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Epidemiology of *Plasmodium falciparum* Malaria in the Ikata-Likoko Area of Mount Cameroon: A Cross Sectional Study

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Authors' contributions

This work was carried out in collaboration between all authors. Authors CBE, HKK, IUNS and LGL conceived the study. Authors CBE, HKK, IUNS and JEY performed the field and laboratory work. Author CBE analyzed the data. Authors CBE, HKK, IUNS and JEY contributed material for the study. Author CBE wrote the manuscript. Authors HKK, IUNS and LGL supervised and revised the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study was aimed at evaluating socio-demographic, clinical, as well as preventive measures associated with malaria parasite prevalence and anaemia in the Ikata-Likoko area.
Study Design: It was a cross-sectional survey.
Place and Duration of Study: This study was carried out in the Ikata-Likoko area of the Mount Cameroon area in the South West Region, from June to July 2014.

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Methodology: Five hundred and sixteen participants (273 females, 243 males) were included in the study. Information on socio-demographic data, febrile/clinical history and malaria prevention methods were recorded on a structured questionnaire. Venous blood was collected for the detection of malaria parasite in Giemsa-stained blood smears and for determination of haematological parameters using an electronic blood cell analyser.
Results: Out of 516 participants, 183 (35.5%) were positive for malaria parasite. Parasite prevalence varied significantly with age (*P*=.001) where children 5-15 years were the most infected (47.7%, 72). Individuals with no formal or primary education were significantly more infected (38.0%, 145) than their counterparts with secondary or tertiary education (*P*=.046). With respect to occupation, pupils and students (41.7%, 108) were the most infected and the difference was significant (*P*=.009). Prevalence was not affected by gender and locality. The overall geometric mean parasite density (GMPD) was 1967/µL of blood (range: 64-31680). GMPD was significantly higher in participants from Mile 14 (21178/µL of blood, range: 64-24000) than those from other localities. GMPD did not vary with gender, age, level of school attainment and occupation. Fever (48.9%, 216), (OR: 47.1, 95%CI: 15.1-71.2, *P*=.00), vomiting (1.17%; 7), (OR: 11.15, 95%CI: 1.2-107.8, *P*=.04) and anaemia (26.1%, 110), (OR: 2.39, 95%CI: 1.3-3.0, *P*=.007) were clinical factors associated with malaria parasitaemia. Individuals living in wooden houses had a higher prevalence of malaria (36.3%, 182), (OR: 0.097 95%CI: 0.1-0.8, *P*=.03) as well as GMPD (1943, CI: 64-31680, *P*=.044) than those in brick houses.
Conclusion: Malaria and anaemia remain high in the area. Community awareness campaign and the intensification of prevention strategies could reduce the prevalence.

Keywords: Malaria; prevalence; anaemia; risk factors; preventive measures.

1. INTRODUCTION

Malaria remains the most common parasitic disease on the globe [1]. And its burden is conspicuous in sub-Saharan Africa including Cameroon. The disease is characterized by paroxysms of fever, joint pains, headache, abdominal discomfort diarrhea, nausea and vomiting [2]. *Plasmodium falciparum* is the most pathogenic and commonest species and its infection leads to severe complications including anaemia. However, it has been reported that malaria case incidence and mortality rates have reduced by 18% and 48% respectively on a global scale during the past fifteen years [1]. As such an estimated 214 million cases with 438000 deaths were reported in 2015 by the WHO [3]. In the year 2000, an estimated 262 million cases of malaria were reported globally, leading to 839000 deaths [3]. Eighty-eight (88) percent of these cases occur in Africa with children under five and pregnant women accounting for the majority of cases. In Cameroon, between 3,400,000 and 7,500,000 cases were recorded for 5,200-14,000 deaths in 2013 [1,3].

This improvement in the malaria situation is thought to be as a result of anti-malarial strategies that have been put in place by WHO and state governments including Cameroon. The measures include the free distribution of insecticide treated bed nets (lately long lasting insecticide treated bed nets (LLINs)), intermittent preventive treatment for pregnant women (IPTp) and infants (IPTi), prompt diagnosis and treatment, and the use of more effective drug combinations such as artemisinin combination therapies. Unfortunately, the strategies do not seem to have been very effective in certain communities in remote areas in South West Cameroon such as the Ikata-Likoko area. It has been reported that though ITNs and LLINs have been distributed free of charge, ownership does not necessarily imply utilisation [4]. Several factors could also influence the level of endemicity of malaria and these include climatic factors (high temperatures and rainfall) which favour the breeding of malaria vector as well as poor socio-economic conditions [5], low level of education and occupation such as farming. These conditions are prevalent in the Ikata-Likoko area. The area is also plagued with bad roads and accessibility to the area is a major problem. The Ikata-Likoko area is endemic for malaria. Consequently, malaria and anaemia continue to pose a serious hindrance to well-being. Although, several varied levels of malaria prevalence have been reported in the Mount Cameroon Region [6-10], none has been reported in the Ikata-Likoko area and the situation needs to be ascertained. Findings from this study will be complimentary and helpful to the Ministry of Public health in the orientation of the strategies against this infection in the country and especially in areas with difficult accessibility. Against this background, the objective of this study was to determine the prevalence of malaria and evaluate the socio-demographic, clinical and preventive factors that are associated with malaria infection in the Ikata-Likoko area.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in the Ikata-Likoko area which is comprised of four rural communities Ikata, Bafia, Mile 14 and Likoko of the Muyuka Health District of the Mount Cameroon region. Mile 14 and Likoko communities make up one village, but are separated by a distance of about two kilometres. Ikata is located between longitudes 9.363 and 9.352, latitudes 4.329 and 4.328 and between 87m and 132m above sea level. Bafia is between longitudes 9.324 and 9.311, latitudes 4.350 and 4.363 and is 229 m to 256 m above sea level. Mile 14 is located between longitudes 9.302 and 9.292, latitudes 4.396 and 4.401 and between 157 m and 168 m above sea level. Likoko is located between longitudes 9.319 and 9.320, latitudes 4.399 and 4.393 and is 108 m to 116 m above sea level. Access to these villages from Muyuka is through an untarred, stony road that is usually muddy and sometimes impassable in the rainy season. In the dry season, it is dusty and full of potholes. The topography is characterized by hills and valleys. Most of the valleys are riverbeds that overflow their banks in the rainy season. It is also very common to find stagnant pools of water that last for weeks, which serve as breeding sites for mosquitoes. Rainfall averages 3126.7 mm annually while temperatures vary between 23℃ and 33℃ with an annual average of about 26.2℃. Two major seasons exist in the area, the rainy (March to October) and the dry (November to February) seasons. The vegetation is mainly the tropical forest type. The main occupation here is farming with cocoa as the main cash crop. Each of the villages has a primary school. Bafia and Ikata have a secondary school and a government owned Integrated Health Centre (IHC) each. Bafia has a second health centre belonging to the Cameroon Baptist Convention. The main religion practised is Christianity.

2.2 Study Population

Participants in this study were inhabitants of Ikata, Bafia, Mile 14 and Likoko villages of the Muyuka Health District in the South West Region of Cameroon. Five hundred and sixteen (516) individuals above one year of age who had sojourned in the area for at least two months were consecutively included in the study. Out of these, 273 (53%) were females while 243 (47%) were males. The age ranged was 2–76 years with a mean of 23.8±17.5 years. Blood samples were collected from all participants. Blood samples that did not meet anticoagulant/blood ratio were not considered for haematological analyses. Participation in the study was totally voluntary.

2.3 Study Design

This cross sectional survey was carried out between June and July 2014. After obtaining administrative and ethical clearances, acquaintance visits were made to the village chiefs and their quarter heads to explain the procedures, the benefits of the study and to fix appropriate dates and collection sites for the study. The village authorities informed the inhabitants about the study and the chosen dates. Informed consent forms carrying information about the procedures were issued on the spot during the study and only those who gave their consent were admitted in the study. A structured questionnaire was used to collect data on socio-demographic, febrile/clinical factors and preventive measures. Blood samples were collected and transported to the Malaria Laboratory of the University of Buea for parasitological and haematological analyses.

2.4 Administration of Questionnaire

A structured questionnaire was used to collect data on socio-demography of the participants, history of febrile illness, as well as associated signs and symptoms of malaria and preventive measures practised. Socio-demographic data included age, sex, level of education, religion and occupation, while the associated signs and symptoms of malaria included headache, joint pains, vomiting and abdominal pains. Data on malaria prevention methods such as use of ITNs and LLINs, use of window nets and nature of house (wooden or cement bricks) were also recorded on the questionnaire. A case report form was used to record laboratory results. Questionnaires were administered in English and exceptionally in Pidgin English where necessary.

2.5 Sample Collection

Four (4) mL of venous blood sample were collected using a syringe (Cathy Yougo) into ethylenediaminetetraacetate (EDTA) anti-coagulant tubes. Thick and thin blood smears were prepared from the blood samples and used for parasitological analyses as described by Cheesbrough [11]. The remainder of the blood was used for complete blood cell counts. The slides were labelled, air dried and placed in slide boxes. They were then transported with the remainder of the blood in a cool box to the Malaria Research Laboratory of the University of Buea.

2.6 Laboratory Analyses

After fixing the thin smears with absolute methanol for two minutes, all the slides were stained with 10% Giemsa solution for 20 minutes, dried and observed using the x100 (oil immersion) objective of the light microscope (Olympus NY-USA). Each smear was read by two parasitologists and in case of disparity, the reading of a third parasitologist was recorded. Asexual parasites and gametocytes were counted against 200 white blood cells and counts were expressed as parasites per µL with reference to white blood cell (WBC) count from haematological analysis [11]. The thin smears were used to determine the species of *Plasmodium* by referring to an identification chart [11]. The haematological analyses were done using an electronic blood cell analyser (URIT 3300 ANALYSER) following the manufacturer's instructions. The following blood parameters were obtained: WBC count, lymphocytes, granulocytes and red blood cell (RBC) counts, haemoglobin (Hb) concentration, mean cell volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC). Anaemia was defined as Hb < 11 g/dL [11].

2.7 Statistical Analysis

Data was entered into Excel version 2013 and analysed using the IBM Statistical Package for Social Sciences (IBM SPSS) version 20 (IBM Inc. 2012). Data was summarised into proportions and means. Proportions were compared using the Cramer's V, while the Mann-Whitney U test was used to compare mean parasite densities for two groups whereas the Kruskall-Wallis H test was used to compare mean parasite densities of more than two groups. Factors that influenced malaria occurrence were determined using the logistic regression model (LRM). The level of significance was set at $P < 0.05$.

3. RESULTS

3.1 Characteristics of the Study Population

A total of 516 participants were sampled from the four localities (Bafia: 122, Ikata: 126, Likoko: 117, Mile 14: 151) and out of this 273 (53%) were females while 243 (47%) were males. Most of the participants had completed primary school (299, 57.9%) and just 3 (0.6%) had attained tertiary education. In terms of occupation, a majority of the participants (259, 50.2%) were pupils/students, while 23 (4.5%) were housewives. Overall 35.5% of the participants had malaria parasitaemia with an overall geometric mean parasite density (GMPD) of 1967/µL of blood (range: 64-31680). Two hundred and sixteen (41.9%) had fever while 110 (26.1 %) were anaemic (Table 1).

3.2 Prevalence and Density of Malaria Parasite with Respect to Socio-demographic Factors

A total of 183 (35.5%) participants were infected with the malaria parasite. All malaria parasites detected (100%) were *P. falciparum*. This prevalence varied with the different demographic factors (Table 2). Although not statistically significant, more males (36.2%) were infected than females (34.8%) while the GMPD/µL of blood was higher in females (1989/ µL) than males (1944/ µL).

Malaria parasite prevalence varied significantly among age groups (V= 0.194, P=.001) where the 5-15 years age group was the most infected (47.7%) while those aged >15 years were the least infected (27.6%). The highest GMPD/µL of blood was observed in the <5 years age group (2478/µL), while the least was in the >15 years age group (1640/ µL) but the difference was not statistically significant (H = 1.484, P=.48) (Table 2).

Although not significant among the localities, the highest prevalence of malaria parasite was observed in participants from Mile 14 (40.4%), while the least was recorded in those from Likoko (29.9%). Conversely, the significantly highest (H= 8.46, P= 0.04) GMPD/µL of blood was observed in participants of Likoko (2574/µL) while the least was in those from Bafia (1300/ µL) as shown in Table 2.

Table 1. Baseline characteristics of the study population

Characteristic	Category	Frequency/Value	Percentage (%)
Sex	Male	243	47
	Female	273	53
Age group (years)	<5	71	13.8
	5-15	151	29.3
	>15	294	57
Age range years (mean±SD[a])		2-76 (23.8±17.5)	
Median age (years)		19.0	
Overall Mean temperature (ºC±SD)		37.16±0.9	
Plasmodium prevalence		183	35.5
Overall GMPD[b]		1967 (Range: 64-31680)	
Overall mean haemoglobin (g/dL±SD)		11.98±2.99	
Overall anaemia		110 (n=422)	26.1
Overall fever		216	41.9
Highest level of school attainment	No formal education and primary	382	75
	Secondary and tertiary	134	25
Nature of house	Wooden	501	97.1
	Bricks	15	2.9
Occupation	Semi-skilled workers	30	5.8
	Babies/children	9	1.7
	Farmers	195	37.8
	Housewife	23	4.5
	Pupils and students	259	50.2
Religion	Christianity	513	99
	Islam	1	0.2
	None	2	0.4

a: standard deviation, b: Geometric Mean Parasite Density (parasite/µL of blood)

With respect to level of school attainment, people with no formal or with primary education had a significantly higher (V=0.088, *P*= .046) prevalence of malaria parasite (38.0%) than those with secondary or tertiary education (28.4%). Similarly, although not significant the GMPD was higher in those with no formal or primary education (2050/ µL) than their counterparts with secondary or tertiary education (1679/ µL).

With reference to occupation, malaria parasite prevalence was significantly highest (V=0.162, *P*= .009) in pupils and students (41.7%) while housewives were the least infected (8.7%). Similarly, the highest GMPD/µL of blood was observed among the pupils and students (2218/ µL) while the least was among farmers (1588/ µL) but the difference was not statistically significant (H= 3.101, *P*=.54).

Participants living in wooden houses (36.3%) had significantly higher (V=0.104, *P*=0.018) malaria parasite prevalence than those in brick houses (6.7%) and in like manner, the GMPD/µL of blood was higher in those in wooden houses (U=3.00, *P*=0.044).

3.3 Clinical and Risk Factors Associated with Malaria Parasite Occurrence

Malaria parasite prevalence was significantly higher in people with: fever (76%, OR: 47.1, 95%CI: 15.1-71.2, *P*=.00), vomiting (85.7%, OR: 11.15, 95%CI 1.15-107.81, *P*=.04) and anaemia (50%, OR: 2.39, 95%CI: 1.25-2.99, *P*=.007).

Although not significant, the prevalence of malaria parasite was equally higher among persons with: fever in the past few days before the survey (40.7%, OR: 1.20, 95%CI: 0.69-2.09, *P*=.50), fever in the past three months (40.4%, OR: 1.52, 95%CI: 0.79-2.90, *P*=.20), diarrhea (50%, OR: 1.28, 95% CI: 0.08-21.58, *P*=.86), self-medication during sickness (40.1%, OR:

1.07, 95%CI: 0.65-1.77, *P*=.78) and those who were on herbal malaria treatment at the time of study (37.5%, OR: 0.88, 95%CI: 0.46-1.67, *P*=.7).

3.4 Malaria Prevention Methods Influencing Malaria Occurrence

As shown in Table 3, the prevalence of malaria was higher among people who did not use mosquito bed-nets (36.1%) than mosquito bed-nets users (36.1%) but the difference was not statistically significant (OR: 0.79, 95%CI: 0.53-1.17, *P*=.25). Malaria parasitaemia was comparable among those who have nets on their windows (37.1%) and those who do not have (35.3%).

3.5 Haematological Indices and Malaria Status

The haematological analyses revealed higher values of parameters in persons negative for malaria than those positive except for WBC and MCHC (Table 4). Significant statistical difference was however recorded only in RBC (U: 15110.0, *P*<.001) haemoglobin (U: 1564.5, *P*<.001) and haematocrit (U: 15623.0, *P*<.001) values.

Table 2. Prevalence and density of malaria parasite with respect to socio-demographic factors

Characteristics	Category	Number of participants tested	Prevalence (n)	GMPD (Range)
Age group (years)	<5	71	42.3 (30)	2479 (400-24000)
	5-15	151	47.7 (72)	2191 (80-31680)
	>15	294	27.6 (81)	1640 (64-16000)
Level of significance		**V=0.194, *P*=.001**		**H =1.484, *P*=.48**
Sex	Male	243	36.2 (88)	1944 (80-31680)
	Female	273	34.8 (95)	1989 (64-16000)
Level of significance		**V=0.015, *P*=.74**		**U=4014.50, *P*=.64**
Highest level of school attainment	No formal education and primary	382	38.0 (145)	2050.39 (80-31600
	Secondary and tertiary	134	28.4 (38)	1679 (64-16000)
Level of significance		**V=0.088, *P*=.046**		**U=2679.50, *P*=.80**
Occupation	Semi-skilled worker	30	30.0 (9)	2120 (1024-7200)
	Babies and children	9	33.3 (3)	1856 (960-6400)
	Farmers	195	31.3 (61)	1588 (80-12800)
	Housewife	23	8.7 (2)	1600
	Pupils and students	259	41.7 (108)	2218 (64-31680)
Level of significance		**V=0.162, *P*=.009**		**H=3.101, *P*=.54**
Locality	Bafia	122	33.6 (41)	1301 (80-7600)
	Ikata	126	36.5 (46)	2101 (80-31680)
	Lykoko	117	29.9 (35)	2574 (80-14400)
	Mile 14	151	40.4 (61)	2118 (64-24000)
Level of significance		**V=0.081, *P*=.33**		**H=8.46, *P*=.04**
Nature of house	Bricks	15	6.7 (1)	19200
	Wooden	501	36.3 (182)	1943 (64-31680)
		V=0.104, *P*=0.018		**U=3.00, *P*=0.044**

V: Cramer's V test, H: Kruskall-Wallis test; U: Mann-Whitney U test

Table 3. Clinical factors and malaria prevention measures associated with malaria occurrence

Characteristic	Factor	Category	Number of participants tested	Prevalence of malaria (n)	OR (95%CI)	*P*-value (LRM)
Clinical factors	Fever	Yes	216	76% (164)	47.1 (15.1-71.2)	.00
		No	300	6.3% (19)		
	Fever in the past few days	Yes	243	40.7% (99)	1.209 (0.697-2.095)	.50
		No	273	30.8% (84)		
	Fever in the past three months	Yes	312	40.4%(126)	1.516 (0.795-2.890)	.20
		No	204	27.9% (57)		
	Self-medication during sickness	Yes	272	40.1% (109)	1.074 (0.651-1.772)	.78
		No	244	30.3% (74)		
	Headache	Yes	42	31.0% (13)	0.497 (0.211-1.167)	.11
		No	474	35.9% (170)		
	Joint pains	Yes	28	32.1% (9)	0.986 (0.379-2.569)	.98
		No	488	35.7% (174)		
	Vomiting	Yes	7	85.7% (6)	11.151 (1.153-107.811)	.04
		No	509	34.8% (177)		
	Diarrhea	Yes	2	50.0% (1)	1.279 (0.076-21.582)	.86
		No	513	35.5% (183)		
	Anaemia	Yes	110	50.0%% (55)	2.39 (1.25-2.99)	.007
		No	312	29.5% (92)		
	currently on herbal malaria treatment	Yes	56	37.5% (21)	0.881 (0.464-1.673)	.70
		No	458	35.4% (162)		
Malaria prevention methods	Sleep under mosquito bed net	Yes	243	34.6% (84)	0.793 (0.534-1.176)	.25
		No	269	36.1% (97)		
	Have mosquito net on windows	Yes	97	37.1% (36)	1.413 (0.855-2.333)	.18
		No	417	35.3% (147)		

Table 4. Haematological parameters with respect to malaria status in the Ikata-Likoko area

Indices	Malaria status	N	Mean (SD)	Range	U-test *P*-value
WBC x 10^9/L	Positive	147	8.97 (4.17)	0.1-29.9	19558.00
	Negative	276	8.81 (5.30)	3.0-21.0	.54
Platelets x 10^9/L	Positive	147	192.76 (92.36)	2.0-530.0	18634.50
	Negative	275	200.17 (85.71)	18.0-500.0	.19
RBCx10^{12}/L	Positive	146	4.18 (0.90)	1.42-9.56	15110.50
	Negative	272	4.47 (0.92)	2.03-9.00	<.001
Hb (g/dL)	Positive	147	11.38 (2.78)	4.0 -26.0	15640.5
	Negative	275	12.29 (3.04)	7.0- 28.0	<001
Hct (%)	Positive	146	34.18 (7.70)	13.0-76.0	15623.00
	Negative	272	36.77 (8.48)	21.0-85.0	<.001
MCV (fl)	Positive	146	81.98 (8.2)	58.0-109.0	18809.00
	Negative	272	82.63 (8.50)	50.0-118	.37
MCH (pg)	Positive	146	27.02 (2.61)	20.0- 35.0	19052.50
	Negative	272	27.23 (3.23)	17.0-56.0	.49
MCHC (g/dL)	Positive	146	33.04(1.30)	30.0-37.0	19279.00
	Negative	272	33.01 (1.51)	30.0-47.0	.61

4. DISCUSSION

Malaria remains endemic in several parts of the tropics despite efforts put in place by governments to fight the disease. Its burden is most conspicuous among the poor populations. The measures put in place seem not to be effective in all areas and so malaria and malaria related anaemia remain in high prevalence in such localities.

The overall prevalence of malaria parasite was 35.5%, *P. falciparum* was the only species detected as is the case with previous studies in nearby areas [10,12]. The high prevalence could be attributed to among other reasons, the likelihood that measures put in place by the Cameroon Government particularly the distribution of long lasting insecticide treated bed nets (LLINs) have not been effective in this area. The prevalence is comparable to others obtained in different studies in other rural communities in the Mount Cameroon region [10,12].

More males were positive for malaria than the females though the difference was not statistically significant. Men have the tendency of staying bare bodied as compared to women especially in places with hot weather as is the case with the Ikata-Likoko area. This finding which corroborates others [3,10,12,13], could also be justified by the nocturnal farming practiced by the males who become more exposed to the malaria *Anopheles* vector which is naturally more nocturnal.

With respect to age group, children aged 5-15 years were most infected. Male children of this age group in the rural communities generally accompany their male parents in their farming process including the nocturnal farming, and so become more exposed. It is also worthy of note that the malaria burden is reported to witness a shift to individuals in age groups above five years [14-16] following measures in endemic areas such as use of insecticide treated nets (ITNs) and LLINs which earlier targeted risk groups including children less than five. Adults being the list infected in this study are in line with other studies that have reported increased anti-parasite immunity with exposure [17].

In terms of occupation, pupils and students were the most infected. Students in the rural communities indulge in several temporal economic activities including farming and petty trade during the holidays that may sometimes keep them out into the night thus exposing them to infection from *Anopheles* mosquitoes and consequently resulting to an increase in malaria prevalence in this group.

In line with the findings of Dike et al. [18] in Nigeria and Sharma et al. [19] in India, individuals with no formal or with primary education were more infected with the malaria parasite than those with secondary or tertiary education. Higher levels of education are generally associated with improved knowledge and practices in relation to appropriate prevention and treatment strategies. Though this study did not evaluate the knowledge of the participants on malaria prevention methods, it is likely that nation-wide campaign on media related to malaria prevention has not been effective in this area.

Likoko community with the least malaria parasite prevalence had the highest parasite density. This could be linked to its lowest altitude with respect to the others, which correlates with reports from other studies [20-23] which depicted higher malaria parasitaemia in lower altitudes. Nonetheless, it is likely that inhabitants here have developed anti-parasite immunity due to possible high transmission rates associated with lower altitudes as reported by Idro et al. [24] and Castello et al. [25]. On the other hand, those with lesser or no immunity within the same community suffer higher parasite densities. Lower altitudes generally have higher temperatures which relatively favour malaria parasite and vector development and hence malaria transmission intensity [26]. These parasite densities may manifest differently from one individual to another.

Observations from this study reveal significant association between fever, vomiting and anaemia with malaria. Malaria generally manifests with clinical signs including, headache, joint pains, diarrhea, vomiting, fever and anaemia. The high value of malaria associated anaemia indicates that malaria contributes to anaemia given that the value is higher than that of the overall anaemia and individuals who are negative for malaria in the study population. Though malaria generally causes fever and reduces haemoglobin and red cell indices [27,28], these parameters could also be exacerbated by co-infections such as parasitic, viral or bacterial which were not taken into consideration in this study. Also, the fact that some of the blood samples were not adequate for haematological analyses might have influenced some of the indices.

In line with the objective of using LLINs, findings in this study show a higher prevalence of malaria parasitaemia among people who do not use LLINs. LLINs prevent contact with *Anopheles* vector and eventually reduce malaria infection. They have been associated with decreased malaria burden in other endemic countries [29,30]. Similarly, as has been reported by Nkuo-Akenji et al. [31] and Kimbi et al. [27] people living in wooden houses were more infected than those in brick houses. Wooden houses unlike brick houses may have holes on them through which the *Anopheles* vector enters the house *ad-libatum* and infects the occupants.

The higher prevalence of malaria among inhabitants having nets on their windows when compared to those without nets is unexpected since window nets are supposed to be protective against malaria infection. Nets on windows however may not serve as sufficient screens especially in an area where wooden houses dominate.

The significantly lower values of RBCs, Hb and Hct in malaria infected individuals is an expected observation, given that lower Hb and red cell indices are common markers of *P. falciparum* infection [15]. These reflects the influence of the malaria parasite on haematological parameters. These findings are consistent with other studies on malaria and malaria associated anaemia [32-34].

The detection of only one species of *Plasmodium* by light microscopy, the non-evaluation of knowledge of participants on malaria prevention methods, the inability to obtain enough venous blood to give adequate anticoagulant/blood ratio from some participants and the fact that we did not investigate the influence of other infections on anaemia are the limits of this study.

5. CONCLUSIONS

Findings from this study depict a high prevalence of malaria with varying degrees of parasite load in the Ikata-Likoko area. Malaria parasite prevalence varied with level of education and age. It is also shown to contribute significantly to anaemia. Living in wooden houses and the non-use of mosquito bed-nets are risk factors for malaria parasite occurrence. Encouraging community awareness campaign, use of bed-nets, and the building of brick houses, may considerably reduce malaria and anaemia in the area.

INFORMED CONSENT

All participants gave their consent before being admitted into the study. Minors were admitted into the study only after the assent of their parents or legal guardians.

ETHICAL APPROVAL

Ethical approval was obtained from the University of Buea Faculty of Health Sciences

Institutional Review Board after an administrative authorisation had been obtained from the Regional Delegation of Public Health for the South West Region, Cameroon. Authorisation was also obtained from the village heads. Participants were informed of the procedures of the study and the potential benefits prior to seeking their consent. Assent for minors was approved by parents or legal guardians. All participants who were positive for malaria were freely treated with artesunate amodiaquin combination.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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