Socio-Economic Status and Prevalence of *P. falciparum* Infection in Symptomatic and Asymptomatic Individuals in Parts of Kaduna Metropolis, Kaduna State, Nigeria

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Abstract: *Plasmodium falciparum* malaria accounts for up to 80% of malaria cases worldwide, and by far the most important malaria parasite in Africa and it is responsible for over 90% of all malaria cases in Nigeria, with varied symptoms. The risk of malaria infection varies widely according to geographical region, seasons, environment and socio-economic status. This study examined the relationship between socioeconomic status (household income),occupation, malaria preventive measures utilisation and prevalence of malaria due to *P. falciparum* among symptomatic and asymptomatic individuals in parts of Kaduna Metropolis. A total of 1000 venous blood samples comprised of 500 each from the two study populations were collected in selected hospitals and National Blood Bank. *P. falciparum* detection and identification was carried out on thick and thin blood films respectively. Also the parasite density (parasitaemia) was determined. The result showed that 34.70% of all the individuals examined were infected by *P. falciparum.* Infection was significantly higher in females (44.66%) than in males (29.19%) ($P<0.05$), and influenced significantly by age and gender in both individuals ($P<0.05$).High prevalence was observed among symptomatic individuals without occupation (47.7%), low and medium income household and among medium income asymptomatic individuals. No significant association was observed between age and parasitaemia in both groups ($P>0.05$),In conclusion, despite reduction in malaria prevalence, adequate utilisation of combined protective measures and improve economic conditions will help in further reducing the prevalence of *P. falciparum* infection.

Keywords: Prevalence, *P. falciparum* infection, Socio-economic status, Symptomatic, Asymptomatic Individuals.

INTRODUCTION

Although, global malaria burden has reduced, the burden is still high in African region (WHO, 2019). In 2018, African region still accounts for the high global malaria burden with an estimated 93% malaria cases and 94% deaths (WHO, 2019). *Plasmodium falciparum* accounted for 99.7% of estimated malaria cases in the region(WHO,2019). Malaria is holoendemic in Nigeria with transmission throughout the year but intense during rainy season (Kalu *et al*., 2012;Umaru and Uyaiabasi,2015). Of the six countries that accounted for more than half of all malaria cases worldwide, Nigeria accounted for 25% of such cases (WHO, 2019).Nigeria is one of the two African countries that accounted for 35% of malaria mortality, much of which occurred in children under five years (WHO,2014;WHO,2015). *Plasmodium falciparum* is the dominant species that is responsible for over 90% of all malaria cases (Otunbanjo, 2013). According to Umaru and Uyaiabasi (2015), malaria accounts for 60% of outpatient hospital visit, 30% of hospitalization, 30% of under five mortality and 25% of infant mortality in Nigeria.

The clinical outcomes of malaria may vary among individuals and locations. Symptomatic patients manifest aggregate of symptoms of *falciparum* malaria. Such symptomatic condition can either be mild uncomplicated or severe complicated. The factors that determined the variation in clinical outcome of malaria have not been completely defined, however, both host and parasite factors as well as the complex interactions between them have been implicated (Amodu *et al*., 2005), untreated case may result to complications such as cerebral malaria, severe anaemia, hypoglycaemia among others, and may result to death.

Asymptomatic carriers show no visible symptoms of *falciparum* malaria, the condition may be due to nature of strain, drug interference, possible environmental factors, and host factors such as immune status, premunition, and blood genotype as well as negligence(Cheesbrough,2005; Paniker,2007).This condition is of public health importance in maintenance and spread of the infection (Otubanjo, 2013).

The risk of malaria infection varies widely according to geographical region, seasons, environment and socio-economic status (SES) (Ifatimehin *et al.*, 2009).The epidemiology of malaria in Sub-Saharan Africa (SSA) has been influenced by several factors including socioeconomic status, that is related to lack of education, low income, inhabiting poorly constructed houses, and farming occupation (Degarege *et al*., 2019).

Several studies have indicated the role of socioeconomic condition (SEC) as one of the factor that is associated with malaria (Ibor and Okonkwo, 2017; Muhammad Asif *et al*., 2018; Vincent *et al*., 2018; Degarege *et al*., 2019).The analysis of socioeconomic conditions associated with malaria was reviewed based on the analysis ofdata setsand findings on occurrence and prevalence of *Plasmodium*infection by different researchers (Edward and Ibrahim, 2016:Degarege *et al*., 2019). Although, studies conducted on the prevalence of malaria in Kaduna State showed the prevalence of 46.5% among patients with febrile complaints in Kaduna Metropolis (Idoko, *et al*., 2015), 35.7% in patients attending hospital Makarfi Local Government Area (Umaru and Uyaiabasi, 2015), and asymptomatic *P. falciparum* prevalence in two agrarian villages within Gurara river basin of Kaduna State (Osue *et al*., 2013) among others, however, the prevalence of 21.7% recorded in malaria patients in Zaria (Benjamin *et al.,* 2019) showed reduction in the prevalence of malaria. Considering the significant role of asymptomatic individuals in the epidemiology of malaria, an understanding of the relationship between socioeconomic status (household income), occupation, malaria preventive measures utilisation and prevalence of malaria due to *P. falciparum*in symptomatic and asymptomatic individuals will aid toward developing more effective strategies of malaria control. The aim of this study was to examine the relationship between socioeconomic status(household income),occupation, malaria preventive measures utilisationand prevalence of malaria due to *P.falciparum* among symptomatic and asymptomatic individuals in parts of Kaduna Metropolis.

MATERIALS AND METHODS

Study Area

Kaduna metropolis is the capital of Kaduna State, Nigeria. It is located in North-western geopolitical zone and lies geographically within latitude $10^{0}21^{1}23^{11}$N and longitude,$7^{0}26^{1}2^{11}$E, and is 608 meters above sea level. It is characterised by two distinct seasons viz: Thedry season commences in the months of November to March andthe rainy season usually from April through October and lasts between 4-5 months in the northern parts of the state, and 5-6 months in the southern parts of the state, with vegetation typically of guinea savannah type (Anonymous, 2016),and high temperatures during the dry season, the annual average high temperature is 31.6˚C,relatively lower temperatures occur during the rainy season with annual low temperatures of 18.5˚C (Anonymous,2016).

Study population

The study population comprised of symptomatic individuals with aggregate symptoms of malaria and asymptomatic individuals that were apparently healthy.

Subject selection criteria

Inclusion criteria: Patients who presented withsymptoms (symptomatic) suggestive of malaria parasiteswho were diagnosed clinically by doctor and referred to the laboratory for malaria test. And apparently healthy individuals (asymptomatic) who presented to laboratory for blood donation in the various hospitals and the National Blood Transfusion Service were recruited.

Exclusion criteria: Patients who did not presentsymptoms suggestive of malaria parasitesand are not referred to the laboratory for malaria testwere excluded. And apparently healthy individuals (asymptomatic) who do not present for blood donation in the hospitals and the National Blood Transfusion Service were alsoexcluded.

Ethical approvals

Ethical approvals were obtained prior to sample collection from Kaduna State Ministry of Health (MOH/ADM/744/T/9), National Blood Transfusion Service (NBTS/HQ/058/04) and Nigerian Army Reference Hospital (44) (44NARHK/GI/300/60), and confirmation was also obtained from Nigerian Defence Academy Medical Centre (N.D.A.M.C.) and St. Gerald Hospital, Kakuri respectively.

Sample Collection

A total of 1000 blood samples were collected and examined between March and November, 2011 from the study populations viz: symptomatic and asymptomatic individuals. This comprised of 500 blood samples from symptomatic patients collected from selected hospitals within the metropolis, and 500 asymptomatic blood samples collected from apparently healthy blood donors in selected hospitals within the metropolis and from the National Blood Bank Kaduna, with assistance of medical personnel.

The hospitals sampled in Kaduna South L.G.A include Yusuf Dantsoho Memorial Hospital, Tudun Wada Kaduna; Nigerian Army Reference Hospital (44) (N.A.R.H.K.44), Kaduna; Gwamna Awang Hospital, Nassarawa Kaduna; St. Gerald Hospital, Kakuri. While in Kaduna North L.G.A, the following hospitals were sampled: BarauDikko Specialist Hospital, Kaduna; Barau Dikko Children Hospital; Kaduna; Nigerian Defence Academy Medical Centre (N.D.A.M.C.), Ribadu Cantonment, Kaduna; General hospital Kawo, Kaduna.

Five millilitre (5ml) of venous blood from each person was collected into vacutainer containing Ethylene diaminetetraacetic acid (sequestrene) anticoagulant. Each sample was labelled properly. A structured questionnaire was administered and biodata of all the individuals sampled was recorded to establish age, sex, occupation and socio-economic status (low, medium and high income) and habitual use of mosquito net and insecticides by symptomatic individuals.

Sample Analysis

Thick and thin blood smear stained with giemsa was carried out on each sample using the procedures described by Cheesbrough,(2005).*Plasmodium falciparum* detection and identification were carried out on thick and thin film blood films respectively (Otubanjo, 2013).Parasite density (parasitaemia) was estimated by counting number of parasite in 200 white blood cells (wbcs) assuming 8000 wbcs per µL of blood (ref). Parasites counts were calculated as follows:

No. of parasite per µL of blood = No. of parasites × (8000÷ No. of WBCs counted) (CDC,2016).

Data Analysis

Data generated in this study was analysed with chi- square test (SPSS version 17) to test for association between infection and age and gender and also between parasitaemia (parasite density) and gender and age in symptomatic and asymptomatic individuals. Data was subjected to Student T-test (Stata version 4.0) to test the level of significant in the various age groups in relation to type of occupation.

RESULTS

Prevalence of *P. falciparum* in relation to occupation was high among symptomatic individuals without occupation (47.7%), followed by symptomatic individuals that are business men/women (46.2%), while studentsin the symptomatic group showed the least prevalence(35.1%). In asymptomatic individuals, students had the highest infection (26.3%), followed by business men/women with a prevalence of 24.6%, while those without occupation recorded the least prevalence of 21.8% (Figure 2).

The prevalence of *P. falciparum* in relation to socio-economic status showed that prevalence was high among medium income class in both symptomatic and asymptomatic individuals, with prevalence of 96.4% and 85.7% respectively. In low income class, prevalence was higher in symptomatic individuals (57.1%) compared to asymptomatic individuals (1.4%), while among high income class, prevalence was recorded only in 17.1% of symptomatic individuals (Figure 3).

Results on the use of protective measures by symptomatic Individuals showed that most frequent protective measures taken by symptomatic individuals were combination of insecticides and window wire mesh net(40%), while the least protective measures taken was wire mesh net (5%) only. About 10% used only insecticide, while insecticide treated net alone was used by 8% of symptomatic individuals. Combinations of insecticide treated net and insecticides was used by 7% and that of insecticide treated net and window wire mesh net was used by 11%. All the three protective measures were taken by 15% of such individuals, while 4% did not utilise any of the protective measures (Figure 4).

The prevalence of *P. falciparum* infection among the symptomatic and asymptomatic individuals in the various hospitals selected in Kaduna metropolis is presented in table 1. The prevalence of *P. falciparum* was found to be significantly higher in symptomatic (45.20%) than in asymptomatic individuals (24.20%) ($P<0.05$).

Out of the 1000 blood samples examined during the study, the overall Prevalence of *P. falciparum* Infection was found to be 34.70% (Table 2). Infection was significantly higher in females than in males with prevalence of 44.66% and 29.19% respectively ($P<0.05$). Individuals aged between 6 and 10yr recorded the highest prevalence (49.09%) of *Plasmodium falciparum* infection. The least prevalence was recorded among individuals aged above 40 yr. The difference in prevalence between the age groups is statistically significant (($P<0.05$)).

Table 3 shows the prevalence of *P. falciparum* infection in relation to age and gender of symptomatic and asymptomatic individuals. Among the symptomatic individuals, the 21-30 yr age group had the highest prevalence of 51.75%, the least prevalence of 31.68% was recorded among individuals above the age of 40 yr (>40). However, asymptomatic individuals above 40 yr (>40) had the highest prevalence of 31.37% and least prevalence of17.31% was observed in age group 11-20 yr. Prevalence of *P. falciparum* infection was significantly associated with age in both symptomatic and asymptomatic individuals ($P<0.05$).

The prevalence of *P. falciparum* infection in relation to gender showed that among the symptomatic individuals, females had higher prevalence (50.00%) of *P. falciparum* infection than their male counterparts (39.47%). Similarly, female asymptomatic individuals recorded relatively higher prevalence (27.38%) of *P. falciparum* infection than asymptomatic male individuals (23.55%). In both categories of individuals infected, prevalence of *P. falciparum* infection was found to be significantly associated with gender ($P<0.05$).

Parasitaemia level distribution in relation to age and gender of symptomatic and asymptomatic individuals is presented in table 4. Highest parasitaemia level of >5000 parasites/µL was observed in 6.63% of symptomatic individuals only compared to the asymptomatic individuals which had parasite density of <3000 parasites/µL. High parsitaemia of >5000 parasites/µL was observed in age groups 0-5 (19.57%) and 6-10 (11.11%) years than other age groups. Asymptomatic individuals aged 21-30yrs (23.08%) had parasitaemia of < 3000 parasites/µL compared to other age groups. No significant association was observed between age and parasitaemia in both groups ($P>0.05$).

Parasitaemia level distribution in relation to gender of symptomatic and asymptomatic

individuals showed parasitaemia levels of >5000 parasites/µL and <5000 parasites/µL were observed in symptomatic males (7.78 and 28.89%) compared to females (5.89% and 27.21%). Although parasitaemia was high in males compared to females, however, no significant association was observed between sex and parasitaemia in symptomatic individuals (P>0.05). High parasitaemia (<3000 parasites/µL) was also observed in asymptomatic males compared to females. Gender was significantly associated with parasitaemia in asymptomatic individuals (P<0.05).

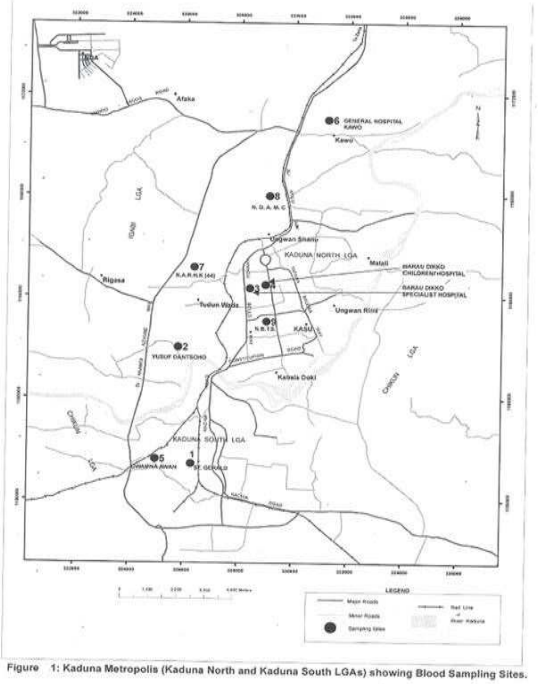

Figure 1: Kaduna Metropolis (Kaduna North and Kaduna South LGAs) showing Blood Sampling Sites.

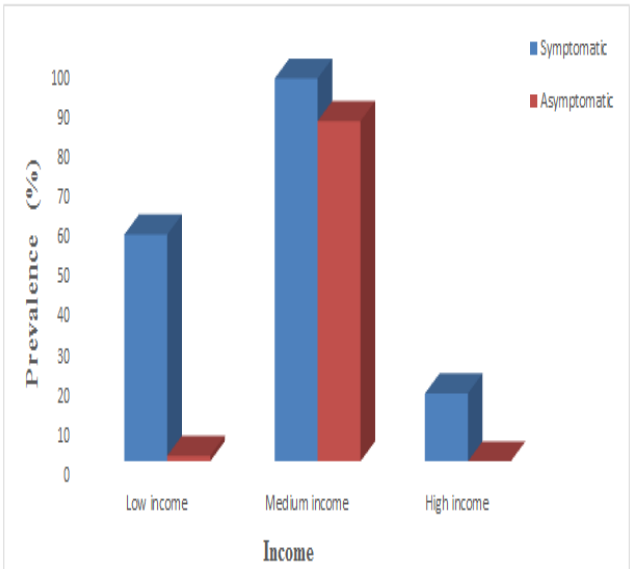

Figure 3: Prevalence in relation to socio-economic status of infected symptomatic and asymptomatic individuals

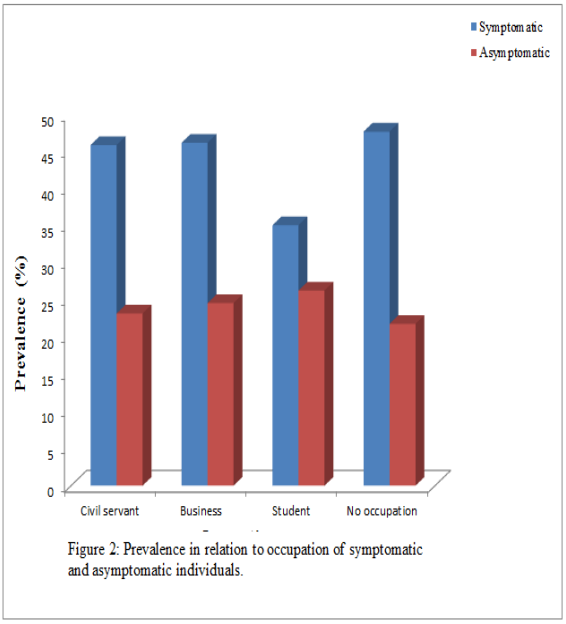

Figure 2: Prevalence in relation to occupation of symptomatic and asymptomatic individuals.

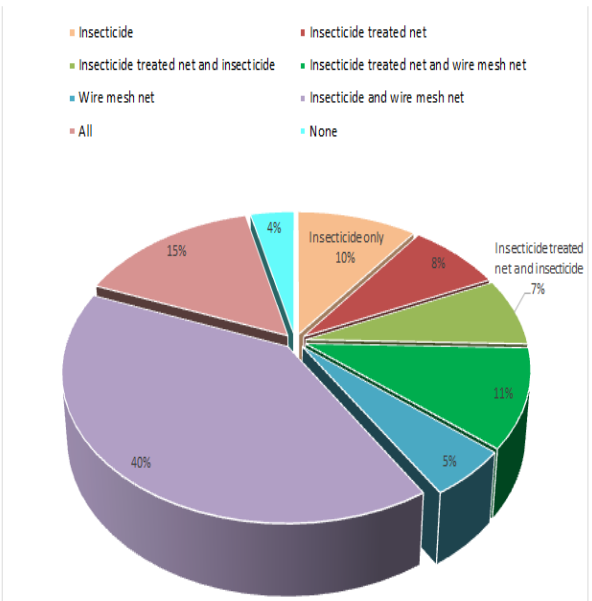

Figure 4: Routine protective measures against malaria taken by symptomatic individuals.

Table 1: Prevalence of *Plasmodium falciparum* parasite among symptomatic and asymptomatic individuals in various Hospitals in Kaduna Metropolis, Kaduna State

Hospitals	Malaria Status					
	Symptomatic			Asymptomatic		
	No. examined	No. Infected	% Infected	No. examined	No. Infected	% Infected
St. Gerald	62	17	27.42	01	0	0
Yusuf Dantsoho	62	28	45.16	0	0	0
Barau Dikko	62	20	32.26	42	06	14.28
Barau. Dik.CH.	62	23	37.09	0	0	0
Gwamna Awan	64	44	68.75	0	0	0
Gen. Hosp.	64	42	65.62	0	0	0
Kawo	62	18	29.03	02	0	0
N.A.R.H.K.(44)	62	34	54.84	0	0	0
N.D.A.M.C.	0	0	0	455	115	25.27
N.B.T.S.						
TOTAL	**500**	**226**	**45.20**	**500**	**121**	**24.20**

Table 2: Overall Prevalence of *P. falciparum* infection in symptomatic and asymptomatic individuals examined

Age group (Yr)	Sex					
	Males		Females			
	No. exam.	No. infected (%)	No. exam.	No. infected (%)	Total Male & Female exam.	Total No. infected (%)
0-5	58	26(44.83)	36	20(55.55)	94	46*(48.94)
6-10						
11-20	30	10(33.33)	25	17(68.00)	55	27* (49.09)
21-30						
31-40	64	17(26.56)	51	20(39.21)	115	37* (32.17)
>40						
	302	82(27.15)	125	55(44.00)	427	137*(32.08)
	110	31(28.18)	47	21(44.68)	157	52*(33.12)
	80	22(27.50)	72	26(36.11)	152	48*(31.58)
Total	**644**	**188(29.19)**	**356**	**159(44.66)**	**1000**	**347(34.70)**

*Statistical significant P-value =0.000 (P< 0.05)

Table 3: Prevalence of *Plasmodium falciparum* infection by age and gender of symptomatic and asymptomatic individuals

Age(yr)/gender	No. examined	No. infected	% infected	No. examined	No. infected	% infected
0-5	94	46	48.94	0	0	0
6-10	55	27	49.09	0	0	0
11-20	63	28	44.44	52	9	17.31
21-30	114	59	51.75	313	78	24.92
31-40	73	34	46.57	84	18	21.43
>40	101	32	31.68	51	16	31.37
Total	**500**	**226**	**45.2**	**500**	**121**	**24.2**
Male	228	90	39.47	416	98	23.56
Female	272	136	50.0	84	23	27.38
Total	**500**	**226**	**45.2**	**500**	**121**	**24.2**

Age-Chi-square=30.000,DF=5,P-value=0.001(P<0.05)**;**Chi-square=222.63,DF=5,P-value=0.000 (P<0.05). \
Gender- Chi-square=726.0,DF=1, P-value = 0.000 (P<0.05)**;**Chi-square=621.0,DF=1, P-value= 0.000 (P<0.05)

Table 4: Parasitaemia level distribution in relation to age and gender of symptomatic and asymptomatic individuals

			<1000 Par./µL	<5000 Par./µL	>5000 Par./µL			<1000 Par./µL	<3000 Par./µL
Age group (yr)/gender	No. exam.	No. infect.	No. (%)	No. (%)	No. (%)	No. exam.	No. infect.	No. (%)	No. (%)
0-5	94	46	22(47.83)	15(32.61)	9(19.56)	-	-	-	-
6-10	55	27	17(62.96)	7(25.92)	3(11.11)	-	-	-	-
11-20	63	28	22(78.57)	6(21.43)	-	52	9	8(88.89)	1(11.11)
21-30	114	59	46(77.97)	12(20.34)	1(1.69)	313	78	60(76.92)	18(23.08)
31-40	73	34	24(70.59)	10(29.41)	-	84	18	15(83.33)	3(16.67)
>40	101	32	17(53.12)	13(40.62)	2(6.25)	51	16	13(81.25)	3(18.75)
Total	**500**	**226**	**148(65.49)**	**63(27.88)**	**15(6.63)**	**500**	**121**	**96(79.34)**	**25(20.66)**
Male	228	90	57(63.33)	26(28.89)	7(7.78)	416	98	74(75.51)	24(24.49)
Female	272	136	91(66.91)	37(27.20)	8(5.88)	84	23	22(95.65)	1(4.35)
Total	**500**	**226**	**148(65.49)**	**63(27.88)**	**15(6.63)**	**500**	**121**	**96(79.34)**	**25(20.66)**

Note: Par./µL= Parasites/µL Blood
Gender-*Statistical significant Chi-square=62.884, DF=1, P-value = 0.000 (P<0.05)
Note: Par. / µL= Parasites/µL Blood.

DISCUSSION

Higher prevalence recorded among those without occupation in this study may be attributed to the activities of both men and women during peak biting period such as religious, cultural, and social gathering (Moshi *et al.,* 2018)may result in equal risk of infection (WHO, 2006). This may lead to greater exposure to mosquito vectors and subsequently malaria infection.

The high prevalence observed among businessmen/women in the study could be due to the fact that certain occupations have been found to place people at greater risk of exposure to malaria than others (Eke *et al*., 2006).These findings are in line with the work of Kalu*et al*., (2012), in which traders were mostly infected in two urban areas of Aba and Umuahia with 94.34% and 93.75% infection rates respectively. Individual

occupation and outdoor activities have been associated with risk of contracting *Plasmodium* infection (Degarege *et al*., 2019).

In this study, the prevalence of *P. falciparum* infection in relation to household income shows high percentage of the middle class income earners in symptomatic and asymptomatic individuals and symptomatic low income earners had high prevalence. *P. falciparum* infection was recorded only in symptomatic high income earners. Poverty is a major factor that predisposes people to infection in areas that are endemic for tropical diseases (Otubanjo, 2013; Houndbebji *et al.,* 2015), both men and women suffer from discrimination due to class inequality and poverty. In a related study, high prevalence (73.9%) of *P. falciparum* infection was observed and has been significantly associated with low socio-economic status in Cote d'ivoire (Houndbebji *et al.,* 2015.The occurrence of *Plasmodium* infection in Sub Saharan Africa (SSA) has been associated with income status (Degarege *et al*., 2019).

The study has revealed that majority of the people utilised the use of personal protective measures, particularly insecticides and wire mesh net. Personal protective measures are very vital in endemic areas, as this will prevent contact between mosquito vector and man (Otubanjo, 2013). The use of combined protective measures impacts positively on the prevalence of the infection as it places people at lower risk of contracting malaria. This may have attributed to the low prevalence of *P. falciparum* infection observed compared to previous reports (Umaru and Uyaiabasi, 2015; Idoko, *et al*., 2015). According to Houndbebji *et al.,*(2015), the frequent used of combined protective measures among children from wealthy household has placed such children at lower risk of infection contrary to the use of insecticide alone that increases risk of infection as observed by Agomo and Oyibo (2013).

The overall prevalence of *P. falciparum* infection observed in this study was 34.70%, although lower than previous reports (Umaru and Uyaiabasi, 2015; Idoko, *et al*., 2015). Several factors may have contributed to the observed prevalence in the study area which may include human altitude and behaviour, socio-economic and political factors, and climatic conditions that favour mosquito vector development and multiplication. This overall prevalence of *P. falciparum* in the study area may be considered high considering the public health implication of malaria. This could be a reflection of the global decline in parasite prevalence and a reduction in malaria morbidity as reported by the WHO (2014).

The distribution of *P. falciparum* infection in symptomatic individuals observed in the study was found to be influenced by age. This could be due to several factors among which is human related behaviour such as social, cultural and economic background in addition to political factors which may influence incidence of malaria (Otubanjo, 2013). Human behaviour may increase or decrease the risk of parasitic infection. This findings is similar to that reported by Olasehinde *et al.,* (2010), Aghedo *et al.,* (2013) and Nmadu *et al.,* (2015). However, the slight decrease in prevalence of *P. falciparum* in 0-5yr age group could be due to protective immunity acquired by newborn infants from their mothers (maternal immunity) by passive maternal antibodies that is acquired from their immune mothers and through the passage of specific IgG antibodies via the breast milk during the first six months of life, compared to aged 6-10 in which the prevalence was relatively higher. (Paniker, 2007;Chatterjee,2009;Alli *et al.,*2010). This contrasts the type of immunity acquired by the older age group, which offer no antiplasmodial effects but rather an antitoxic immunity that tends to neutralise the toxic products of parasite metabolism (Chatterjee, 2009).

The low prevalence of *P. falciparum* infection observed among age group >40 yr shows that prevalence decreases with increase in age. Similar trend was observed

by Amadi *et al.* (2011), which the authors associated it to immunity that confers protection in adults living in endemic areas of moderate transmission. Exposure to infection over the years results in development of immunity. Although, such immunity may not confer complete protection, it reduces the risk of developing severe malaria (Alli *et al.,*2010).

The high prevalence observed among the higher age group of asymptomatic individuals {>40 yr} could have been attributed to premonition (Paniker, 2007). Similar trend of infection was previous reported in Brazil (Maselli *et al.,* 2014) and Nigeria, (Amadi *et al.,* 2011). Alli*et al.,* (2010) also reported 46.55% *P. falciparum* positive cases among blood donors aged 65 yr.

The gender-related prevalence of *P. falciparum* infection observed among symptomatic and asymptomatic individuals sampled revealed a higher prevalence among females than males Gender norms and behaviours have been shown to coincide with the pattern of malaria exposure. Outdoor activities may expose women to mosquito vectors and consequently to malaria infection (WHO, 2007). In Nigeria, similar findings were reported by Kalu *et al.,* (2012) in which high prevalence of *falciparum* malaria was observed among females in Aba (91.20%) and Umuahia, (80.80%) in Abia state. High prevalence of malaria parasite infection among female donors (51.6%) than their male counter parts (0.6%) in university college hospital, Ibadan was also reported (Alli *et al.,* 2010).

In the study, high parasitaemia of >5000 parasite/µL observed in symptomatic individuals could probably account for the observed or presented symptoms among such individuals compared to asymptomatic individuals. This is in line with the work of Koepfl*et al*. (2015) who observed high parasite density among symptomatic individuals. This is contrary to the findings of Umaru and Uyaiabasi (2015), who observed that high parasitaemia does not always result in manifestation of clinical symptoms.

The high parasite density observed in symptomatic individuals of lower age group (0-5 and 6-10 yr) may have been due to protective immunity developed by older children and adults over long exposure compared to younger children (Umaru and Uyaiabasi, 2015).

This finding is similar to that of Ng'onga *et al*., (2011) who observed high parasitaemia among younger children than older ones. The significant association observed with respect to age and parasitaemia in symptomatic individuals in this study is contrary to the work of Ojurongbe *et al.,*(2011) in which no significant different was observed with respect to parasite density and age.

The high parasitaemia observed in males compared to females in the study may probably be due to the fact that more males presented with symptoms of malaria than their females counter parts even though prevalence of *P. falciparum* infection was higher in females than males. According to Wdairatana *et al,*(2013), parasite density correlates with presentations of malaria. The significant association observed with respect to parasitaemia and sex in asymptomatic individuals could be due to immunity as manifestations of clinical symptoms may not always be due to high parasitaemia (Umaru and Uyaiabasi, 2015). In addition, in areas of moderate to high transmission, much higher parasitaemia is often well tolerated (Wdairatana *et al.,* 2013).

In conclusion, prevalence of *P. falciparum* infection was found to be influenced significantly by age and gender ($P<0.05$). Occupation and income of both symptomatic and asymptomatic individuals also influenced *P. falciparum* infection. Asymptomatic infection though lower prevalence in this study, however, carriers are of great importance in the spread and transmission of malaria. Despite the reduction in malaria prevalence, adequate utilisation of combined protective measures and improve economic conditions of

individuals may help in further reducing prevalence of *P. falciparum.*

DECLARATIONS

Ethical approvals were obtained from Kaduna State Ministry of Health (MOH/ADM/744/T/9) for the sampling of symptomatic and asymptomatic individuals in the selected hospitals within the state. Approval for the sampling of asymptomatic individuals in the National Blood Transfusion Service was obtained from the Federal Ministry Of Health (NBTS/HQ/058/04).Approvals were also obtained from the Nigerian Army Reference Hospital (44) (44/NARHK/GI/300/60) Kaduna and confirmation was obtained from Nigerian Defence Academy Medical Centre and Saint Gerald Hospital respectively.

Consent of publication,

Not applicable.

Availability of data

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

Authors have no competing interest.

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Authors contribution

KB Dikwa was the lead researcher, conceived the study, carried out sample collection, sample analysis, data analysis and manuscript writing. DB Maikaje, YA Umar and AB Suleiman supervised and provided guidance on research conduct, manuscript review and production. BB Alhaji participated in data analysis, Y Rabe participated in manuscript production.

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