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Cross sectional study on prevalence of malaria case and malaria infection in children under 15 years after the military crisis in Bouake, Côte d'Ivoire

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During the recent crisis in Côte d'Ivoire that lasted 9 years (2002-2021) many health workers were moved from the affected areas to safer places, The aim of the study is to update malaria epidemiology in one of the most affected area (Bouake city) after the crisis ended. Cross-sectional surveys were conducted in children aged 6 months - 14 years old, one in the rainy season and in the dry season in three districts of the city of Bouake and two villages. Microscopy results were used to determine malaria endemicity in children of 2-9 years old, the prevalence of *Plasmodium* species and *Plasmodium falciparum* infection. Logistic regression was used to analyse the relationship between the prevalence of malaria infection, episodes of fever and malaria attacks as diagnosed by microscopy, RDT and the type of setting, age groups, sex, season and the use of LLIN. A total of 859 children were enrolled of which 378 from rural and 481 from urban areas. *P. falciparum* was the predominant parasite species with a prevalence ranging 99.48% from urban to 100% from rural. The plasmodic index sowed hyper-endemicity both in urban (77.60%) and rural (77.11%). *P. falciparum* infection prevalence was high (78.7%) with no significant differences between areas, sex, age and season. The prevalence of microscopic-confirmed malaria cases was significantly higher in rural than in urban (27.78% vs 21.62%; p=0.032). Children 5 and 9 years old had higher prevalence of malaria attack (p<0.001). This high endemicity was linked to lower access to health facilities due to the crisis.

Key words: Prevalence, malaria cases, infection, Bouake, Côte d'Ivoire.

INTRODUCTION

Malaria remains a major cause of human morbidity and mortality in many countries of the world. The disease represents a complex public health problem in Africa where 94% of the global cases and deaths occur (WHO,

2020). The infection is widespread in tropical and subtropical regions with the most intense transmission occurring in sub-Saharan Africa. Therefore, it is important to understand temporal changes in malaria transmission, to determine the factors that contributed to these changes, and best monitor tools to design future control interventions (malERA, 2017). A number of studies have shown that *Plasmodium* infections are influenced by environmental factors such as temperature, rainfall, humidity and altitude (Cohen et al., 2008; Hay et al., 2002). These factors indirectly or directly influence and affect the geographical distribution of malaria. Urbanization profoundly changes the epidemiology of malaria, causing a decrease in risk, when compared with rural areas (Robert et al., 2003; Keiser et al., 2004; Hay et al., 2005). For long, malaria was considered as a rural disease in Africa and therethore most malaria research were conducted in rural settings (Kaiser et al., 2004; Donnelly et al., 2005).

In Côte d'Ivoire, malaria is the major reason for consultations in heath centers, representing 30 to 40% of all consultations (Yavo et al., 2002; Wang et al., 2006), Few epidemiological studies involving malaria have been conducted in Côte d'Ivoire after the political crisis with almost all of them done in Abidjan, the economic capital city of the country. In central Bouake city (the second largest city of the country) where the political crisis initialy triggered, previous report highlighted the relationship between peri-urban development and malaria transmission (Dossou-yovo et al., 1994).

This socio-political crisis which lasted more than 9 years (2002-2011) placed this city at disadvantage since malaria control provision by the National Malaria Control Programme (NMCP) through the Global Fund could not access the city due to insecurity (Bonfoh et al., 2011). After such a long period of time, it was critical to provide detailed information on malaria epidemiology in this area at the end of the crisis.

The aim of this paper is to update malaria transmission indicators, including the prevalence of *Plasmodium falciparum* infection and the level of the disease in rural and urban areas within Bouake city after the armed crisis ended.

MATERIALS AND METHODS

Study area and human population

A cross-sectional study was carried out in Bouake (lat. 7°69'N and long. 5°03'W), part of the Gbêkè health regional in central Côte d'Ivoire (Figure 1), in August 2014 and then March-April 2015. It is the second largest city of Côte d'Ivoire, with a population size 680,694 inhabitants according to the national census conducted in 2014. The local climate is of a humid tropical type encompassing two seasons: a rainy season from April to October and a dry season from November to March. The average annual rainfall was 1,100 mm and temperature fluctuating between 24 and 34°C throughout the year.

Three sanitary districts within Bouake (Kennedy, Dar Es Salam and Ngattakro) from urban and two villages (Allocokro and Petessou) from rural were selected for the study. Participants were children aged 6 months to 14 years old, whose parents or legally acceptable representative provided informed consent prior to the study.

Size

The sample size was determined using the standard statistical formula:

$N= E^2. (PQ) / i^2$

Where N = the sample size required, E = 1.96: confidence level test statistic at the desired level of significant, P = 50%: Plasmodium falciparum malaria infection prevalence, Q = (1-P): proportion of plasmodium malaria negative, and I = acceptable error willing to be committed.

For each of the study settings (rural and urban), the total number of people needed was calculated based on a parasite prevalence of 50%. This yielded 384 as the minimum number of individuals aged 6 months - 14 years required per setting.

Data collection procedures

Cross-sectional surveys (CSS) were conducted during each monitoring periods in all selected sites and the prevalence of malaria was measured during the rainy and the dry seasons to capture any seasonal variation.

An experienced health team, including a physician, a nurse, a laboratory technician and a local guide visited each village to enroll eligible children.

For all participants structured questionnaires were administered to record age, sex, household characteristics, malaria prevention methods including ownership and use of ITN. Any history of fever, malaria treatment, recent illness or chronic diseases was recorded. Secondly, for each child, axillary temperature was recorded, a rapid diagnostic test (RDT SD Bioline, one step Malaria *Pf* HRP II Antigen Rapide TEST, Standard Diagnostics, Inc.) was performed in each participant who had a history of fever within 24 h or an axillary temperature ≥ 37.5°C. A finger prick blood was collected in all children for thick films and was examined posteriori. Individuals with symptoms suggestive of malaria, including fever, associated with positive RDT was recorded as a confirmed case of malaria and was immediately treated as per the national malaria control programme guideline. In the event of fever with negative RDT, children were treatedaccording to the clinical diagnosis as assessed by the physician.The presence of the parasite was confirmed posteriori in the laboratory, by microscopy examination.

Laboratory procedures

The RDT SD Bioline Malaria Antigen *P.f.* test kit is a rapid,

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qualitative test for the detection of histidine-rich protein II (HRP-II) antigen of malaria *Plasmodium falciparum* in human whole blood. This RDT was shown to have 99.0% sensitivity and 97.8% specificity of *P. falciparum* (Tadesse et al., 2016) and the results from these RDT kit in the present study helped guide treatment in the field.

Parasite was identified by examining thick blood smear. Each slide was air-dried and stained with 10% Giemsa for 22 min. Parasitemia was determined by counting the number of asexual parasites and number of leucocytes in 200 high-powered fields based on a putative count of 8,000 leucocytes/µL of blood (Assi et al., 2017) at Pierre Richet Institute in Bouake by experienced technicians under the supervision of a parasitologist.

The slide was considered positive if malaria parasites were detected in the blood smear. A blood smear was considered negative if no parasite was detected after the examination of 200 oil-immersion fields on the thick smear. The count was made by species *(P. falciparum, P. malariae, Plasmodium vivax,* or *P ovale*). Cross-check quality control was done on a randomly selected sample representing 10% of all thick smears by independent microscopists.

Data analysis

Demographic, clinical and parasitological data were entered into Excel, coded and were analyzed using Stata software 14.1, College Station, Texas. The four dependent variables (prevalence rate of *P. falciparum* infection among asymptomatic and symptomatic children, prevalence of illness, prevalence of confirmed malaria cases with thick blood and with RDT) were analyzed according to demographic (age groups 6 months-4 years; 5-9; 10-14 years and sex), environmental (season and area) and LLIN actual use (never and always) variables. Microscopy results were used to determine malaria endemicity in children aged 2 to 9 years old, the prevalence of *Plasmodium* species and *P. falciparum* infection in every asymptomatic and symptomatic children. The prevalence rate of *P. falciparum* infection also termed as plasmodial index was the percentage of children whose thick blood smear were positive for *P. falciparum* (Number of children positive by microscopy divided by the number of children tested, according to the age group, seasons, area and use of LLINs). Malaria attack was defined as the presence of fever (axillary temperature ≥37.5°C or history of fever within 24 h) associated with any parasitaemia (malaria cases with thick blood) or with RDT positive (malaria cases with RDT). The prevalence of malaria cases was the prevalence of confirmed cases of malaria (number of malaria confirmed cases by RDT or by microscopy divided by the number of children examined according to the age group, sex, season, area and use of LLINs). Unadjusted odds ratios (OR) with their corresponding 95% confidence intervals (CI) were calculated using bivariate logistic regression analysis.

Ethical considerations

All data and blood samples were collected after informed consent from each participant through their parent/guardian. Ethical approval for the study was granted by the National Ethical Committee in Côte d'Ivoire (Ref: letter N°41 / MSLS /CNER-dkn, of 25 June 2014 Session).

RESULTS

Demographic characteristics of study population

Characteristics of study participants are presented in Table 1. A total of 859 children were included in the study. The sex ratio was almost even (0.93), in favor of women though (51.33%). The majority (56%) of them were urban dwellers and the mean age of the study subjects was 6.97 (6.72-7.22) years old (Table 1). Age ranged 6 months - 14 years old with the age group of 5-9 years old the most represented (39.46%), followed by the age groups of 6 months-4 years old (30.73%) and 10-14 years old (29.8%). There were fewer children living in rural areas (44%) than in urban areas (56%). The mean percentage usage of LLIN was 34.10% and varied from 46.08% (95% CI 40.26-51.96) in rural areas to 53.92% (95% CI 48.03-59.73) in urban areas.

Plasmodial formula or species

Three species of human malaria parasites (*P. falciparum, P. malariae* and *P. ovale*) were observed in the rural zone versus two species (*P. falciparum* and *P. malariae*) detected in the urban area. Nearly 100% of malaria parasite found in both settings was *P. falciparum,* with rare occasions where *P. malariae* and *P. ovale* (< 6%) were in sympatry with *P. falciparum* (Table 2). No cases of triparasitism (*P. falciparum* + *P. malariae* + *P. ovale*) were observed in the study (Table 2).

Prevalence of *P. falciparum* infection

Overall, a total of 859 thick smears collected during the study in rural and urban areas were examined. Of these, 678 were carriers of malaria parasites and the mean plasmodic index was 78.92% (95%IC: 76.04-81.61). By setting, the plasmodic index was 78.30% (95%CI: 73.80-82.36) and 79.42% (95%CI: 75.52-82.94), respectively, in rural zone and in urban zone.The overall plasmodic index in children aged 2 to 9 years old was 77.42% (95%CI: 73.72-80.82), indicating a hyper-endemic statut of the Bouake area, regardless of the setting, *P. falciparum* infection prevalence was analyzed in 593 asymptomatic and 266 symptomatic children (Table 3). In the asymptomatic group, *P. falciparum* infection prevalence in rural zone (79.53%) was similar to the urban zone (78.19%) (p=0,683). There was no significant association between age groups, sex or season and the prevalence of infection in children (Table 3). Oddly, asymptomatic children who constantly reported sleeping under LLIN the night before had higher parasite prevalence (83.33%) than those who did not sleep under a net (76.13%) (p=0.017). The trend in the symptomatic children was similar to that observed in the asymptomatic group (Table 3).

Febrile episode prevalence

Overall, fever as defined by an axillary temperature ≥37.5

Table 1. Demographics characteristics of study population by area.

Variable		N	Rural		Urban	
			n	% (95%CI)	n	% (95%CI)
Overall		859	378	44.0 (40.65-47.40)	481	66.00 (52.60-59.35)
Sex	Male	418	188	45.0 (40.14-49.90)	230	55.00 (50.11-59.86)
	Female	441	190	43.08 (38.40-47.85)	251	56.91 (52.14-61.59)
Mean of age		859	378	7.04 (6.66-7.43)	481	6.90 (6.58-7.24)
Age groups (years)	0 to 4	264	111	42.00 (36.02-48.25)	153	58.00 (51.75-63.98)
	5 to 9	339	148	43.66 (38.31-49.12)	191	56.34 (50.88-61.69)
	10 to 14	256	119	46.48 (40.25-52.80)	137	53.52 (47.20-59.75)
Season	Wet	298	135	45.30 (39.55-51.14)	163	54.70 (48.86-60.44)
	Dry	561	243	43.31 (39.17-47.53)	318	56.68 (52.47-60.83)
Use of LLINs	No	566	243	42.93 (38.81-47.13)	323	57.07 (52.87-61.19)
	Yes	293	135	46.08 (40.26-51.96)	158	53.92 (48.03-59.73)

LLINs: Long lasting insecticide nets.
Source: Authors

Table 2. Distribution of *Plasmodium* species according to area.

***Plasmodium* species**	**Rural**	**Urban**	**Total**
Number of thick bloods	378	481	859
Number of positive thick bloods	296	382	678
% of *Plasmodium falciparum*	100.00	99.48	99.71
% of *Plasmodium malariae*	5.10	1.10	2.80
% of *Plasmodium ovale*	0.34	0.00	0.15
% of *P. falciparum* + *P. malariae*	5.10	0.52	2.51
% P. falciparum + *P. ovale*	0.34	0.00	0.15
% of *P.f* + *P.m* + *P.o*	0.00	0.00	0.00
% of *P.m* + *P.o*	0.00	0.00	0.00

P. f = Plasmodium falciparum; P. m= Plasmodium malariae; P. o= Plasmodium ovale.
Source: Authors

°C or history of fever within 24 hours, was detected in 30.96 % of the children with no significant difference between sex (p=0.342) (Table 4). Children from the urban area had 27% (OR=0.63; 95%CI: 0.47-0.84) lower prevalence of fever than those living in rural setting (p=0,002). Prevalence of fever in age group 5 - 9 years old but not above, was significantly higher than in those below five (OR: 2.04 95%CI: 1.43-2.91, p=0.0001) (Table 4). Usually declared users of LLINs were associated with reduced prevalence of fever (29%) compared to those who never slept under LLINs (p=0.033) (Table 4). There was significantly more fever in the dry season than in the raining season (p=0.034) in children but the difference between sex was never significant (p=0.342).

Prevalence of malaria attacks

Confirmed malaria cases were determined from both the results of the thick blood and the RDT (Table 5). According to malaria definition with thick blood results (fevers with any parasitaemia), 209 (24.33%) cases of malaria attack were recorded in the 859 children. Overall, prevalence of malaria cases as detected with thick blood was associated with children location (p=0.032), those with age below 9 years old (p=0,001)

Table 3. Analysis of the prevalence rates of *Plasmodium falciparum* infection in asymptomatic and symptomatic children.

Variable	Asymptomatic children					Symptomatic children				
	N (593)	Positive thick blood smear	Prevalence Rate (95%CI)	Unadjusted odds-ratio (95%CI)	p-value	N (266)	Positive thick blood smear	Prevalence Rate (95%CI)	Unadjusted odds-ratio (95%CI)	p-value
Aera										
Rural	240	191	79.53 (73.92-84.50)	1		138	105	76.09 (68.09-82.93)	1	
Urban	353	276	78.19 (73.50-82.38)	0.91(0.61-1.37)	0.683	128	104	81.25 (73.40-87.60)	1.36 (0.75-2.46)	0.306
Age group (years)										
0 to 4	200	159	79.5 (73.23-84.86)	1		64	48	75.00 (62.60-84.99)	1	
5 to 9	205	159	77.56 (71.22-83.08)	0.89 (0.55-1.43)	0.512	134	101	75.37 (67.19-82.40)	1.02 (0.51-2.03)	0.955
10 to 14	188	149	79.25 (72.75-84.81)	0.98 (0.60-1.61)	0.865	68	60	88.24 (78.13-94.78)	2.50 (0.97-6.33)	0.053
Season										
Wet	192	159	82.81 (76.72-87.86)	1		160	124	77.50 (70.24-83.72)	1	
Dry	401	308	76.80 (72.36-80.85)	1.45 (0.93-2.26)	0.096	106	85	80.18 (71.32-87.30)	1.18 (0.64-2.15)	0.601
Sex										
F	298	238	79.87 (74.86-84.27)	1		143	113	79.02 (71.43-85.38)	1	
M	295	229	77.62 (72.44-82.25)	1.01 (0.77-1.69)	0.505	123	96	78.05 (69.69-85.00)	1.06 (0.59-1.90)	0.847
Use of LLINs										
Never	377	287	76.13 (71.50-80.34)	1		189	145	76.72 (70.04-82.55)	1	
Always	216	180	83.33 (77.68-88.04)	1.57 (1.02-2.40)	0.017	77	64	83.12 (72.86-90.69)	1.49 (0.75-2.96)	0.040

LLINs: Long Lasting Insecticide Nets.
Source: Authors

and the season (p=0,037). Children in urban area had 28% lower prevalence of malaria cases than those in rural places.

Likewise, children between 5 and 9 years old had higher prevalence of malaria attack than those under 5 years but there was no significant difference between the age group > 9 years old and the kids below 5 years (p=0.141). The prevalence of malaria cases was similar between male and female (22.97% versus 25.62% p= 0.365) and also between the group always under LLINs and none users (OR: 0.81; CI95% 0.59-1.13; p=0.222). There were more malaria cases in the end of dry season (28.52% (95%CI: 23.46-34.01)) than the rainy season (22.10% (95%CI: 18.73-25.77). In febrile children, 78.6% (209/266) had laboratory-confirmed malaria infection.

Regarding malaria definition with RDT results (fevers with RDT positive), 101 (11.76%) cases of malaria attack were recorded in the 859 children. In febrile children, 44.69% (101/266) had RDT-confirmed malaria cases.

The trend in the prevalence of malaria cases with RDT detection mirrored that with thick blood analysis for both setting and age groups (Table 5). No significant differences in prevalence of malaria

Table 4. Analyse univariate of febrile episode prevalence in children.

Parameter	N	Number of cases	Prevalence of fever (95% CI)	Unadjusted OR (95% CI)	p-values
Area					
Rural	378	138	36.50 (31.64-41.58)	1	
Urban	481	128	26.61 (22.71-30.80)	0.63 (0.47-0.84)	0.002
Age group (years)					
0 to 4	264	64	24.24 (19.20-29.87)	1	
5 to 9	339	134	39.52 (34.29-44.95)	2.04 (1.43-2.91)	0.0001
10 to14	256	68	26.56 (21.56-32.42)	1.13 (0.76-1.68)	0.543
Season					
Rainy	561	160	28.52 (24.82-32.45)	1	
Dry	298	106	35.57 (30.13-41.30)	1.38 (1.02-1.86)	0.034
Sex					
F	441	143	32.42 (28.07-37.01)	1	
M	418	123	29.42 (25.09-34.05)	1.55 (0.86-1.54)	0.342
Use of LLINs					
Never	566	189	31.82 (27.17-36.28)	1	
Always	293	77	26.28 (21.33-31.71)	0.71 (0.52-0.97)	0.033

LLINs: Long Lasting Insecticide Nets.
Source: Authors

cases were observed between dry and raining seasons (p=0.379) nor between female and male (p=0.546). The usual use of LLINs was associated with 44% reduction in prelance of malaria attack (p=0.021).

DISCUSSION

The study assessed the epidemiology of malaria in rural and urban areas of the Bouake, central Côte d'Ivoire. During the study, Rapide Diagnostic Tests (RDTs) were used to confirm malaria cases in febrile subjects. As the thick blood sample collected were to be read retrospectively, a rapid diagnostic method was needed to detect children with malaria, which was in agreement with recommendation by the National Malaria Control Programme which only advocates treatment of malaria cases confirmed by an RDT or thick blood drop (NMCP, 2014).

The analysis included 859 participants aged 6 months to 14 years and the overall mean malaria infection prevalence as determine by microscopy was 78.92% (678/859). This rate was higher than those reported in a previous study conducted in Taabo, south‑central Côte d'Ivoire with a prevalence of 46.0% in 2010 and 56.6% in 2011 (Bassa et al., 2016). The difference can be explained by the fact that in Taabo the entire population (children and adults) was examined whereas only children under 15 years were considered in the study. Elsewhere in sub-Saharan Africa, similar high intensity of plasmodium infection (70.3%) was observed in south-eastern Senegal during the malaria transmission season (Aida et al., 2021). This contrasts with low prevalence of *Plasmodium* infection (13%) reported in north-eastern Tanzania (Mmbando et al., 2010).

Unlike in previous study reporting higher *Plasmodium* infection prevalence in rural relative to urban areas (De Beaudrap et al., 2011), the prevalence of *Plasmodium* infection in rural was similar to the rate observed in urban areas of Bouake.

This would mean that, in either rural or urban settings, the ecological conditions are suitable for malaria transmission. In fact, urban farming is expanding across Bouake city and most of the agricultural practices are irrigation-based, producing anopheles breeding sites, that could increase the risk of urban malaria (Afrane et al., 2004; Keating et al., 2004). The high plasmodic index (77.42%) observed in children aged 2 to 9 years in the study areas is proof of Bouake being hyperendemic for malaria. Earlier trial in Bouale region found intense Entomological Inoculation Rate (EIR) of 155 infectious bites received per individual in a year (Dossou-Yovo et al., 1998). Similar plasmodic index of hyperendemicity was observed in northern Côte d'Ivoire (Henry et al.,

Table 5. Univariate analysis of malaria attack prevalence according positive thick bloods and positive RDT.

Variable	Malaria cases with thick bloods					Malaria cases with RDT			
	N (859)	Number of malaria cases	Prevalence of malaria cases (95%CI)	Unadjusted OR (95%CI)	p-value	Number of malaria cases	Prevalence of malaria cases (95%CI)	Unadjusted OR (95%CI)	p-value
Area									
Rural	378	105	27.78 (23.32-32.59)	1		78	20.63 (16.67-25;07)	1	
Urban	481	104	21.62 (18.02-25.57)	0.72 (0.52-0.98)	0.032	23	04.80 (03.05-07.08)	0.19 (0.12-0.31)	0.0001
Age group (years)									
0 to 4	264	48	18.18 (13.72-23.37)	1		19	07.19 (04.39-11.01)	1	
5 to 9	339	101	29.79 (24.97-34.97)	1.90 (1.29-2.82)	0.001	59	17.40 (13.52-21.87)	2.72 (1.58-04.68)	0.0001
10 to 14	256	60	23.44 (18.40-29.11)	1.38 (0.89-2.11)	0.141	23	08.98 (05.78-13.18)	1.27 (0.66-2.40)	0.455
Season									
Rainy	561	124	22.10 (18.73-25.77)	1		62	11.05 (08.58-13.94)	1	
Dry	298	85	28.52 (23.46-34.01)	1.40 (1.02-1.94)	0.037	39	13.09 (09.50-17.50)	1.21 (0.79-1.85)	0.379
Sex									
F	441	113	25.62 (21.61-29.97)	1		52	12.44 (09.43-15.99)	1	
M	418	96	22.97 (19.02-27.30)	1.55 (0.84-1.57)	0.365	49	11.11 (08.33-14.42)	0.87 (0.58-1.33)	0.546
Use of LLINs									
Never	566	145	25.62 (22.07-29.42)	1		77	13.60 (10.89-16.70)	1	
Always	293	64	21.84 (17.24-27.02)	0.81 (0.58-1.13)	0.222	24	08.19 (05.32-11.94)	0.56 (0.35-0.92)	0.021

Malaria cases with thick blood = History of fever within 24 h or fever (body temperature > = 37.5°C) with positive thick blood. Malaria cases with RDT = History of fever within 24 h or fever (body temperature > = 37.5°C) with positive RDT.
Source: Authors

2003) and in a forest area of southern Côte d'Ivoire (Assi et al., 2010). These high endemicity levels are the result of an important and perennial transmission pattern of malaria in Côte d'Ivoire.

Species analysis indicated that *P. falciparum* was the predominant malaria species whereas *P. ovale and P. malariae* were detected at low rate (<6%), mostly as mixed infections with *P. falciparum*. Similar observations were reported elsewhere in Côte d'Ivoire (Dossou-Yovo et al., 1994; Diakité et al., 2010) and in others part of Africa (Mvumbi et al., 2016; Zimmerman et al., 2004).

While, the risk of malaria in males was higher than females in some studies in Ghana (Owusu-Agyei et al., 2001), Latin America (Cucunuba et al., 2008) and Asia (Erhart et al., 2004; Reza et al., 2011), no sex-specific association with risk of malaria infection was found in the present study.

The results of the study showed an association between fever and the presence of malaria parasite in most malaria cases (78.6%). This confirming that fever is a major clinical sign in the occurrence of malaria. However, a nonnegligible proportion of fever (21.42%) was not associated with plasmodium infection, as also observed in previous study in Taabo (Bassa et al., 2016).

These observations highlight the importance, in malaria endemic, to diagnose all suspected malaria in patients with fever in health facility before the decision to treat the patient (Kabir et al., 2014). Such attitude will reduce (i) the risk of overdiagnosis of malaria when patients are treated presumptively, (ii) the risk of experiencing side effects and treatment cost, and (iii) the risk of drug resistance (Porras et al., 2014; Glinz et al., 2010). Also, diagnosing suspected malaria cases would allow clinicians to look for other causes of the patient's illness, thereby improving clinical outcomes when patients are properly managed (Becker et al., 2011; Righetti et al., 2012).

In the current study, the percentage of malaria attack (24.33%; 209/859) was relatively small because the majority (64.2%) of children with malaria parasites was asymptomatic, suggesting they may have developed anti-malarial immunity, although the anti-parasite immunity did not reach levels high enough to eliminate the infection (Greenwood et al., 1987).

Our results showed that the thick blood smear was reliable and was able to detect more malaria cases than the RDT kit. For example, the thick blood smear analysis detected 24.33% malaria cases compared to only 11.75% with the RDT. The higher sensitivity of the thick blood smear relative to the RDT and reading technique of the smears in microscopy based on 200 microscopic fields rather than 200 white blood cells could explain the difference in performance between the two malaria detection methods.

Malaria cases prevalence in children by microscopy was higher in rural than urban area (27.78% vs. 21.62%; $p<0.032$). This is in line with findings in the Hohoe municipality of Ghana, where the prevalence of malaria attack by microscopy was significantly higher in rural than urban zone (28.5% vs. 16.0%) (Margaret et al., 2017). Similarly, the study conducted in Southern Sudan reported higher prevalence of malaria cases by RDT in rural Sonsoro (41%) than in urban Gansosso (7.5%) (Govoetchan et al., 2014), probably due to the lack of health facilities in thsese areas (Wanji et al., 2012; Achidi et al., 2008).

The data showed that effective usage of LLIN in Boauke area was lower than the rate at national level, as per the demographic and health survey data gathered during 2010-2011 (EDS-CI, 2013). According to WHO, the minimum criteria for optimum community protection against malaria is an ownership rate of LLIN of at least 80% (WHO, 2010). Nervertheless, report indicated that effective use of LLIN is better than ownership and should be preferred as indicator of malaria risk (Moiroux et al., 2012). It is interesting to note that no clear impact derived from ITNs use was observed on the different parameter (*P. falciparum* infection prevalence, fever prevalence and malaria attacks prevalence) relative to none users. Surprisingly, children reported always sleeping under ITN were more infected with parasites than those who never used them. This contradicts other studies where substantial ITN use had a significant impact on malaria infection and incidence (Moiroux et al., 2012; Lengeler, 2004). Some and parents giving false information about their history of LLIN use during the survey might partly explain the observed differences.

Conclusion

This study, carried out after the military-crisis, showed that malaria was hyper-endemic in both urban and rural areas of Bouake, central Côte d'Ivoire. Parasitological indicators highlighted the fact that parasite transmission occurred equally in rural an urban areas, both in the dry and wet seasons. Confirmed malaria cases were higher in rural areas in children aged 5-9 years old and at the end of the dry season.

This high endemicity was partly linked to power access of families to health facilities due to the crisis. It is of paramount importance for government reforce local capacity including infrastructure, health facilities and commodities for a prompt management of malaria in remote areas affected by political crisis.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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