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Diversity of *Plasmodium* Species in Patients Attending Public Health Institution in Doma, Nassarawa-Eggon and Kokona Local Government of Nasarawa State

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Abstract

Malaria remains a significant health challenge in Nigeria and millions of people are still at risk of contracting the parasite. This research determined the diversity of *Plasmodium* species in patients attending public health institutions of Nasarawa State with respect to their age, gender, occupation and risk factors of infection. A total of 1200 blood samples were collected through venous puncture from consenting patients attending the hospitals and analyzed using two malaria diagnosis methods that is, Giemsa stained blood film microscopy and Rapid Diagnostic Tests (RDTs). Microscopy had 62.5% while RDTs had 59.7% positive malaria cases. The age group with highest infection were 11-20 years (18.9%) and the least was 51 and above 8.5%. Females (54.1%) were more infected

than males having 45.8%, ($p<0.05$). Farmers were the most infected (26.0%) and the least infected were students with a prevalence rate of 16.66%, ($p<0.05$). *Plasmodium falciparum* was highest (78.2%) followed by *P. malariae* (20.2%), the least species found was *P. ovale* (4.1%). Based on risk factors associated with malaria, patients who reside in rural areas are more infected (54.9%) than those who stay in urban area (45.1%), those who use ITNs (26.9%) were less infected than those who do not (73.1%); the patients who wear protective clothing at night (29.4) were less infected than those who did not (70.5) and those who use insect repellant (33.9%) were less infected than those who did not (66.1%). There was a statistically significant difference in relation to these factors ($p<0.05$). A malaria prevalence rate of 62.5% is considered extremely high and should be a cause for significant concern and urgent intervention efforts and malaria control measures by the Government should be encouraged. These include campaigns promoting the use of insecticide treated nets and the maintenance of good personal and environmental hygiene.

Introduction

Malaria is one of the major important human parasitic diseases throughout the subtropical and tropical regions of the world due to its high prevalence and mortality rate. It is a major tropical disease infecting approximately 500million people and causing 1.5-2.7 million deaths annually and it is transmitted throughout Nigeria, with 97% of the population at risk of malaria (World Health Organization [WHO], 2021).

Malaria is endemic in about 32 countries in Sub-Saharan Africa, and these countries are responsible for almost 93% of malaria death worldwide. It is a major public health challenge in Nigeria; being one of the countries with the highest burden of the disease. Nigeria (31.9%) is the leading country among the four African countries responsible for half of the malaria mortality all over the

world (WHO, 2022). The duration of the transmission season ranges from year-round transmission in the south to three months or less in the north. *Plasmodium falciparum* is the predominant malaria species (WHO, 2021). Seventy six percent (76%) of the populations live in high transmission areas while 24 % of the population lives in low transmission areas (WHO, 2020). The transmission season can last all year round in the south and is about 3 months or less in the northern part of the country (WHO 2019).

According to the 2020 World Malaria Report, Nigeria had the highest number of global malaria cases (27 % of global malaria cases) in 2019 and accounted for the highest number of deaths (23% of global malaria deaths) (President's Malaria Initiative [PMI], 2020).The use of laboratory methods has become necessary because health workers cannot identify malaria cases reliably using clinical signs and symptoms alone (WHO, 2011). Malaria in humans is caused by six *Plasmodium* species: *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium malariae*, *Plasmodium ovalecurtisi, P. ovalewallikeri* and *Plasmodium knowlesi* which, although zoonotic, is an important pathogen in humans in several regions of Nigeria (WHO, 2017).

Statement of the Problem

The main interventions of the Global Malaria Control Strategy include the prompt and accurate diagnosis of the disease as it is the key to effective disease management (WHO, 1993; 2020). Therefore it is of interest that inaccurate diagnosis continued causing hitches on the effective control of malaria. Many factors are the causes of this, including symptomatic diagnosis that is non-specific, lack of resources and widespread practice of self-treatment for clinically suspected malaria (WHO, 2000; Tizzifa *et al.,* 2018; Orok *et al.,* 2021). In clinical care, species determination is commonly performed by light microscopy, which has limited sensitivity and specificity. Double, triple or even quadruple infections can be detected more reliably by molecular methods. In addition, presence of distinct genotypes (strains) of the same species cannot be discerned microscopically. An important proportion of naturally occurring infections consists of multiple genotypes and "multiplicity of infection" (MOI) refered to as the number of different genotypes of one species infecting a single host (Schneider *et al.,* 2022). For *P. falciparum*, MOI has been associated with several conditions, including age of the host, clinical severity, and transmission intensity. Determination of within-host diversity may be a useful marker to

assess the impact of interventions (Zhan *et al.,* 2024). Genotyping of polymorphic genes such as merozoite surface proteins (MSPs) and glutamate-rich protein (*glurp*), by nested-PCR is a gold standard method for assessing Multiplicity of Infection (MOI) in *P. falciparum* infections. An alternative approach uses next generation sequencing (NGS) technologies, which allow high-resolution analyses of a heterogeneous mixture of the parasites within the host (Tessema *et al.,* 2019).

The aim of this study is to determine the diversity of *Plasmodium* species in patients attending public health institutions in Doma, Nassarawa-Eggon and Kokona local government area of Nasarawa State of Nigeria.

Materials and Methods

Study Area

Nasarawa State is located in North Central Nigeria, it is situated in the interval of longitude 7° and 9° 37' East of the Greenwhich Meridian and latitude 7° 45' and 9° 25' North of the equator. Plateau State shares boundary with the State in the East, in the North, Kaduna State, in the South, Benue and Taraba States, while Kogi State and Federal Capital Territory flanks it in the West.

Nasarawa State falls under Koppens climatic classification, that is, tropical rainy climate with distinct dry season in winter. The rainy season span a period of seven months (April-October) with an annual rainfall of about 1200-2000mm. Humidity is generally high during the rainy seasons, about 95 percent in parts of the State. The figure drops to about 55% for the dry season. Sunshine hours are high between January to April and decreases between May through October because of the effects of cloud. The State has an Area of 27, 117km^2(10, 470 sqmi), a population of 1, 863, 275 (as at 2006 population census), and a density of 75/km^2 (190/sqmi).

Doma is a Local Government Area in Nasarawa State, its headquarters are in Doma. It has an area of 2,714km^2 and a population of 137607 in the 2006 census. The postal code of the area is 950. Farming is the occupation of most of the Alago people who are the predominant tribe in Doma. The kingdom of Doma was founded in 1232 by Andoma and lasted until 1901 when it became part of the British Protectorate of northern Nigeria (Yaro, 2018).

Nassarawa-eggon is a Local Government Area in Nasarawa State, its headquarters is in the town of Eggon. It has an area of 1.208km^2 and a population of 149,129 at the 2006 census. The postal code of the area is 960.Nassarawa-

eggon Local Government Area towns and districts of Ende, Ginda, Alizaga, Arugbadu, Bakyano, Eggon, Sako, Umme, Agunji, Alogani, Arikpa, Ezzen, Wakama, Angbaku, Buba, Galle, Gbamze,,Ogbagi, Wogan and Ubbe (Akwa *et al*., 2007).

Kokona Local Government Area is located in Nasarawa West Senatorial District, with an area of 1,844 km² and a population of 109,749 at the 2006 census. Kokona lies between 8°51'0"N and 5°05' 0"E of the Greenwhich Meridian and located on an altitude of 850m above sea level. The postal code of the area is 961. It is a fertile land with Agriculture as its main stay of the economy and subsistence of peasant farming is greatly enhanced among the people and also rearing of domestic animals. Trading is also an important economic activity in the community (Akwa *et al*., 2007).

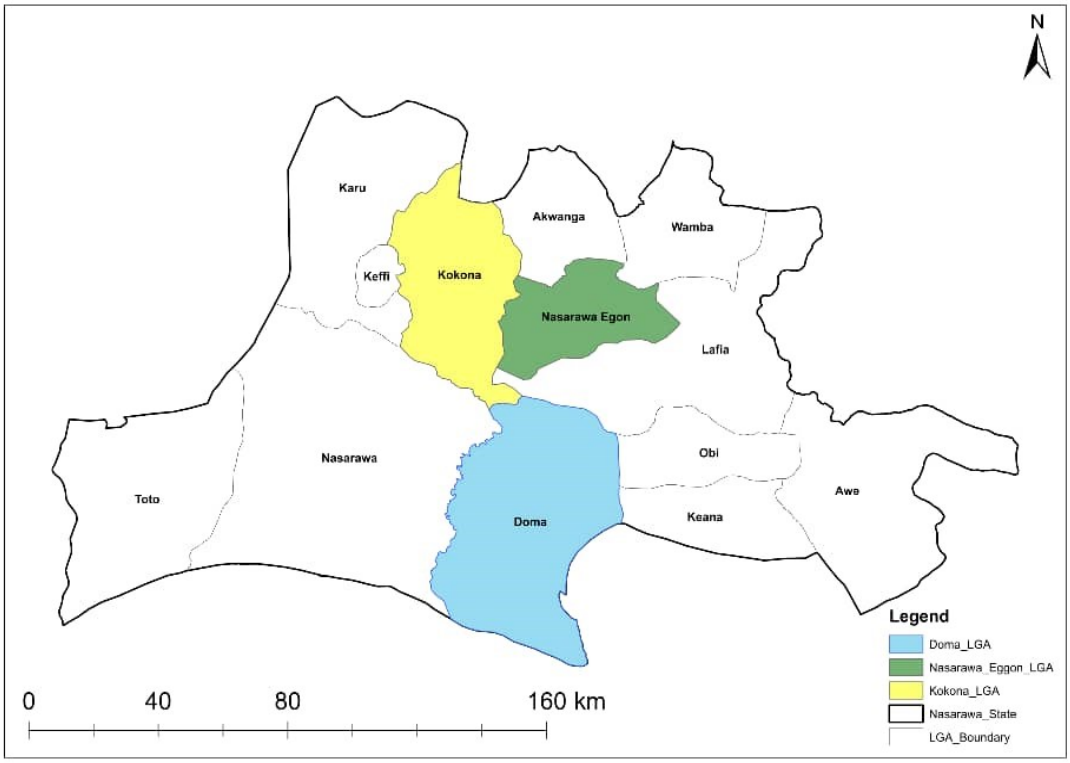

Figure 1: Map of Nasarawa State showing the study areas

Study Population and Sampling

The study was conducted in Three Local Government Areas of Nasarawa State, that is made up of 13 (thirteen) Local Government Areas and three (3) National Senatorial Districts (South, North and West). A Local Government Area was

picked from each of the three Senatorial Districts. This includes Doma from the South, Nassarawa-Eggon from the North and Kokona Local Government from the West Senatorial District of Nasarawa State, Nigeria.

The study population consists of one thousand two hundred (1200) consenting patients attending Doma, Nassarawa-Eggon and Kokona Local Government public health institutions. Two hundred (200) samples were collected from each of the three Local government secondary health institution (General Hospitals) and one hundred (100) samples were collected from any two of each local government primary health institution (Primary Health Centres) of Doma, Nassarawa-Eggon and Kokona Local Government Area of Nasarawa State. The samples were randomly selected from both sexes from September 2022 through September 2023 on weekdays (Mondays to Fridays) from 8am to 11am. Socio demographic information of each participant was obtained through oral interview. Such information included sex, age, pregnancy status, occupation and locality.

Two types of analysis were carried out; Microscopy and the Rapid Diagnostic Tests (RDTs)

The rapid diagnostic tests (RDTs) were done prior to microscopy on each participant sample according to the manufacturer's instructions.

The thick and thin film was done by dropping a blood in the centre of a microscopic glass slide, then using the side of a neat cover slide to spread the blood to cover an area of about 10mm2 (Cheesbrough, 2017).

A rapid lateral flow immunochromatographic in vitro antigen detection test kit (Bioline™ by Abbot global point of care United States of America) for detecting malaria Histidine-rich protein 2 HRP2 antigen of *P. falciparum* lactate dehydrogenase (pLDH) in human whole blood was used following the manufacturer's instructions.

Sample Size Formulation

Using the 2021 data of patients that visited Nassarawa-Eggon public health institution, a total of 75, 653 patients were tested for malaria of which 59,515 patients were positive for malaria infections. Assuming that the actual number of patients having malaria infections were not more than 78% for each of the public health institution of Doma, Nassarawa-Eggon and Kokona Local Government of Nasarawa State, using the formula below;

A sample size of approximately 400 participants is targeted.

$$n = \frac{Z^2 p(1-p)}{E^2}$$

Where:

n = required sample size

Z = Z-value 95% (Z = 1.96)
p = estimated prevalence of in the population (0.20)
E = margin of error 5% (0.05)

$$n = \frac{(1.96)^2+0.5+(1-0.5)}{(0.05)^2} \quad n = \frac{3.8416+0.25}{0.0025}$$

$$n = \frac{0.9604}{0.0025}$$

= 384.16 for each Local Government Area
≈ 400

Therefore the sample size was approximated at 1200 after substituting the variables.

Inclusion and Exclusion Criteria

The entry criteria of this study are based on a clinician's demand for a malaria diagnosis in a patient of any occupation, age and sex at the primary and secondary Health Istitution of Doma, Nassarawa-eggon and Kokona Local Government of Nasarawa State.
Patients who treated malaria three weeks before the research were excluded. In addition, only a brand of Rapid Diagnostic Test (RDT) kit was used.

Statistical Analysis

Data obtained was analyzed using Statistical Package for Social Sciences (SPSS version 23.0). Pearson's Chi-square test was used to compare proportions of prevalence of malaria infection in relation to age, gender, and occupation of the subjects respectively. Additionally, chi-square test was used to compare sensitivity as well as specificity levels between the two diagnostic techniques. The p-values < 0.05 were considered statistically significant.

Results

Malaria Infection in Patients attending the Primary and Secondary Health Centres in Doma, Nassarawa-eggon and Kokona Local Government Area, Nasarawa State, Nigeria
One thousand two hundred (1200) blood samples were collected and analyzed from consenting patients attending the primary and secondary health care facilities of Doma, Nassarawa-eggon and Kokona Local Government of Nasarawa State. Six hundred (600) blood samples were collected through venous puncture from each of the three secondary health care facilities (200 blood samples in each General Hospital) and six hundred (600) blood samples were collected from two (2) of the Primary Health Care Facilities in the three Local Government Areas (100 blood samples in each Primary Health Centers).
Out of the six hundred (600) blood samples examined in the secondary health care facilities, General Hospital Doma had the highest prevalence (68.0%),

followed by General Hospital Garaku (63.5%) and then General Hospital Nassarawa-eggon (51.0%). Among patients attending the six primary health centers studied, those in Doma (66.5%) had the highest prevalence of Malaria infection, closely followed by those in Nassarawa-eggon (63.5%) while those in Kokona (62.5%) encountered the least malaria infection. The prevalence of malaria infection among patients attending the Secondary health Clinics showed there was a significant difference (df = 2, $p<0.05$) while Primary Health Centers showed that there was no any significant difference (df = 2, $p>0.05$, Table 1).

Table 1: Comparison of Malaria Infections among Patients Attending Secondary and Primary Health Centres in Doma, Nassarawa-eggon and Kokona Local Government of Nasarawa State.

L.G.As	No. Examined	No. Positive (%) Microscopy	No. Positive (%) RDTs	χ2	df	p-value
Secondary Health Clinics						
G.H. Doma	200	136 (68.0)	132 (66.0)	3.841	2	0.00
G.H.Nas. Eggon	200	102 (51.0)	109 (54.5)			
G. H. Kokona	200	127 (63.5)	114 (57.0)			
Total	**600**	**365 (60.8)**	**(355 59.1)**			
Primary Health Clinics						
Doma	200	133 (66.5)	128 (69.0)	11.070	2	0.68
Nas.Eggon	200	127 (63.5)	118 (54.0)			
Kokona	200	125 (62.5)	116 (65.0)			
Total	**600**	**385 (64.1)**	**362 (60.3)**			
Grand Total	**1200**	**750 (62.5)**	**717 (59.75)**			

Key:

GH=General Hospital

No=Number

χ2=Chi square

Df=Degree of freedom

Nas=Nassarawa

Demographic-wise Prevalence of Malaria infection in patients attending the Public Health Centres of Nasarawa State

Patients within age group 31-40 (72.2%) had the highest prevalence of malaria infection, followed by those within 11 – 20 (70.3%), then ages 21 – 30 (64.4%), then ages 5 – 10 (63.1%), then ages 0 – 4 (57.7%), ages 41 – 50 (53.%) while those aged 51 years and above were least parasitized (50.3%). The prevalence of malaria infection in relation to age groups showed a significant difference (df = 6, $p<0.05$).

The prevalence of malaria infection with respect to gender revealed that males (66.6%) were more infected than females (59.3%). Malaria infection in relation to gender showed a significant difference (df = 1, p<0.05).
In table 2, the frequency of malaria infection based on occupation showed that civil servants (72.8%) were the most infected with malaria parasites, followed by farmers (66.5%) then students (62.5%), others which include housewives and unemployed patients (60.2%) the least infected individuals based on occupational status were traders (52.7%). Statistically, the frequency of infection based on occupation of patients showed that there is no significant difference (df = 4, p<0.05).

Table 2: Demographic Prevalence of Malaria infection in patients attending the Public Health Centres of Nasarawa State

Demographics	No. Examined (%)	No. Positive (%) Microscopy	No. Positive (%) RDTs	$\chi 2$	df	p-value
Age (Years)						
0 – 4	180 (15.0)	104 (57.7)	101 (56.1)	12.592	6	0
5 – 10	163 (13.5)	103 (63.1)	94 (57.6)			
11 – 20	202 (16.8)	142 (70.3)	138 (68.3)			
21 – 30	194 (16.1)	125 (64.4)	118 (60.8)			
31 – 40	180 (15.0)	130 (72.2)	126 (70.0)			
41 – 50	154 (12.8)	82 (53.2)	78 (50.6)			
51 and above	127 (10.5)	64 (50.3)	62 (48.8)			
Total	**1200 (100)**	**750 (62.5)**	**717 (59.7)**			
Sex						
Male	516 (43.0)	344 (66.6)	337 (65.7)	3.841	1	0.01
Female	684 (57.0)	406 (59.3)	380 (55.5)			
Total	**1200 (100)**	**750 (62.5)**	**717 (59.7)**			
Occupation						
Traders	292 (24.3)	154 (52.7)	148 (50.6)	9.488	4	0
Farmers	293 (24.4)	195 (66.5)	183 (62.4)			
Civil servants	206 (17.1)	150 (72.8)	149 (72.3)			
Students	200 (16.6)	125 (62.5)	120 (60.0)			
Others	209 (17.4)	126 (60.2)	119 (56.9)			
Total	**1200 (100)**	**750 (62.5)**	**717 (59.7)**			

Plasmodium species found in the Health Centres

With respect to the prevalence *Plasmodium* species found using Giemsa stained microscopy, *Plasmodium falciparum* was found to be the highest (78.0%)

followed by *P. malariae* (17.6%) and the least species found was *P. ovale* with 4.1%.

Table 3: *Plasmodium* species found in Patients attending the Health Centres

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	*P. falciparum*	587	78.3	78.3	78.3
	P. malariae	132	17.6	17.6	95.9
	P. ovale	31	4.1	4.1	100.0
	Total	750	100.0	100.0	

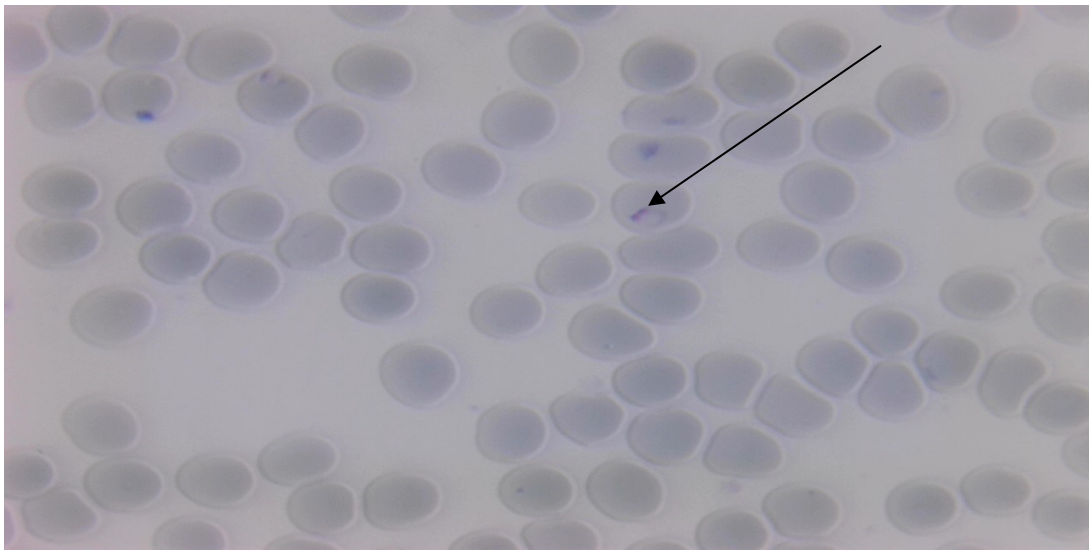

Plate I: Trophozoite of *Plasmodium falciparum* in a thin blood slide

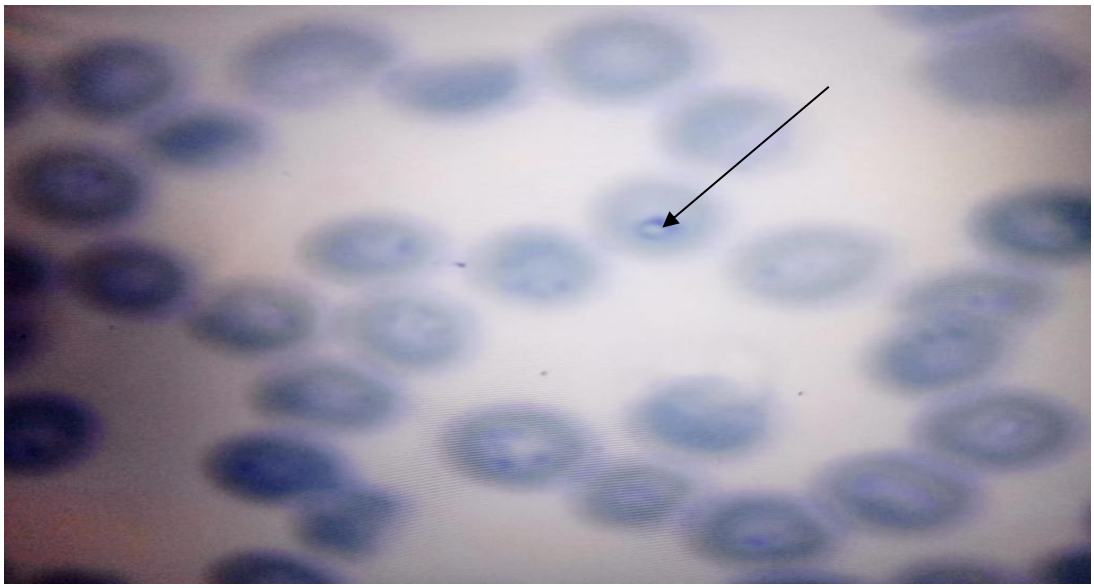

Plate II: Ring stages of *Plasmodium ovale* in a stained blood slide

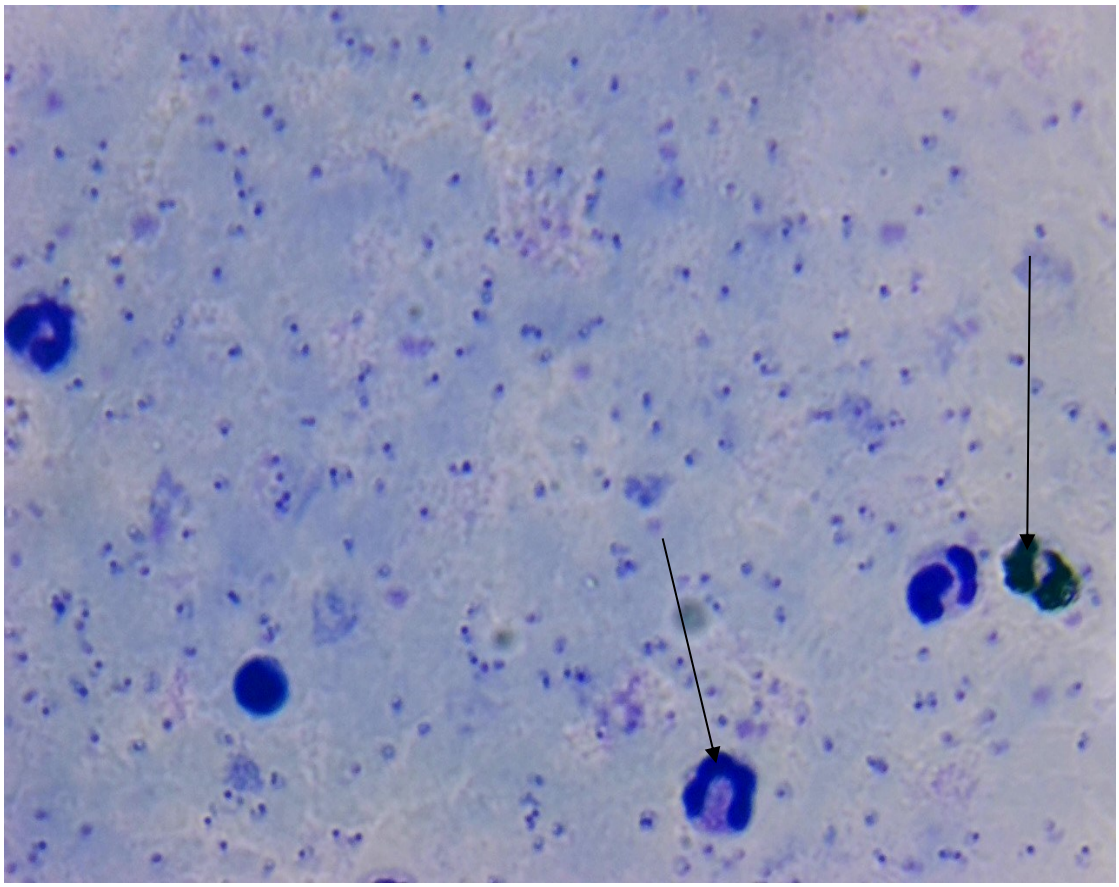

Plate III: Trophozoite of *P. malariae* in a thick blood slide

Risk Factors Associated with Malaria Infection in Patients attending Public Health Institution of Nasarawa State

The risk factors associated with malaria infection in patients attending the public health institution were determined through questionnaire and patients were asked about their residence, use of Insecticide Treated Nets (ITNs), wearing of protective clothing at night and the use of insect repellants. Pearson's Chi-square statistical analysis was used to compare proportions of these factors. Patients who reside in rural area are more infected (54.9%) than those who stay in urban area (45.1%), those who use ITNs (26.9%) were less infected than those don't (73.1%), the patients who wear protective clothing at night (29.4) were less infected than those who don't (70.5) and those who use insect repellant (33.9%) were less infected than those who don't (66.1%) there was a statistically significant difference in relation to these factors ($p<0.05$).

Table 4: Risk Factors Associated with Malaria Infection in Patients attending Public Health Institution of Nasarawa State

Risk factors	No. Examined (%)	No. Positive (%)		df	χ^2-value
		Microscopy	RDTs		
1. Residence					
Rural	519 (43.2)	412 (54.9)	382 (53.3)	1	0
Urban	681 (56.7)	338 (45.1)	335 (46.8)		
Total	**1200 (100)**	**750 (100)**	**717 (59.7)**		
2. Use of ITNs					
Yes	410 (34.2)	202 (26.9)	182 (25.4)	1	0
No	790 (65.8)	548 (73.1)	535 (74.6)		
Total	**1200 (100)**	**750 (62.5)**	**717 (59.7)**		
3. Wearing of protective clothing					
Yes	575 (47.9)	221 (29.4)	201 (28.1)	1	0
No	625 (52.1)	529 (70.5)	516 (71.9)		
Total	**1200 (100)**	**750 (62.5)**	**717 (59.7)**		
4. Use of Insect Repellant					
Yes	552 (46)	254 (33.9)	215 (29.9)	1	0
No	648 (54)	496 (66.1)	502 (70.1)		
Total	**1200 (100)**	**750 (62.5)**	**717 (59.7)**		

Discussion

The prevalence of 62.5% of malaria parasites in the study area is considered high and is similar to the findings of Abah and Temple who had 63.3% prevalence in a 2015 study in Bayelsa State, also 64% prevalence was recorded by Haji and others (2016) and 63% in a 2019 study in Ekiti State (Simon-Oke *et al.,* 2019). The findings in this study is also in accordance with the work of Thu *et al.,* (2016), in Malaysia who had 63.3% prevalence rate and that of Bismarck and others (2016) who performed a cross-sectional study on patients with a suspicion of malaria in four hospitals in the Volta region of Ghana who recorded a prevalence rate of 57% (94/164), 59% (13/22), 61% (43/71) and the lowest was 39% (83/211). The prevalence is rate also comparable to the overall risk map of 56.3% found in a study in Rivers State by Egbom *et al.,* (2023), also a 63.3% prevalence rate was found in a 2015 study in Bayelsa State by Abah and Joe-Cliff (2016) and to the 56.3% prevalence rate by Jemimah *et al.,* (2019). The research is higher in prevalence than the 23% of Kolawole in Nigerian Army Reference Hospital in Kaduna State Nigeria and the 15.83% documented by Kurmi *et al.,* (2023) in a study in Bauchi State of Nigeria. Also, Nwaneli *et al.,* (2020) had 23.3% prevalence rate of malaria and its socio-demographic determinants in febrile children in Enugu as well as the 38.6% recorded by David *et al.,* (2022) and 34.66% prevalence rate of Malann *et al.,* (2016) and the 23.4% by Tadesse *et al.,* (2023). However, the prevalence of malaria in febrile patients reported by Nas *et al.,* (2017) in Kano, Northern Nigeria was 84% and the 78.1% by Gboeloh *et al.,* (2022) in a study in Rivers State Nigeria, and the 92.7% prevalence rate by Ogbole *et al.,* (2023) as well as the 81.9% in a study by Olasehinde *et al.,* (2015) in Edo State, is higher than the findings of this study. This variation in prevalence of malaria in different places in Nigeria could be either due to inadequate protection against mosquito bites or insufficient knowledge about malaria transmission, climatic differences, period of study and socio-cultural factors.

Doma Local Government Area had an overall highest prevalence rate (67.2%) followed by Kokona Local Government Area (63.2%) and is comparable to a study by Eke *et al.,* (2018) who worked in General hospital Minna, North Central Nigeria and had the prevalence rate of 69.19%.The least of infection was Nassarawa-eggon Local Government Area (57.2%), which is comparable to the work of Abubakar *et al.,* (2016), George *et al.,* (2015) and Udomah *et al.,* (2015).

The high prevalence of malaria infection in the three Local Government Areas stated the need for more efforts to be targeted at controlling malaria in Nasarawa State. Nevertheless, statistically, the prevalence of malaria infection compared in the three Local Government Areas revealed that there is no difference.

Although patients within the middle age group (31-40 years) were most parasitized in this study, there was a statistical significance in the prevalence of malaria infection in relation to age. This signifies that all the age groups encountered all had equal risk to malaria infection. This result agrees with that of Smith *et al.,* (1994), Nasiru *et al.,* (2024), Hussaini *et al.,* (2024), Tadesse *et al.,* (2023) and Iyabo *et al.,* (2023) who observed the lack of variation in the prevalence of malaria infection and age. However, the result does not agree with that of Dicko *et al.* (2003) and Abdulazeez *et al.* (2017) who opined that older people were more susceptible to malaria. However this agrees with the findings of Dicko, *et al.,* (2003) who opined that people with older age were susceptible to malaria because of immunity. This agrees with most researchers reports, showing that premunition immunity in malaria increases with age for people living in endemic areas like Nasarawa State, Nigeria. Antibody levels have been noted to increase with age and exposure to malaria parasite in hyper endemic areas. It was also noted that most cases of severe clinical malaria occurred among children while constant exposure confers some levels of partial immunity in terms of clinical symptoms and parasitaemia burden (WHO, 2018). Also, Paniker reported a slow gain of active immunity to malaria; and this may be the cause of patients of medium group of age having more malaria positive cases in this study.

The prevalence of malaria infection with respect s to gender revealed that females (57.0%) were more infected than males (43.0%). This study corroborates the findings of Jemimah *et al.,* (2019), Nwalozie *et al.,* (2023a), Quaresima *et al.* (2021), Otojareri *et al.,* (2023), Briggs *et al.,* (2020), Acheampong *et al.,* (2022), Ndubuisi *et al.,* (2021), Binta *et al.,* (2023) Hussaini *et al.,* (2024) and Jafer and others (2022) who researched on the gender difference in the incidence of malaria diagnosed at public health facilities and found females to be more infected than males. The higher prevalence in females than in males in this study suggests that female disproportionately contribute to the burden of malaria diagnosed at public health facilities in Nigeria. Higher prevalence among the females in this study could also be attributed to greater

exposure of women in their immediate environment due to their routine household activities at dusk and dawn, especially in the rural settings where they have to prepare meals and carry out their domestic chores outside their houses It could also be attributed to immune suppression due to pregnancy (Belete and Roro, 2016). The findings of this study contradict the report of Eke *et al.,* (2018), Erinle and Bada (2023), Wokem *et al.,* (2020), Oladele, *et al.,* (2018), Zeleke *et al.,* (2023), Madkhali *et al.,* (2022), Gobena and Mebrate (2022), Runmomkum *et al.,* (2019), Taye and Alexander, (2024) and Uzoma *et al.,* (2023) who recorded that males may be more prone to the disease than the females. Till date, there has not been any scientific evidence documented to prove the higher prevalence of malaria was associated to sex susceptibility because Anopheles mosquito which is vector of malaria is not gender discriminatory during biting (Jemimah, *et al.,* 2019). However, malaria infection in relation to gender showed a significant difference.

The frequency of malaria infection based on occupation showed that civil servants being the most infected with malaria parasites in this study (72.82%) is similar to the 75% prevalence rate found in a study by Ndubuisi *et al.,* (2021), Hussaini *et al.,* (2024) and Nwalozie *et al.,* (2023b) and in contrast to the findings of Nanvyat *et al.,* (2017), who recorded low rate of malaria prevalence among civil servant and traders. Enyi *et al.,* (2023) also stated that occupation and level of education may contribute to high malaria infection. Also, Benjamin *et al.,* (2019) who studied demographic factors associated with malaria in Zaria, Kaduna State of Nigeria and found out that the highest prevalence was detected among individuals who are not educated. The economic and social background may have been the reason of the differences on the prevalence rate; therefore, these findings depict the fact that occupation is a risk factor in the study population. Hewever, Onah and Omudu (2016) contradicted the relationship between occupation and high prevalence of Malaria. Statistically, the frequency of infection based on occupation of patients showed that there was a significant difference.

With respect to the prevalence *Plasmodium* species found using Giemsa stained microscopy, *Plasmodium falciparum* was found to be the highest (78.2%) followed by *P. malariae* (17.6%) and the least species found was *P. ovale* (4.13%) and this coincides with the work of Langford *et al.,* (2015), Bradines *et al.,* (1998), Hemingway *et al.,* (2004), Ranson *et al.,* (2000), Abah and Temple, 2015, Ross and Fidock (2019), Michael and Florence (2016) and Larson *et al.,* (2023) as well

as the World Health Organization reported that in sub-Saharan Africa *P. falciparum* is the most common malaria parasite (WHO, 2023).

Based on the risk factors influencing the transmission of infections in the study area, the patients who live in a rural settlement had higher rate of infection than those who reside in urban areas, this is in accordance with the findings of Enyi *et al.,* (2023), Benjamin *et al.,* (2019) and Tatteh *et al.,* (2023) who all recorded higher rate of malaria infection among the rural dwellers compared to the urban dwellers, and Ofori, *et al.,* (2019) stated that residence area and source of drinking water could influence high prevalence of malaria infection. The higher prevalence among patients who do not use insecticides treated nets (ITNs) than those who use in this study indicates that ITNs can be used as a preventive method for malaria infections and this is in line with the work of Mtonga and Nawa, (2024). According to Yeboah (2023), individuals with higher education levels and those residing in urban areas are more likely to utilize ITNs effectively. Doe *et al.,* (2024) emphasized on positive attitudes towards elimination of malaria and exposure to malaria-related messages can lead to a regular usage of the ITNs by individuals. According to Tesfaye & Teshome (2022), Klu *et al.,* 2024 and Musa *et al.,* (2023), individuals rejects the ITNs as a result misconceptions about its toxicity.

Conclusion

This study has shed light on the concerning prevalence rate of malaria infection, which stands at 62.5%. The findings underscore the urgent need for concerted efforts to address this public health challenge.

This analysis has revealed several key insights into the factors contributing to the high prevalence of malaria in the study population. These include inadequate vector control measures, limited access to effective treatment, emerging drug resistance, and socio-economic disparities exacerbating vulnerability to infection.

Moving forward, effective intervention strategies must be implemented to mitigate the burden of malaria. This includes scaling up vector control efforts through the distribution of insecticide-treated bed nets, indoor residual spraying, and larval source management. Additionally, strengthening healthcare infrastructure to improve diagnosis, treatment, and surveillance is paramount.

Furthermore, community engagement and targeted health education programs should be prioritized to promote behavioral changes, such as seeking timely treatment and adopting preventive measures.

Collaborative efforts involving governments, non-governmental organizations, healthcare providers, and local communities are essential to combat malaria effectively. By implementing a multifaceted approach that addresses the underlying drivers of transmission, we can strive towards reducing malaria prevalence rates and ultimately achieving the goal of malaria elimination.

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Conflict of Interest

The authors declare no competing interest.

Limitations

One limitation of this study is that only the parasitological aspects of malaria were investigated, while the molecular analysis was yet to be conducted. This restricts the ability to detect low-level parasitemia and differentiate between *Plasmodium* species with high specificity and sensitivity. Blood samples were kept using the dry blood spot method, molecular techniques, such as PCR, will be used to provide a more comprehensive understanding of the epidemiology and genetic diversity of malaria parasites in the study area.

This research paper was published in batches, additional factors influencing transmission such as seasonal variation, intensity and sensitivity and specificity of infection is in another batch.

References

Abah, A.E. and Joe-Cliff, O. (2016). Current status of malaria Parasite Among Blood Donors in Port Harcourt, Rivers State, Nigeria. *Journal of Applied Science and Environmental Management*, 20(1):187.

Aba, A. & Temple, B. (2015). Prevalence of Malaria Parasite among Asymptomatic Primary School Children in Angiama Community, Bayelsa State, Nigeria. *Tropical Medicine and Surgery,* 4(1): 203-207. doi:10.4172/2329.1000203.

Abubakar, S., Yunusa, I., Ahmad, M. K., Abdullahi, M. K., Ibrahim, I. & Zakariya, M. (2016). Cross Sectional Study of Malarial Parasite among Patients Attending General Hospital, Hadejia, Jigawa State, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 9(2): 57-60 *ISSN* 2006-6996.

Abdulazeez, A. M., Ya'u, M. and Kurfi, B. (2017). Association of Hypertension and Activity of Angiotensin Converting Enzyme in Malaria Patients Attending Sheik Muhammad Jidda General Hospital, Kano State, Nigeria. *Nigeria Journal of Basic Clinical Science*, 14:121-126.

Acheampong, D. O., Aninagyei, E., Mavis, P. D., Attoh, J., Adedia, D., Tettey, O. C. & Kyei-Barffour, I. (2022). Ecological and seasonal variations and other factors associated with clinical malaria in the Central Region of Ghana: A cross-sectionall study. *Journal of Infection and Public Health,* 15(2). Pp.631-637. https://doi.org/10.1016/jiph.2022.04.014.

Akwa, V. L., Bimbol, N. L., Samaida, K. L. & Markus, N.D. (2007). Geographical Perspectives of Nasarawa State. Onaivi Printing and Publishing Company, Keffi.;pp.3.

Benjamin, Y. G., Bartholomew, B., Abdullahi, J., and Labaran M. L. (2019). Assessment of Demographic Factors Associated with Falciparum Malaria among Hospital Patients in Zaria, Kaduna State, Nigeria. *South Asian Journal of Research in Microbiology*, 5 (3): 1-7. ISSN: 2582-1989.

Belete, E. M. and Roro, A. B. (2016). Malaria Prevalence and its Associated Risk Factors among Patients Attending Chichu and Wonago Health Centres, South Ethiopia. *Journal of Research Health and Science*, 16(4):185-189

Binta, A., Musa A. M., Patrick D.B., Habiba D. J., Shamsiya M. U. Edith E. I., & Danta B. T.(2023).Ten-year trend of malaria prevalence in Kaltungo general hospital, Gombe state, Nigeria. *Bima Journal of Science and Technology,* 7 (2), 1-8.

Bismarck, D., Reuben A., James, A., Eric, A., Gideon, K., Senyo, T., John, T., Festus, A., Fred, N. B., and Gordon A. A. (2016). Comparison of Malaria Diagnostic Methods in Four Hospitals in the Volta Region of Ghana.*Malaria World Journal*, www.malariaworld.org. ISSN 2214-4374.

Bradines, B., Mamfoumbi, M. M., Parzy, D., Medang, M. O., Lebeau, C., Mourou, J. M. R., Doury, J. C. & Kombila, M. (1998). In vitro susceptibility of Gabonese wild isolates of *Plasmodium falciparum* to artemether, and comparison with chloroquine, quinine, halofantrine and amodiaquine. *Parasitology,* 117(6):541–5.

Briggs, J., Teyssier, N., Nankabirwa, I. J., Rek, J., Jagannathan, P., Arinaitwe, E., Bousema, T., Drakely, C., Murray, M., Crawford, E., Hathaway, N., Staedke, G. S., Smith, D., Rosenthal, J. P., Kamya, M., Dorsey, G., Rodriguez-Barraquer, I. & Greenhouse B. (2020). Sex-based differences in clearance of chronic *Plasmodium* infection. *eLife*, 9, e59872. DOI: 10.7554/eLife.59872 PMCID: PMC7591246.

Cheesbrough M. (2017). District Laboratory Practice in tropical countries, second edition. Cambridge University press, United States of Americapp. 268-271.

David, E. N., Ikechukwu, O. O., Milliam, O. I., Michael, O. E. and Ogbonna, E. S. U. (2022). Malaria Endemicity in the Rural Communities of Ebonyi State, Nigeria. The Korean Journal of Parasitology, 2022; 60(3): 173-179. Published online: June 30, 2022. doi: https://doi.org/10.2247/kjp.2022.60.3.173.

Dicko, M. B., Diarra, B., Samassekou, S. and Ballo, A. (2003). Clearance of Drug Resistant Parasites as a Model for Protective Immunity in Plasmodium falciparum malaria" American Journal of Tropical and Medical hygiene 69 (5), 2003 pp 558-563.

Doe, P. F., Druye, A. A., Azu, T. D., Boso, C. M., Commey, I. T., Agyare, F. D., Berchie, O. G., Opoku-Danso, R., Owusu, G., Yeboa, K. N., Dzah, S. S., Davis, E. A., Ofori, O. G., Akoto-Buabeng, W., Odonkor, O. F., Alhassan, A., Gyan, B. T., Okantey, C., Ninnoni, P. J., Aboh, I. K., Abraham, A. A. & Amoadu, M. (2024). Ownership and usage of insecticide-treated nets in Ghana: a scoping review of facilitators and barriers. *Malaria Journal*, 23, 238. https//doi.org/10.1186/s12936-024-05072-0.

Egbom, S. E., and Nzeako, S. O. (2017). Malaria parasitaemia amongst military personnel households in a military formation in Port Harcourt, Nigeria. *International Journal of Scientific Research in Environmental Sciences*, 5(1):0010-0016.

Eke, S. S., Omalu, I. C. J., Olayemi, I. K., Egwim, E. C., Hassan, S. C., Otuu, C. A., Boyi, A. A. and Abdullahi, M. (2018). Malaria Parasitaemia among Patients Attending General Hospital Minna, North Central Nigeria. *Journal of Bioscience and Biotechnology Discovery,* Volume 3(4), pages 78-82, August 2018. https;//doi.org/10.31248/JBBD2018.069. ISSN: 2536-7064.

Enyi, E. O., Ikegbunam, N. M., Iroha, I. R., Udeagbala, T. N. and Esimone, O. C. (2023). Effect of Formal Education on Malaria Knowledge among People attending Federal Medical Center, Owerri, Imo State Nigeria. *GSC Biological and Pharmaceutical Sciences,* eISSN: 2581-3250. Cross Ref. DOI: 10.30574/gscbps. https://gsconlinepress.com/journals/gscbps/.

Erinle, B. A., & Bada, E. O. (2023). Prevalence of malaria infection amongst students of a southwest Nigerian federal university.*GSC Advanced Research and Reviews,* 15(01), 110–114.

Gboeloh, L.G., Elele, K.,Wokoma, O., & Gura, B.(2022).Evaluation of the Current Status of Malaria Prevalence in the Three Senatorial Zones of Rivers State, Nigeria. *International Journal of Health Sciences,* 5(2), 67 – 86.

Gobena, B. & Mebrate, D. (2022). Malaria Infection, Parasitemia, and Hemoglobin Levels in Febrile Patients Attending Sibu Sire Health Facilities, Western Ethiopia. *Hindawi Biomedical Research International,* Volume 2022, Article ID 6161410, 8 pages https://doi.org/10.1155/2022/6161410.

Haji, Y., Fogarty, A. W. & Deressa, W. (2016). Prevalence and Associated Factors of Malaria among Febrile Children in Ethiopia: A Cross-Sectional Health Facility-Based Study. *Acta Tropica*, 2016 March 1;155:63-70. Available online at doi: 10.1016/jactatropica.2015.12.009 [PubMed] [CrossRef] [GoogleScholar].

Hemingway, J., Hawkes, N. J., McCaroll, L. & Ranson H. (2004). The molecular basis of insecticide resistance in mosquitoes. *Insect Biochemistry and Molecular Biology*, 34(7):653–65.

Hussaini, F. A., Aliyu, A. A. & Umbuguama, D. B. (2024). Survey of Malaria Infection among In-Patients at Federal Medical Center Keffi, North Central, Nigeria. *Journal of Science Innovation & Technology Research,* Vol. 05, No. 9, E-ISSN 3026-958X P-ISSN 3027-1169.

Jafer, O., Adreienne, E., Jane, F. N., Emmanuel V. K., Isiah, N., Martha, N.……& Grant, D. (2022): "Gender Difference in the Incidence of Malaria Diagnosed at Public Health Facilities in Uganda" *Malaria Journal,* 21, Article number: 22 (2022).

Jemimah, Y., Victor, O., Elizabeth, A., Akpu, P., & Lynda, A. (2019). *Plasmodium falciparum* Infection among Febrile Patients Attending a Tertiary Healthcare Facility in Central Nigeria: Prevalence, Hematologic and Socio-demographic Factors. *International Journal of Tropical Disease,* 2(019):1-6.

Iyabo, A., Oluwasegun, B. A. & Olatunji, O. (2023): Prevalence of Malaria and COVID-19Infection in Akure North Local Government Area of Ondo State, Nigeria. Journal of Parasitology Research. Volume 2023, Article ID 9529563, 7 pages, 2023. https://doi.org/10.1155/2023/9529563

Kangming, L., Duoquan, W., Fei, L., Shenning, L., Mihayo, G. M., Yeromin, M., Prosper, C., Ning, X.&Xiao-nong, Z. (2024). Evaluation of Malaria Standard Microscopy and Rapid Diagnostic Tests for Screening-Southern Tanzania, 2018-2019. *China CDC Weekly,* 2022 15; 4 (28), 605-608.

Klu, D., Frempong, A. G. & Odame, L. M. (2024). Factors predicting insecticide-treated bed net use among children under age five in female-headedhouseholds in Ghana: An analysis of 2019 malaria indicator survey. Advances in Public Health, 24(1). https://doi.org./10.1155/2024/4277069.

Kurmi, U. M., Nanvyat, N., Lapang, M. P., Mafuyai, J. M., Isah, L., Ombugadu, A., Yina, G. I., Otakpa, E. O., Simse, R. L. & Mwansat, G. S. (2024). Vectors, Knowledge, Attitudes, and Practices in Relation to Malaria Transmission in Bauchi State, Nigeria. *Journal of Vector Borne Diseases*, 61:176-182.

Langford, S., Douglas, N. M., Lampah, D. A, Simpson, J. A., Kenamgalem, E., Sugiarto, P., & Price, N. R. (2015).*Plasmodium malariae* Infection Associated with a High Burden of Anemia: A Hospital Based Surveillance Study. *PLoS Neglected Tropical Diseases,* 9(12): e0004195. Doi:101371/journal.pntd.0004195.

Larson, B., Michelle, B., Serge-Ely, D., Landry, E. M., Clauve, J. M., Dorothé, M. W.……& Richard, O. (2023): "Decrease on Malaria Clinical Cases from 2017 to 2019 in Franceville, Southeast Gabon, Central Africa" Wed,03May2023. *Journal of Public Health in Africa,* doi:10.4081/jphia.2023.1865.

Madkhali, A. M., Ghzwani, A. H., & Al-Mekhlafi, H. M. (2022). Comparison of Rapid Diagnostic Test, Microscopy and Polymerace Chain Reaction for the Detection of *Plasmodium falciparum* Malaria in a low Transmission Area, Jazan Region, Southwestern Saudi Arabia. *Diagnostics,* 2022, 12 (6), 1485. https://doi.org/10.3390/diagnostics12061485.

Malann, Y. D., Oguegbe, N. G. & Deme, G. G. (2016).Comparative diagnosis of malaria using routine microscopy and Rapid diagnostic technique with Lactan Dehydrogenase. *FULafia Journal of Science and Technology*, 2(1).

Micheal W. & Florence N. (2016). Validity of Presumptive Diagnosis among Outpatients in a Tertiary Healthcare facility in Rivers, Nigeria. *British Journal of Medical and Health Research,* 2016:3, (10) *ISSN: 2394-2967.*

Musa, Y. T., Oseratin, I. Benjamin, D. T., Abumhere, S. A. & Thomas, M. (2023). Ownership, usage and perception of insecticide-treated nets (ITNs) for the prevention of malaria among students of a tertiary institution in northeastern Nigeria. *Public Health Toxicology*, 3(1):8. Doi: https://doi.org/10.18332/pht/162333.

Mtonga, B. & Nawa, M. (2024). Prevalence and risk factors associated with malaria infection in children attending Luangwadistrict Hospital, in Zambia; A facility-based cross-sectional study. *medRxiv*, https://doi.org/10.1101/2024. 06.23.24309356.

Nanvyat, N., Mulambalah, C. S., Ajiji, J. A., Dakul, D. A. & Tsingalia, M. H. (2017). Prevalence of Human Malaria Infection and its Transmission Pattern in the Highlands and Lowlands of Plateau State, Nigeria. *Indian Journal of Science and Technology*, Volume 10(32), doi:10.17485/ijst/2017/v10i32/113622, August 2017.

Nasiru, S. Y., Nasiru, J. U. & Jahun, B. M. (2024). Seasonal Variations and the Prevalence of Malaria among Patients at Bichi General Hospital Kano, Nigeria. Book of Proceedings, 14th Nigeria Association of Hydrological Sciences Conference (Okitipupa 2024) held at Olusegun Agagu University of Science and Technology, OKitipupa, Ondo State Nigeria, November 5-8, 2024.

Ndubuisi, J., Aisha, M., Ansari, R.& Ude, U. (2021). Prevalence of Malaria among Patients Attending Primary Health Care Clinic Garaku, Nasarawa North Central Region of Nigeria. *South Asian Journal of Research in Microbiology*, 10(1): 51-55, 2021; Article no. SAJRM.68964. https://doi.org/10.9734/sajrm/2021/v1.

Nwalozie, R., Onosakponome, E. O., Nnokam, B. A., & Lawson, S. D. (2023a). Study on the association between malaria and occupation among Covid-19 Subjects. *Journal of Applied Health Sciences and Medicine,* 3(4), 22 –30.

Nwalozie, R. M., Nnokam, B. A., Esiere, R, K. &Azike, C, A. (2023b). Evaluation of Malaria Parasitaemia and Associated Risk Factors among Patients Living at Community Slums Waterfront in Port Harcourt, Rivers State, Nigeria. *Parasitological and Public Health Society of Nigeria*, paper no.: PPSN/2023/ABS/003, 2023 Edition pp.: 2.

Nwaneli, E. I., Eguonu, I., Ebenebe, J. C., Osuorah, C. D. I., Ofiaeli, O. C. &Nri-Ezedi, C. A. (2020). Malaria Prevalence and its Sociodemographic Determinants in Febrile Children: A Hospital-Based Study in a Developing Community in South-East Nigeria. *Journal of Preventive Medicine and Hygiene*, 202 June; 61(2): E173-E180. Published online 2020 July 4. doi:1015167/2421-4248/jpmh202.61.2.1350. PMCID: PMC7419130 PMID: 32803002.

Ofori, M. Ansah, E., Agyepong, I., Ofori-Adjei, D., Hviid, L., and Akanmori, B. (2019). Pregnancy associated malaria in a rural community of Ghana. *Ghana Medicine Journal*, 43(1):13-8.

Ogbole, F. A., Igwe, C. U., Onuoha, H. C., & Nzebude, C. P. (2023). Evaluating the Prevalence of Malaria Parasite Infection among Adults in Wetlands Using Nested PCR and High Resolution Melting Analysis. *Asian Journal of Biochemistry, Genetics and Molecular Biology*, 14(4), 53-63.

Oladele, O. V., Onuoha, S. C., Hamafyelto H. S., Omisope, O., Fauziyya, A., Akindigh, M.....& Ikeh, E. (2018): Prevalence of Malaria Infection among Patients Attending Murtala Muhammed Specialist Hospital Kano, Nigeria. *African Journal of Clinical and Experimental Microbiology*, 19(3):214- 220.

Olasehinde, G. I., Ojurongbe, D. O., Akinjogunla, O. J, Egwari, L. O. &Adeyeba A. O. (2015). Prevalence of Malaria and Predisposing Factors to Antimalarial Drug Resistance in SouthWestern Nigeria. *Research Journal of Parasitology*, 10: 92-101.

Onah I. E., & Omudu E. A. (2016). Prevalence of Malaria in Relation to Insecticide Treated-nets Usage in a Rural and Urban Settlement in Benue State. *Nigerian Journal of Parasitology,* 37(1) March, 2016.

Orok, A. B., Ajibaye, O., Aina, O., Iboma, G., Adagyo Oboshi, S., Iwalakun, B., & Shiri, R. (2021). Malaria intervensions and Control Programmes in Sub-Saharan Africa: A narrative review. *Cogent Medicine*, 8(1). https://doi.org/10.1080/2331205x .2021.1940639.

Otojareri, K. A., Isah, U. L., Joseph, J. K., Tsado, S. N., Adama, V. N. & Emmanuel, M. E. (2023). Comparative Study of Rapid Diagnostic Test (RDT) and Microscopic Diagnosis of Malaria Infection among Patients attending General Hospital Minna, Niger State. *Texila International Journal of Public Health*, DOI: 10.21522/TIJPH.2013.11.02.Art005. ISSN: 2520-3134.

President's Malaria Initiative (2020). Management Sciences for Health. President's Malaria Initiative (2020). Management Sciences for Health. https://msh.org.

Quaresima, V., Agbenyega, T., Oppong, B., Awunyo, J. D. A., Adoma, P. A., Enty, E., Donato, F & Castelli, F. (2021). Are malaria risk factors based on gender? A mixed-methods survey in an urban setting in Ghana. *Tropical Medicine and Infectious Diseases,* 6(3): 161. DOI: 10.33/tropicalmed6030161Reiter, P. (1999).From Shakespeare to Defoe: Malaria in England in the Little Ice Age.". *Emerging Infectious Diseases*. **6** (1): 1–11. *doi:10.3201/eid0601.000101*. PMC 2627969 . PMID 10653562.

Ranson, H., Jensen, B., Vulule, J. M., Wand, X., Hemingway, J. & Collins, F. H. (2000). Identification of a point mutation in the voltage-gated sodium channel gene of Kenyan Anopheles gambiae associated with resistance to DDT and pyrethroids. *Insect Molecular Biology*, 9(5):491–7.

Ross, L. S. & Fidock, D. A. (2019). Elucidating mechanisms of drug-resistant *Plasmodium falciparum*. *Cell host Microbe*, 26(1):35–47.

Runmonkum, O. B., Ebong, O. O. & Georgewill, U. O. (2019). Comparison of Malaria Rapid Diagnostic Test Kit and Microscopy. *Pharmacology & Pharmacy*, 10, 109-115. https://doi.org/10.4236/pp.2019.103009.

Schneider, K. A., Tsoungui Obama, H. C. J., Kamanga, G., Kayanula, L., Adil, M. Y. N. (2022). The many definitions of multiplicity of infection. *Frontiers in Epidemiology*, 5;2:961593. doi: 10.3389/fepid.2022.961593. PMID: 38455332; PMCID: PMC10910904.

Simon-Oke, M. F., Ogunseem, M., Afolabi, O. & Awosolu, O. (2019). Prevalence of Malaria Parasites among Pregnant Women and Children under Five years in Ekiti State, Southwest Nigeria. *Journal of Biomedicine and Translational Research*, (Online). 2019 July (1):5-10. https://doi.org/10.14710/jbtr.v4i1.3711.

Samdi, L. M., Stephen, A. J., Oguche S. O. & Ayanlade A. O. (2012). Seasonal Variation of Malaria Parasite Density in Paediatric Population of North Eastern Nigeria. *Global Journal of Health Science*, 4(2): 103-109. DOI: 10.5539/gjhs.v4np103.

Smith T., Genton, B., Baea, K., Gibson, N., Taime, J., Narara, A.....& Alpers, M. (1994). Relationships Between *Plasmodium* falciparum Infection and Morbidity in a Highly Endemic Area. *Parasitology*, 109, 539-540. https://doi.org/10.1017/s00311820000.

Tadesse, D., Dessalew, W., Aberash, A., Nebey, F. &Dassalegn, M. (2023). Malaria Prevalence and Associated Factors among Symptomatic Children Aged Under Five Years Attending Sheko District Health Center, Southwest Ethiopia: A Cross-Sectional Study. *Plos One*, 2023; 18(12): e0295237. Published online 2023 December 1. Doi:10.1371/journalpone.0295237 PMCID: PMC10691728 PMID: 2803922289.

Tatteh, J. A., Djissem, P. E., and Manyeh, A. K. (2023). Prevalence, trends, and associated factors of malaria in the Shai-Osudoku District Hospital, Ghana. *Malaria Journal,* 22, 131. https://doi./10.1186/s12936-023-04561-y.

Taye, B. and Alexander, S. (2024). Identifying childhood malaria hotspots and risk factors in a Nigerian city using geostatistical modeling approach. *Scientific Reports*, 14:5445. https://doi.org/10.1038s41598-024-55003-x.

Tesfaye, A. & Teshome, T. (2022). Prevalence and associated factors of malaria infection among outpatients visiting Shewa Robit health center, North-central Ethiopia. *Journal of Tropical Medicine*, 22, 1784012. doi: 10.1155/2022/1784012.

Tessema, S. K., Raman, J., Duffy, C. W. Ishengoma, D. S., Amambua-Ngwa, A., Greenhouse, B. (2019). Applying next-generation sequencing to track *falciparum* malaria in sub-Saharan Africa. *Malaria Journal,* 18, 268. https://doi.org/10.1186/s12936-019-2880-1.

Thu, Z. H., Kay, T. H., Kyin, H. A., Thaung, H., Kyaw, Z. T. & Indra, V. (2016). Comparison of microscopy and PCR for the detection of human Plasmodium species and Plasmodium knowlensi in Southern Myanmar. Asian Pacific Journal of Tropical Biomedicine, 7(8): 680-685. http://dx.org/10.1016/j.apjtb.2017.06.004.

Tizifa, I. A., Kabaghe, A. N., McCann, R. S., Van den Berg, H., Van Vugt, M. & Phiri, K. S. (2018). Prevention Efforts for Malaria. *Currents Tropical Medical Reports*, 5;(1): 41-50. Doi: 10.1007/s40475-018-0133-y. Epup 2018 Feb 8. PMID: 29629252; PMCID: PMC5879044.

Udoma, F. P., Isaac, I. Z., Lukman, I., Nwobodo, D., Osaro, E., Abdulrahman, Y. & John, R. T. (2015).*Plasmodium* Parasitaemia among Pregnant Women Attending Antenatal Clinic in Sokoto North Western Nigeria. *Journal of Nursing Science,* 1(1): 9-14.

Uzoma, V. C., Odoh, V. O. & Etusim, P. E. (2023). Malaria Parasitaemia and Mosquito Control Strategies among Children Living in a Resource Constrained Community of Uturu, Abia State" *Parasitology and Public Health Society of Nigeria*, Paper No.: PPSN/2023/ABS/176, pp. 88;2023 Edition.

Wokem, G. N., Erasmus, A. M., & Wokem, V. C. (2020). "Malaria Status in Relation to Risk Factors among Attendees of Two Health Facilities in Port Harcourt, Rivers State, Nigeria". *Journal of Advances in Medicine and Medical Research*, 32(23):222-230.

World Health Organization (1993).*A global strategy for malaria control. Geneva*. http://whqlibdoc.who.int/publications/9241561610.pdf (accessed 2009 July 7).

World Health Organization (2000). Roll Back Malaria Department Website at *http://mosquito. whoint/malariacontrol* Management of Severe Malaria; A Practical hand book, 2nd edition Geneva.

World Health Organization (2011).*Universal Access to Malaria Diagnostic Testing*. An Operational Manual, WHO, Geneva, Switzerland, *http/:www.into/malaria/end/*.

World Health Organization (2017). *Malaria Fact sheet* N°94". Retrieved 2 February 2017.

World Health Organization (2018). *Global Technical Strategy for Malaria* 2016 – 2030". World Health Organization, Geneva

World Health Organisation (2019). *Global Fund to Fight against AIDS. Tuberculosis and Malaria*; Nigeria Funding Request malaria 2017 World Malaria Report 2019.

World Health Organization (2020).*World Malaria Report*; WHO: Geneva, Switzerland, (2020): Available online: https://www.who.int/publications/i/item/9789240015791 (accessed on 8 December 2020).

World Health Organisation (2021). *World Malaria Report* 2021 National Malaria Indicator Survey (NMIS), 2015; p96 & 99.

World Health Organization (2022).*Malaria*, Available from: *https://www.who.int/ news-room/fact-sheets/detail/malari*a. Accessed 18th August, 2022.

World Health Organization (2023). World malaria report 2023. Geneva. ISBN: 978-92-4008617-3 (electronic version), ISBN: 978-92-4-008618-0 (print version). Licence: CC BY-NC-SA 3.0 IGO. https://apps.who.ints/iris. Pp. 8-12.

Yamane T. (1967).*Statistics*: An introductory analysis, 2nd Edition,New York: Harper and Row.

Yaro, K. D. (2018). Colonial Economy of Ibi and Wukari Divisions 1900-1960. Department of History, Faculty of Arts, Ahmadu Bello University, Zaria, Nigeria.

Yeboah, A. (2023). Comparative analysis of factors associated with insecticide-treated net utilization between rural and urban areas in Ghana: implication for malaria control and prevention. University of Bergen, *Master Thesis*. https://hdl.handle.net /11250/3070427.

Zeleke, M. T., Gelaye, K. A., Hirpa A. A., Teshome, M. B., Guma, G. T. & Abate, B. T. (2023). Diagnostic performance of *Pf*HRP2/pLDH malaria rapid diagnostic tests in elimination setting, northwest Ethiopia. *PLOS Global Public Health*, 3(7), e0001879. https://doi.org/10.1371/journal.pgh.0001879.

Zhan, Q., Tiedje, K. E., Day, K. P., Pascual, M. (2024). From multiplicity of infection to force of infection for sparsely sampled *Plasmodium falciparum* populations at high transmission. *medRxiv* [Preprint]. 2024 May 27:2024.02.12.24302148. doi: 10.1101/2024.02.12.24302148. PMID: 38853963; PMCID: PMC11160831.