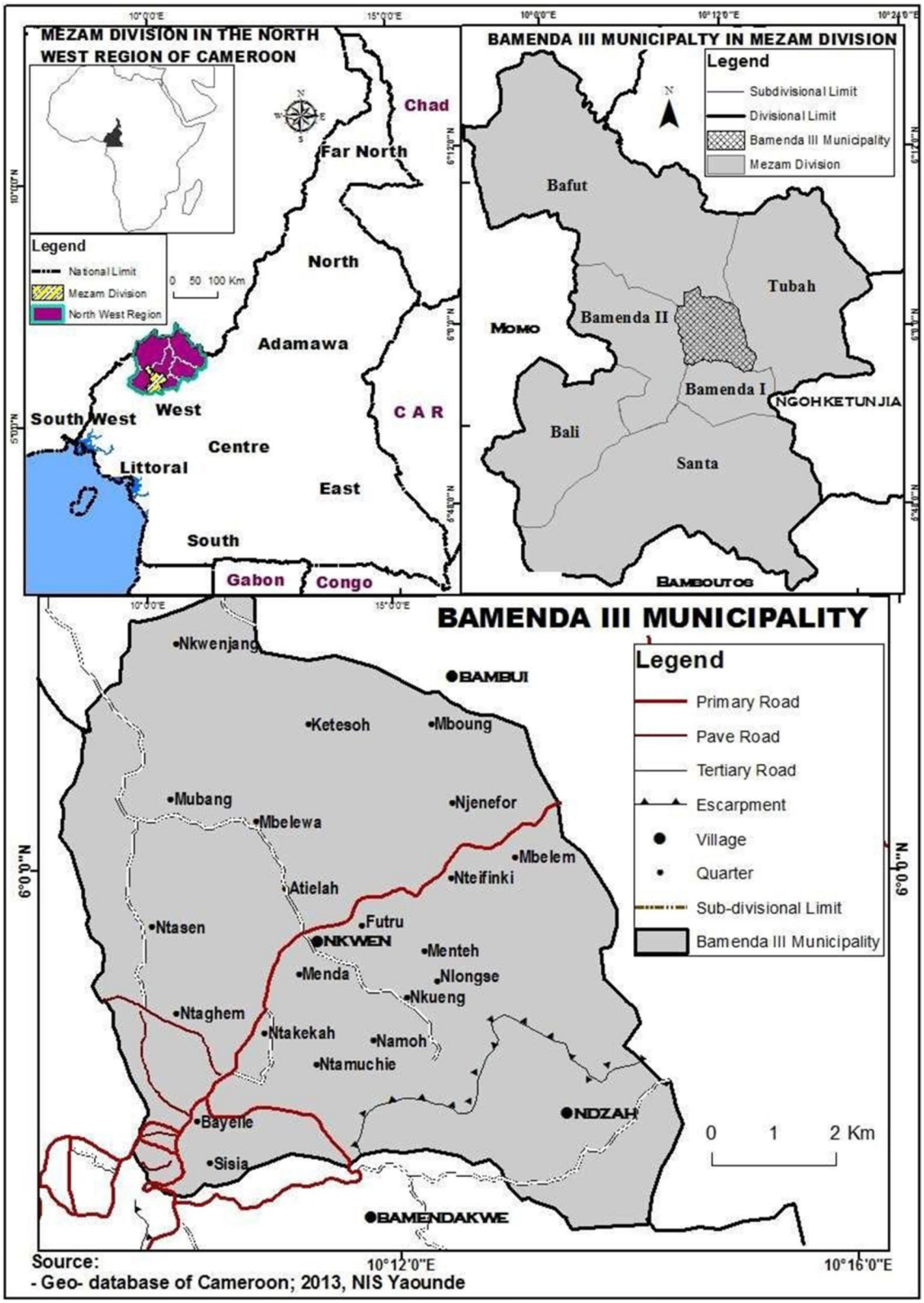

Fig. 1 Map of Cameroon showing location of the study site-Nkwen (Field work of Mbanga, 2018 adapted from Geo-Database of Cameroon; NIS Yaounde)

Data analysis

Data from the laboratory and information in questionnaires were entered into Excel worksheet, and analysed using SPSS version 23, software package. Levene's and Kolmogorov-Simonov test were used to verify if the data was homogenous and normally distributed, respectively. The chi-square test and bivariate logistic regression analysis was used to evaluate the significant relationship between variables. The resulting findings were displayed in tables as percentages and frequencies (number). The threshold p-value less than (<) 0.05 was considered significant.

Results

Socio-demographic and clinical characteristics of the participants

A total of 246 children were included in this study of which most respondents were females 51.6% (127/246). Most of the participants39.0% (96/246) were between the ages of 5–8 years, while 28.9% (79/246) were between 9–11 years and 32.1% (79/246) were between the ages of 12–14 years. Most of the parents/guardian 125 (50.8%) attended primary level or had no formal education. About 53.3% had household size between 6–7 members (Table 1). The overall mean temperature was 37.4 ± 1.1 °C and the geometric mean parasite density (± SD) in parasite/microlitre of blood was 1772.87 (± 1792.77).

Most of the respondents 66.7% (164/246) reported a family history of malaria with most 51.2% (126/246) reported having previous malaria episodes. Majority of the households 51.2% (126/246) had breeding sites/swamps around them. The majority 77.2% (190/246) possess insecticide-treated bed nets but only 42.3% (104/246) reported sleeping under the treated bed nets. Most of the respondents 66.7% (164/246) had houses with opened eaves. Most of the respondents 60.6% (149/246) had their walls constructed with cement blocks as seen on Table 1

Table 1 Socio-demographic and individual characteristics of respondents

Variables	Frequency (n)	Percentages (%)
Sex		
Male	119	48.4
Females	127	51.6
Age (years)		
5–8	96	39.0
9–11	71	28.9
12–14	79	32.1
Educational level of parent/guardian		
Primary/no formal	125	50.8
Secondary	78	31.7
Tertiary	43	17.5
Household size		
≤ 5	72	29.3
6–7	131	53.3
> 8	43	17.5
Family history of malaria		
Yes	164	66.7
No	82	33.3
Previous episode of malaria (some months or years ago)		
No	120	48.8
Yes	126	51.2
Presence of swamp/breeding sites		
Yes	126	51.2
No	120	48.8
Possession of bed nets		
Yes	190	77.2
No	56	22.8
Always Sleeping under ITN		
No	142	57.7
Yes/sometimes	104	42.3
Use of IRS		
No	123	50.0
Yes/sometimes	123	50.0
Eaves		
Opened	164	66.7
Closed	82	33.3
Type of wall		
Cement	149	60.6
Mud block	97	39.4

**IRS* Indoor residual sprays, *ITN* Insecticide treated nets

Prevalence of malaria by blood smear microscopy and polymerase chain reaction

Table 2 depicts the prevalence of asymptomatic malaria by microscopy and polymerase chain reaction. Among the 246 children examined by blood smear microcopy, 146 (59.3%) had malaria parasites, and all of them were *P. falciparum*. The prevalence of malaria was highest 66.2% (47/71) in children aged 9–11 years ($p = 0.09$, $\chi^2 = 4.63$). Females had a higher prevalence 63.3% (79/127) of asymptomatic malaria compared to males 56.3% (67/119); s ($\chi^2 = 0.88$; $p = 0.36$).

Polymerase chain reaction—derived prevalence of asymptomatic malaria revealed that 162 (65.9%) were found to be asymptomatic (Table 2). The prevalence of malaria was higher 60.4% (58/96) in children aged 5–8 years compared to the other age groups ($\chi^2 = 2.13$; $p = 0.034$). The prevalence of asymptomatic malaria was higher in females 67.7% (86/127) compared to males 63.9% (76/119); ($\chi^2 = 0.41$; $p = 0.59$).

Table 2 Malaria parasite prevalence by microscopy and polymerase chain reaction in relation to age and gender

Variables	Total (N)	Malaria symptom status		X^2-value	p-value
		Asymptomatic positive N (%)	Asymptomatic negative N (%)		
Blood smear microscopy	246				
Age (years)				4.63	0.09
5–8		49 (51.0)	47 (49.0)		
9–11		47 (66.2)	24 (33.8)		
12–14		50 (63.3)	29 (36.7)		
Gender				0.88	0.36
Males		67 (56.3)	52 (43.7)		
Females		79 (62.2)	48 (37.8)		
Total		146	100		
Prevalence (%)		59.3	40.7		
PCR	246				
Age (years)				2.13	0.34
5–8		58 (60.4)	38 (39.6)		
9–11		50 (70.4)	21 (29.6)		
12–14		54 (68.4)	25 (31.6)		
Gender				0.41	0.59
Males		76 (63.9)	43 (36.1)		
Females		86 (67.7)	41 (32.3)		
Total	246	162	84		
Prevalence (%)		65.9	34.1		

* Figures in parentheses indicate percentages, X^2; Chi-square

Classification of parasitaemia by sex and age among the parasitaemic school children

Table 3 shows the classification of asymptomatic malaria with respect to sex and age groups among children with positive blood smears. Most of the children 134/146 (91.8%) had low parasite density (< 1000 parasites/μL); with 98.0% (48/49) being children between 5–8 years ($\chi^2 = 11.90$; p-0.02). with regards to sex, majority 94.9% (75/79) were females having low parasitaemia compared to males 88.1% (59/67) with no significant difference ($\chi^2 = 5.02$; p = 0.08).

Risk factors associated with asymptomatic malaria

Table 4 displays some of the risk variables linked to asymptomatic malaria. It is observed that educational level of parent/guardian, household size, use of IRS,

Table 3 Classification of parasitemia by gender and age among the parasitemic school children

Variables	Parasite density distribution			X2-value	p-value	Total
	< 1000 N (%)	1000–4999 N (%)	5000–9999 N (%)			
Age (years)						
5–8	48 (98.0)	1 (2.0)	0	11.90	0.02*	49
9–11	39 (83.0)	8 (17.0)	0			47
12–14	47 (94.0)	3 (6.0)	0			50
Total	134 (91.8)	12 (8.2)				146
Gender						
Male	59 (88.1)	8 (11.9)	0	5.02	0.08	67
Female	75 (94.9)	4 (5.1)	0			79
Total	134 (91.8)	12 (8.2)				146

*Figures in parentheses indicate percentages; X^2 = Chi square

Table 4 Factors associated with asymptomatic *Plasmodium* infection

Variables	Asymptomatic plasmodium infection		COR (OR)	95% CI		p-value
	Positive N (%)	Negative N (%)		Lower	Upper	
Family history of malaria						
Yes	115 (70.1)	49 (29.9)	3.86	2.21	6.74	0.11
No	31 (37.8)	51 (62.2)				
Previous episodes of malaria (some months or years ago)						
Yes	94 (78.3)	26 (21.7)	5.14	2.94	9.01	0.001*
No	52 (41.3)	74 (58.70)				
Presence of swamp/ breeding sites						
Yes	93 (73.8)	33 (26.2)	3.56	2.10	6.09	0.45
No	53 (44.2)	67 (55.8)				
Possession ITNs per households						
Yes	122 (64.2)	68 (35.8)	2.39	1.3	4.39	0.056
No	24 (42.9)	32 (57.1)				
Always Sleeping ITN						
No	105 (73.9)	37 (26.1)	4.36	2.53	7.51	0.001*
Yes/sometimes	41 (39.4)	63 (60.6)				
Use of IRS (last 6 months)						
No	99 (80.5)	24 (19.5)	6.67	3.75	11.86	0.001*
Yes/sometimes	47 (38.2)	76 (61.8)				
Type of wall						
Cement	92 (61.7)	57 (38.3)	1.29	0.76	2.16	0.45
Mud	54 (55.7)	43 (44.3)				
Eaves						
Open	115 (70.1)	49 (29.9)	3.86	2.21	6.74	0.001*
Closed	31 (37.8)	51(62.2)				

COR or OR Crude odds ratio or odds ratio, *CI* confidence interval; IRS; Indoor residual sprays, *ITN* Insecticide treated nets

* Significant p-value

family history of malaria, previous malaria episodes, presence of swamps, possession and usage of insecticide treated nets, and presence of eaves were found to be significantly associated with asymptomatic malaria ($p < 0.05$), while gender, age and type of wall (house construction material) did not show significant ($p > 0.05$) association with asymptomatic malaria. Based on exposure and intervention measures, it is observed that, the risk of developing asymptomatic malaria was 4 times (OR = 3.56; 95%CI 2.10–10.6.09; p = 0.45) higher among children residing near swampy area than their counterpart. Children with previous family history of malaria were 3.86 times (OR = 3.86; 95%CI 2.21–6.74; p = 0.11) at risk of developing asymptomatic malaria than their counterparts. Participants with previous malaria episodes were more than 5 times (OR = 5.14; 95%CI 2.94–9.01; p = 0.001) at risk of being asymptomatic compared to counterparts with no previous malaria episodes. The risk of being asymptomatic was 2.39 (OR = 2.39; 95%CI 1.30–4.39; p = 0.05) higher in children possessing ITNs compared to their counterparts not in possession of ITNs. In a like manner, who reported not using insecticide-treated net were more than 4 times (OR = 4.36; 95%CI 2.53–7.5; p = 0.001) more likely to develop asymptomatic malaria compared to those who sleep under ITNs sometimes. Children who reported not using IRS were more than 6 times (OR = 6.67; 95%CI 3.75–11.86; p = 0.001) at risk of developing asymptomatic malaria than those who use IRS. Children whose houses had opened eaves more at risk of developing asymptomatic malaria (OR = 3.86; $p < 0.001$) as opposed to their counterparts with closed eaves.

Discussion

The main objective of this study is to investigate the prevalence and risk factors linked with asymptomatic malaria in children (5–14) years in Nkwen village, NorthWest Region, Cameroon.

The prevalence of asymptomatic malaria was high (65.9% and 59.3%), irrespective of the diagnostic method

used. This results are in line with studies carried out by Ojurongbe et al. [27] in Ekondo titi, South West Region, where a prevalence of 74.2% was reported. In Lipenja Barombi community, the prevalence reached 89.6%, which was the highest recorded in the country so far. These results could be explained on the understanding that, repeated exposure to malaria parasite increases the host's immune system's ability to tolerate both parasite density and symptoms in Regions with low malaria transmission, Hence, the immune system can tolerate parasites with no clinical symptoms and, thus, a high prevalence of asymptomatic malaria [18].

The children might have developed an immunity that does not protect them from being infected with the parasite but shields them from exhibiting signs and symptoms of the disease. As a result, the children appear healthy but infected. This high frequency indicates a sizable pool of asymptomatic parasitaemia in children, who are probably going to infect other children be it at home or in school. However, a low prevalence has been recorded in other studies; 44.3%, in Makenene, Centre Region of Cameroon, 38.42% in South West, 6.8% in Ethiopia, 25.6% and 19.0% in Osogbo and Ido-Ekiti (Nigeria), respectively [7, 14, 18, 28, 29]. The discrepancies in the results could be accounted for by the location, study size, period and diagnostic method. The investigation was carried out in a Region where hyper endemic malaria transmission was prevalent among the local population. Furthermore, as evidenced by the conflicting research, parasite infection was identified by PCR, which is recognized to be more sensitive than microscopy.

In this investigation, *P. falciparum*, a malaria parasite species known to cause severe malaria, was the only one found. This results corroborates a study in Makenene [18]. This might be the case because *P. falciparum* is more commonly found in Africa as it is the case in certain Regions of Cameron, such as the South West [16] and North West [2]. To ascertain whether certain factors could be involved in malaria's development and persistence, the disease's prevalence was evaluated based on the other criteria. Regarding protective immunity in malaria-endemic areas, age plays a significant role. The prevalence was higher (60.4%) in children (5–8) years. However, this prevalence decreased with age. A comparable pattern was noted [25], where a prevalence of 45.9% was observed in children 5–10 years old, followed with a decrease to 30.6% in children 10–15 years. Same trend of results with age was also reported by Quang et al. [29]. The reason for this could be that, children develop immunity to malaria as they get older and are exposed to malaria infections. For up to 6 months, a newborn baby develops immunity against malaria through mother's antibodies. To neutralize malaria infection and sustain low parasitaemia for extended periods, children raised to adulthood through repeated malaria infections develop partial immunity over time [27–31]. These differences observed amongst these age groups may be explained by the fact that immunity increases with age, hence protect against malaria infection. Children have been hypothesized to have weak or not well-developed immune systems to fight against malaria compared to adults [18]. The reason is that children develop immunity to malaria throughout their early years of exposure to the illness on multiple occasions [32].

With regards to sex, females were shown have a higher prevalence of 67.7% compared to males with 63.9% though not significant ($p > 0.05$). This findings do not agree with previous studies [14, 16] which revealed the prevalence in males to be higher compared to females. Sex discrepancies can be accounted for factors such as use of preventive and control measures, treatment speed, nutrition, immune system variations [11, 29, 30].

It is observed that most of the participants regardless of sex and/or age groups had low parasite density (< 1000 parasites/microlitre). This could be because of the low sensitive limitation of microscopy compared to other diagnostic tools. These findings run counter to earlier research [32, 33]. High malaria density (> 1000/µl) in children 5–10 and 10–15 years was previously reported by Agaba et al. [33]. A quantitative technique called parasite density can be used to quantify the number of parasite present in an affected person. In order to identify and categorize the severity of the disease, parasite density may be a crucial measure [33] for managing cases of malaria. Previous work by Njama-Meya et al. [34] revealed a link between severe and hyper-parasitaemia as well as the pathophysiological effects of the illness. Therefore, higher parasitaemia in silent cases were linked to higher chance of experiencing symptomatic malaria [35], underscoring the significance of estimating parasitaemia and treating asymptomatic cases. Parasite density is an accurate method of diagnosing malaria since rapid diagnostic test kits have low sensitivity of detecting very low parasite levels.

The odds of developing asymptomatic malaria were about 4 times higher in children with a family history of malaria than their counterparts (OR = 3.86; 95%CI 2.21–6.74; p = 0.11). The findings are in line with earlier reports [36, 37]. It is hypothesized that previous malaria history serves as a channel and reservoir for parasites that can be transmitted to other members of the house. Children with previous malaria episodes were more than 5 times (OR = 5.14; 95%CI 2.94–9.01; P = 0.001) at risk of being asymptomatic compared to those who reported no previous malaria episodes. Similar trend was also observed in Sanja, Debre Elias

district communities and Gondar District (Northwest Ethiopia) [7, 36, 38]. The return of malaria following clinical cure is one explanation for this. Swamps, one of the suitable thriving environments for mosquitoes was associated with asymptomatic malaria. This results corroborates with earlier studies in Ethiopia [13, 39]. Possession of ITNs is not always correlated with its usage, as possession is not utilization. The risk of asymptomatic malaria was more than 2 times higher in children who possess insecticide treated bed nets (OR 2.39; 95%CI 1.30–4.39; $p=0.05$) than children who do not possess ITNs. Since there was no discernible difference between the people who had insect repellent and those who did not, this indicates that there is a disconnect between owning and using mosquito nets. This is corroborates with earlier investigations in Ethiopia [7, 13, 36, 39], Northern Uganda [25] and China [11]. Reports revealed that those who do not use IRS were more than 6 times at risk of being asymptomatic (OR = 6.67, 95%CI 3.75–11.86; $p=0.001$) than those who sometimes use IRS. This results was consistent with [39] h but not with [13]. It has been demonstrated that certain features of a home increases the risk of contracting malaria [40]. Here, children resident in house with mud walls and opened eaves were more at risk of developing asymptomatic malaria compared to their counterparts living in houses with cement walls and closed eaves. Better built homes with excellent drainage systems have been linked to a lower chance of contracting malaria, according to earlier research [41].

Limitations

The study could not be conclusive based on limitations including.

- Being a cross-sectional study, the risk factors observed shows a temporal relationship between asymptomatic malaria and the observed variables. In conclusion, a longitudinal strategy is the most effective way to investigate the wide range of clinical consequences that might results from asymptomatic parasitaemia.
- Difficulty in remembering previous malaria episodes and the ability to draw firm conclusions about the rate of disease transmission in the Region are restricted by the absence of entomological data in this study.
- Because the study was carried out in a rural location with smaller sample size, the findings cannot be applied to the entire country.

Conclusions

In the Nkwen locality, asymptomatic malaria is highly prevalent in children and varies according to age and gender. Risk factors such as swamps, possession and non-usage of ITNs and a family history of malaria were linked with asymptomatic malaria. Furthermore, children who did not use IRS and whose homes had eaves or opening between roof and wall had higher chances of being asymptomatic of malaria. The authors recommend consistently using of ITNs, IRS, enhanced environmental control and house building. To produce more informative factors, a study that considers elements of the natural causal pathway is needed. In addition, it is advised that active case detection be used to eliminate asymptomatic *Plasmodium* carriers effectively.

Abbreviations

WHO	World Health Organization
PCR	Polymerase chain reaction
ITN	Insecticide-treated nets
IRS	Indoor residual spray
OR	Odd ratio

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Author contributions

MMK, CAP, TNM conceived and designed the study. MMK participated in sample collection, laboratory analysis, data analysis and interpretation and was a major contributor to the write-up of the manuscript. MMK wrote the original draft of the manuscript. MMK, CTF, SB, MB and AC critically revised the manuscript. CAP and TMN supervised the work. All authors read and approved the final manuscript.

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Availability of data and materials

All data on which the conclusions are drawn are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Research authorization and Ethical clearance was obtained from the Regional Ethical Committee for Human Health Research for the North West Region, Cameroon Ref No. 2024/01/001/CERSH-NW. Written informed consent was obtained from guardians or parents of the participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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