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Seasonal Variation and Intensity of Malaria Infection in Patients Attending Public Health Institution in Nasarawa State of Nigeria

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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 seasonal variation and intensity of malaria infection in patients attending the public health institutions in Nasarawa State with respect to the seasonal variation, intensity, sensitivity and specificity 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. With respect to the seasonal variation, infection was high during the early rainy season and late rainy season (69.1%), and moderate during early dry and late dry

season with a prevalence rate of 30.9% ($p<0.05$). RDTs had 97% sensitivity and 90% specificity and predictive values of 96.6% (positive) and 93.6% (negative). The intensity of the parasitic infection was determined and parasites load ranges from ≤ 200 parasites per microlitre of blood to >1500 per microlitre of blood with a mean of 21.4/µl of blood. Females had higher occurrence of malaria leading to a higher level of parasitemia while males had a higher parasite density of >1500. Patients were examined to determine the level of parasites level among malaria positive patients. There were 344/750 (45.9%), 232 (30.9%) and 174 (23.2%) patients with low, moderate, and high parasitemia, respectively. This study highlights the significant seasonal variation in malaria prevalence, with an overall infection rate of 62%. The findings suggest that malaria transmission intensifies during specific periods, likely influenced by climatic factors such as rainfall and temperature. These seasonal fluctuations emphasize the need for targeted intervention strategies, including intensified vector control and public health campaigns during peak transmission seasons.

Introduction

Malaria remains one of the most significant parasitic diseases affecting humans, particularly in tropical and subtropical regions, due to its widespread prevalence and high mortality rate. As a leading tropical disease, it infects an estimated 500 million people each year and is responsible for approximately 1.5 to 2.7 million deaths annually, making it a critical global health concern (World Health Organization [WHO], 2021).

Malaria remains a major public health concern in Sub-Saharan Africa, where it is endemic in approximately 32 countries, accounting for nearly 93% of global malaria deaths. Nigeria bears one of the highest burdens of the disease, leading among the four African nations responsible for half of malaria-related mortality worldwide, with 31.9% of the total deaths. This underscores the urgent need for

sustained intervention and control efforts to reduce its devastating impact (WHO, 2022). Malaria transmission varies across regions, with year-round transmission in the south and a shorter season of three months or less in the north. *Plasmodium falciparum* remains the dominant malaria parasite (WHO, 2021). Approximately 76% of the population resides in high-transmission areas, while the remaining 24% live in regions with lower transmission rates, highlighting the uneven distribution of malaria risk (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). Laboratory diagnostic methods have become essential, as clinical signs and symptoms alone are not sufficient for health workers to accurately identify malaria cases (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 Global Malaria Control Strategy emphasizes the importance of prompt and accurate disease diagnosis as a cornerstone of effective malaria management (WHO, 1993; 2020). However, inaccurate diagnosis continues to pose a significant challenge to malaria control efforts. This issue arises from various factors, including the reliance on non-specific symptomatic diagnosis, limited healthcare resources, and the widespread practice of self-treatment for suspected malaria cases (WHO, 2000; Tizzifa *et al.,* 2018; Orok *et al.,* 2021).

The World Health Organization recommends that all malaria cases be confirmed through parasite-based, quality-assured diagnostics before initiating treatment (WHO, 2011; Lalremuata *et al.,* 2017). However, in Nigeria, and particularly in Nasarawa State, limited studies have been conducted to assess the molecular diversity of Plasmodium species in routine clinical malaria diagnosis. This study aims to fill that gap by providing molecular insights into the seasonal variation, intensity and sensitivity and specificity of malaria

infections in the region, which may enhance diagnostic accuracy and inform better malaria management strategies.

Materials and Methods

Study Area

Nasarawa State is located in North-Central Nigeria, positioned between longitude 7° and 9° 37' East of the Greenwich Meridian and latitude 7° 45' and 9° 25' North of the equator. It shares boundaries with Plateau State to the east, Kaduna State to the north, Benue and Taraba States to the south, and Kogi State and the Federal Capital Territory (FCT) to the west.

The state falls under the Köppen climatic classification, characterized by a tropical rainy climate with a distinct dry season during winter. The rainy season lasts approximately seven months (April to October), with an annual rainfall ranging between 1,200mm and 2,000mm. Humidity levels are generally high during the wet season, reaching about 95% in some areas, but drop to approximately 55% during the dry season. Sunshine hours peak between January and April, gradually decreasing from May to October due to increased cloud cover.

Covering a total land area of 27,117 km² (10,470 sq mi), Nasarawa State had a population of 1,863,275 according to the 2006 national census, with a population density of 75/km² (190/sq mi) (Akwa *et al.,* 2007).

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 the public health institutions of these local Government Areas. The samples were randomly selected from both sexes from September 2022 through September 2023 on weekdays (Mondays to Fridays) from 8am to 11am. Two types of analysis were carried out; Microscopy and the Rapid Diagnostic Tests (RDTs)

Diagnostic Methods

Three diagnostic techniques were employed in this study:

1. Microscopy (Gold Standard)
2. Rapid Diagnostic Tests (RDTs)
3. Molecular Analysis (PCR – Yet to be performed)

Since the molecular analysis is pending, microscopy served as the gold standard for diagnosis, using thin and thick film preparations as described by Cheesbrough (2017). A sample was recorded as positive if the asexual form of Plasmodium species was detected.

Microscopy for Malaria Diagnosis

Thin Film Preparation: A small drop of blood was placed at the center of a glass slide and spread using a cover slide to 10mm² (Cheesbrough, 2017). The slides were air-dried, stained with 5% Giemsa solution for 20 minutes, rinsed with tap water, and air-dried before microscopic examination at 100x oil immersion objective lens.

Thick Film Preparation: A small drop of blood was placed at the center of a grease-free glass slide and spread in a coil shape (~2 cm diameter). The slides were labeled, air-dried horizontally, and protected from dust before staining with 5% Giemsa stain for 20 minutes. Microscopic examination was performed using a 100x oil immersion objective lens, and results were recorded (Cheesbrough, 2017).

Both thin and thick blood films were examined by expert laboratory scientists to ensure accuracy.

Rapid Diagnostic Test (RDTs) for Malaria

A lateral flow immunochromatographic RDT kit (Bioline™ by Abbott Global Point of Care, USA) was used to detect Histidine-rich protein 2 (HRP2) antigen of Plasmodium falciparum and lactate dehydrogenase (pLDH) in human blood. The procedure followed the manufacturer's instructions:

1. The researcher wore new sterile gloves for each patient and labeled the test kit.
2. The fingertip was cleaned with an alcohol pad, and a sterile lancet was used for capillary blood collection.

3. The first drop of blood was wiped off, and 5 µl of blood was collected using a micro-pipette.
4. The blood sample was added to the "S" well of the test cassette, followed by 60 µl of assay buffer in the "A" well.
5. Results were read after 20 minutes:
    a. Positive: Presence of both the control line and either PF or Pan test lines.
    b. Negative: Only the control line appeared.
    c. Sensitivity and specificity of the RDT were evaluated according to WHO standards and manufacturer guidelines (WHO, 1998; Ogunfowokan *et al.,* 2020).

Determination of Sensitivity and Specificity

Sensitivity

Sensitivity refers to the ability of a test to correctly identify an individual with a condition.

$$\left[\text{Sensitivity} = \frac{\text{True Positive}}{\text{True Positive}} + \text{ False Positive}\right]$$

This measures the probability of being test positive when disease present

Specificity

This is the ability of a test to identify an individual as free of the disease correctly.

$$\left[\text{Specificity} = \frac{\text{True Negative}}{\text{True Negative}} + \text{ False Negative}\right]$$

This measures the probability of being tested negative when disease is not present.

Positive predictive value (PPV)

This stands for the percentage of patients who have the disease as a matter of facts and came out with a positive test. It shows the number of positive tests that are true positives. When the number shown by PPV is higher (when it narrows 100%), that means the new test is just as good as the gold standard.

$$\left[\text{Positive Predictive Value} = \frac{\text{True Positive}}{\text{True Positive}} + \text{ False Positive}\right]$$

Equals to probability of testing positive when the patient has the disease

Negative predictive value (NPV)

This stands for the percentage of patients having a negative test who do not have the disease. NPV tells us the number of test negatives which are negatives truly; and when number is high (should narrow 100), then it recommends that the new test is just as good as the gold standard.

$$\left[\text{Negative Predictive Value} = \frac{\text{True Negative}}{\text{True Negative}} + \text{False Negative}\right]$$

Equals to probability of having a negative test when patient do not have the disease.

Determination of Parasites density in Microscopy Malaria diagnosis

The parasites density provides information on the severity of infection and on the response to treatment. Parasites counts were performed for *P. falciparum, P. Malariae* and *P. ovale* asexual stage at 100x oil immersion using a tally counter. Parasite and white blood cells were counted by clicking on the assigned key as parasites or white blood cells were observed (WHO, 2016).

Quantification on thick film using the absolute value method.

If ≥ 100 parasites in 200 white cells were counted, the count stops and the results were recorded as the number of parasites per 200 white cells or if ≤ 99 parasites were counted in 500 white cells the count was either stopped or continued and the result was recorded as 500 white cells seen and calculated using the absolute value method on thick film and the relative value method on thin film.

$$\left[\text{No. of parasite } /\mu\text{l} = \frac{\text{Parasite count x Absolute WBC value}}{\text{No. of WBC counted}}\right]$$

For example;

Parasite counted = 210

Absolute WBC value = 8000/ µl

No. of WBC counted against parasite = 200

No. parasites /µl = $\frac{210 \text{ x } 8000}{200}$

No. of parasites / µl = 8400 parasites / µl of blood.

Quantification on thin film using the relative value method

If ≥ 100 parasites are present in each field of a thick film under the 100x objective, the parasites found on the tin film were calculated. All parasitized and non-

parasitized red blood cells were counted using two tally counters. The count was stopped when about 20 fields with about 250 red cells (about 5000red cells) have been counted. A typical field at 100x magnification contains 250 red blood cells. The actual numbers counted were recorded on a worksheet and the figures were used to calculate the total parasite count per µl of blood. The parasite density was calculated from using an estimated average red cell count of 5, 000, 000 / µl and the following formula;

$$\text{Infected Red Blood Cell (RBC)}/\mu l = \frac{\text{Count of infected RBC x No of RBC}/\mu l}{\text{Total RBC counted (infected} + \text{non} - \text{infected)}}$$

For example, if infected RBC = 82
Total RBC count = 2,000
No of RBCs/ µl = 5,000,000
Infected RBC/ µl = 82 x $\frac{5000000}{2000}$ = 205, 000 infected RBC

Calculation of result for percentage (%) parasitemia.

$$\text{Percentage (\%) Parasitaemia} = \frac{\text{Parasitized RBC x 100}}{\text{Total RBC}}$$

For example; infected Red Blood Cell (parasitized) = 45,
Total RBC count = 2000
Therefore;
Percentage (%) parasitaemia = $\frac{45}{2000}$ x 100 = 2.25%
Percentage (%) parasitaemia = 2.25%.
The level of parasitemia was expressed as percentage of erythrocytes infected with malarial parasites. Percentage parasitemia was calculated by dividing the number of infected RBC by the total number of RBCs indexed and multiplied by 100. For levels of malarial parasitemia, parasite density was grouped as high parasitemia >10%; moderate parasitemia 1–10%, and low parasitemia <1% (Centers for Disease Control and Prevention CDCP, 2016).

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

Seasonal Variation of Malaria in the Public Health Institution of Nasarawa State

The seasonal variation of malaria in the different clinical institution indicates that there is high prevalence of infection during the early rainy season (April to June) and late rainy (July to September) there is low to moderate rate of malaria infection during the early dry (October to December) and late dry season (January to March). There was a significant difference ($p<0.05$, df = 13) in the prevalence in relation to season (Table 3).

Table 1: Seasonal Variation of Malaria Infection in the different Health Institutions

Month	No. Examined (%)	No. Positive (%)	$\chi 2$	df	p-value
Late Rainy Season					
September 2022	96 (8.00)	36 (75.0)	16.841	13	0.000
October 2022	92 (8.33)	56 (60.87)			
November 2022	74 (6.70)	35 (47.30)			
December 2022	61 (5.53)	47 (77.05)			
Late Dry Season					
January 2023	81 (7.34)	42 (51.85)			
February 2023	67 (6.07)	28 (41.79)			
March 2023	80 (6.66)	24 (75.0)			
Early Rainy Season					
April 2023	88 (7.97)	52 (59.09)			
May 2023	53 (4.80)	31 (58.49)			
June 2023	108 (9.72)	82 (75.93)			
Late Rainy Season					
July 2023	94 (8.51)	61 (64.89)			
August 2023	204 (18.48)	186 (91.18)			
September 2023	102 (9.24)	70 (68.63)			
Total	**1200 (100)**	**750 (62.5)**			

Effects of Malaria Prevalence on Parasitemia levels among infected Patients

Table 2 showed all the patients examined to determine the level of parasites level among malaria positive patients. There were 344/750 (45.9%), 232/750

(30.9%) and 174/750 (23.2%) patients with low, moderate, and high parasitemia, respectively. The age groups 11-20, 21-30 and 31-40 which had the highest number of patients was with high level of parasitemia which accounts for 187/750 (25%), however, there was no significant difference (P>0.05). A relatively high level parasitemia was recorded in males compared to female patients and there was a statistically significant difference (P<0.05).

Table 2: Prevalence of Malaria Parasite Density across age and sex of infected Patients (n=750)

Parasite density (No. of parasites/µl of blood)							
Variables	≤200	201-500	501-1000	1001-1500	>1500	Mean parasites/µl	P-value
Sex							
Male	25	49	89	119	62	68.8	0.00
Female	120	156	29	68	33	81.2	
Age							
0-4	21	12	39	19	13	20.8	0.00
5-10	18	15	42	16	12	20.6	
11- 20	12	15	37	26	52	28.4	
21-30	17	23	22	24	39	25	
31- 40	23	21	17	34	35	26	
41- 50	25	14	31	11	1	16.4	
51 and above	12	18	14	9	11	12.8	

Table 3: Effects of Malaria Prevalence on Parasitemia level among Infected Patients (n=750)

Parasitemia level				
Variables	<1%	1-10%	>10%	p-value
	Positive (%)	**Positive (%)**	**Positive (%)**	
Age groups				
0-4	48 (6.4)	38 (5.1)	18 (2.4)	0.006
5-10	38 (5.1)	39 (5.2)	26 (3.4)	
11-20	58 (7.7)	33 (4.4)	51 (6.8)	
21-30	72 (9.6)	27 (3.6)	26 (3.4)	
31-40	57 (7.6)	39 (5.2)	34 (4.5)	
41-50	41 (5.4)	31 (4.1)	10 (1.4)	
51 and above	30 (4.0)	26 (3.4)	8 (1.0)	
Sex				
Male	138 (18.4)	128 (17.6)	78 (10.4)	0.028
Female	206 (27.4)	104 (13.6)	96 (12.6)	

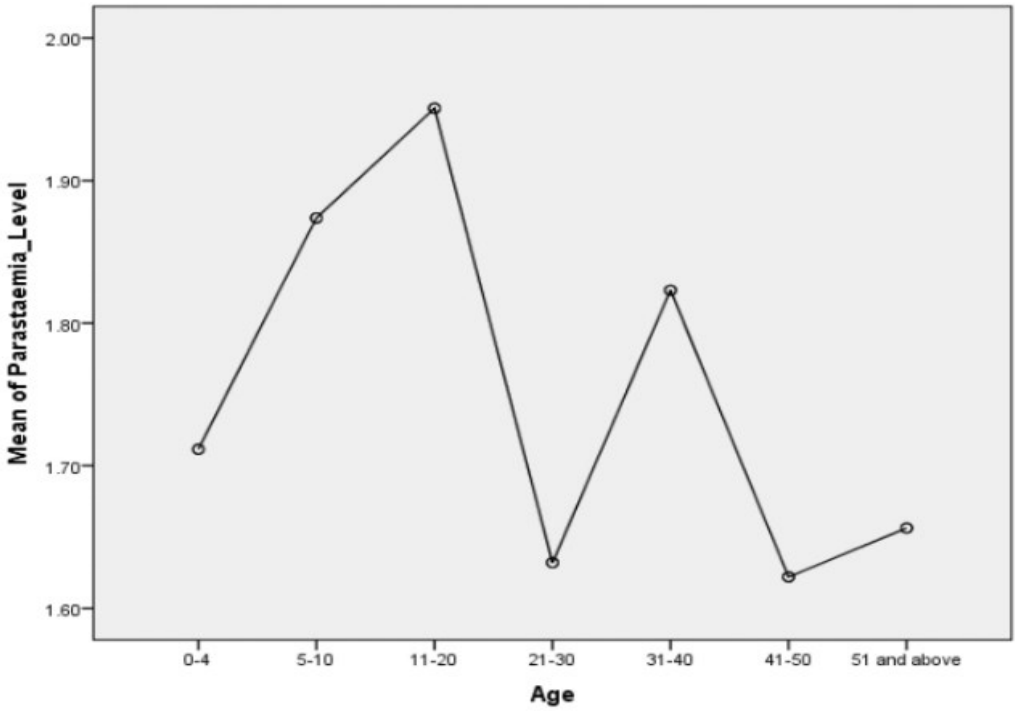

Fig. 2: The effects of malaria prevale valence on parasitemia level among infected Patients based on their age group

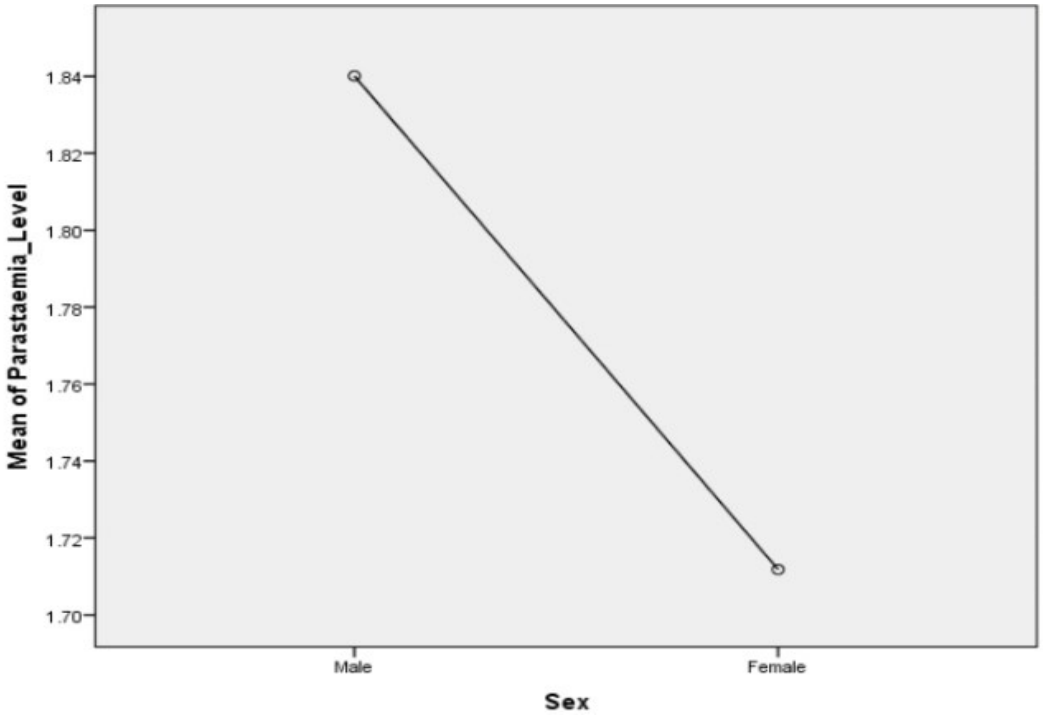

Fig. 3: The effects of malaria prevalence on parasitemia level among infected Patients based on their sexes

Sensitivity and specificity of Rapid Diagnostic Tests diagnosing Malaria

The Rapid Diagnostic Tests results for the 1200 consenting patients were compared to giemsa stained microscopy which is the gold standard for malaria diagnosis to obtain the parameters for calculating sensitivity, specificity, negative and positive predictive values. The RDTs came out with a high positive predictive value (94.7%), this means patients will be accurately tested as positive for malaria and abstain from unneeded treatments. The high negative predictive value (95.6%) shows that RDT is suitable in eliminating malaria.

With respect to sensitivity, stained blood film microscopy as a standard method with 100% sensitivity, rapid diagnostic test had 97% sensitivity and 90% specificity and having predictive values of 96.6% (positive) and 93.6% (negative).

Table 4: Sensitivity and specificity of Rapid Diagnostic Tests diagnosing Malaria

Positive	Negative	Sensitivity (%)	Specificity (%)	NPV (%)	PPV (%)
750	450	97	90	93.6	96.6

Key: Positive Predictive Value (PPV)
Negative Predictive Value (NPV)

Discussion

Seasonal variation is among the factors affecting malaria transmission in these health institutions which played a central role in malaria transmission, as higher *Plasmodium* infection rate was observed in the rainy season than in the dry season. The discrepancy observed might be due to differences in ecological and environmental factors (season, climates and altitude) and community awareness of malaria transmission and control. The monthly distribution of malaria cases showed that the highest cases were reported in mid-April to September, with a peak in August during the transition from the rainy to the dry season. This suggests that the rainy season in Nasarawa State creates a suitable environment for breeding in Anopheles mosquitoes. This study agrees with the earlier work of Nasiru *et al.,* (2024), Simon-Oke *et al.,* (2023), Acheampong *et al.,* (2022), Ibrahim *et al.,* (2021), Fassinou *et al.,* (2020), Boundenga *et al.,* (2015), Kumar *et al.,* (2014), Oesterholtet *et al.,* (2006), Thomson *et al.,* (2005), Ayanlade *et al.,* (2010) and Samdi *et al.,*(2012) who stated that it is obvious that there is significant relationship between climate and

malaria occurrences. This is in contrast with the wet forest areas of Nigeria where malaria transmission occurs at high level all year round (FMOH, 1991). Though, Enosolease and Awodu (2003) and Coban (2020) reported that malaria parasitaemia fluctuates throughout the year without any clear pattern and devoid of seasonality in Benin, Southern Nigeria. This study agrees that the seasonality of climate greatly influences the seasonality of malaria transmission. Microscopy diagnostic technique detecting more malaria parasites than RDTs in this study is in accordance with the work of Gosselle and others (2007) who conducted a study on Malaria and the effect of malaria parasitemia on albumin level among HIV/AIDS patients in Jos Nigeria. However, this prevalence is lower than the estimated risk map of 70% to 25% prevalence in some areas in Nigeria (Abdulazeez *et al.,* 2017).

Adepeju (2017), Oladele *et al.,*(2018), Jemimah *et al.,*(2019) and Awosolu and Agboaja (2021) found a higher percentage of 70.50% and what was observed in other parts of Nigeria they all reported prevalence of higher than 70%. Also, the prevalence of malaria in febrile patients reported by Nas, *et al.,* (2017) in Kano, Northern Nigeria was 84% which is higher than the findings of this study.

This variation in prevalence of malaria in different places in Nigeria could be due to inadequate protection against mosquito bites, insufficient knowledge about malaria transmission, negligence of the community members, climatic differences or period of study and socio-cultural factors. A malaria prevalence rate of 62.5% is considered extremely high and should be a cause for significant concern and urgent intervention efforts in the affected area. Such a high prevalence suggests widespread transmission of the disease and would likely have severe public health implications.

The high level of sensitivity (97%), specificity (90%), negative (93.6%) and positive predictive values (96.6%) are similar to the work of Wogu and Nduka 2018 who evaluated malaria prevalence using clinical diagnosis compared with microscopy and Rapid Diagnostic Tests in a tertiary healthcare facility in Rivers State, Nigeria and came out with the sensitivity, specificity, and diagnostic accuracy values of 73.7%, 97.3%, and 88.3%, and that of Adeniyi (2019) who worked on the discriminatory and predictive accuracy of the RDT against the microscopy in the diagnosis of malaria among under-five children in Nigeria respectively. The prevalence of malaria using microscopy was higher than RDT method in this study, similar findings was previously reported by Zeleke *et al.*(2023), Tolulope *et al.*(2021), Alshamrani *et al.,* (2022), Pembele, *et al.,* (2015),

Malann *et al.,* (2016), Wogu and Nduka (2018), and Runmonkun *et al.*(2019), who reported that microscopy has higher malaria positive cases than RDTs, and contradicts other studies who reported higher prevalence rate in RDTs than microscopy (Opoku *et al.,* 2023, Kangming *et al.,* 2024 and Madkhali *et al.,*2022). The sensitivity of the RDT could be affected by storage temperature which may have been responsible for low sensitivity in this study. Also, while microscopy permit parasite differentiation and quantification, RDT is very fast and it require little expert (Ojurongbe *et al.,* 2013). However, RDTs should be used alone when expert microscopy is unavailable else it should complement microscopy.

Females had higher occurrence of malaria leading to a higher level of parasitemia while males had a higher parasite density of >1500. This is in accordance with the findings of Atah *et al.,* (2022) and that of Gobena and Mabrate (2022) who worked on the Malaria infection, parasitemia, and hemoglobin Levels in Febrile patients attending Sibu Sire health facilities, Western Ethiopia and found out that the females had higher level of parasitemia. However, this finding is in contrast to that of Antwi-Baffour *et al.,* (2023), who found out that males had higher level of parasitemia than the females.

All patients who examined to determine the level of parasitemia among them were 344/750 (45.9%), 232 (30.9%) and 174 (23.2%) patients with low, moderate, and high parasitemia, respectively. The age groups 11-20, 21-30 and 31-40 which had the highest number of patients was with high level of parasitemia is comparable with the work of Antwi-Baffour *et al.,* (2023), who worked on the haematological parameters and their correlation with the degree of malaria parasitemia among outpatients attending a polyclinic and also Atah *et al.,* (2010) and Gobena and Mabrate (2022).

Conclusion

This study highlights the significant seasonal variation in malaria prevalence, with an overall infection rate of 62%. The findings suggest that malaria transmission intensifies during specific periods, likely influenced by climatic factors such as rainfall and temperature. These seasonal fluctuations emphasize the need for targeted intervention strategies, including intensified vector control and public health campaigns during peak transmission seasons. Strengthening surveillance systems and promoting timely treatment can help mitigate the burden of malaria and reduce its impact on affected populations.

Acknowledgment

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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 Demographic and socio-economic factors influencing transmission is in another batch.

References

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.

Adeniyi, F. F. (2019). On the Discriminatory and Predictive Accuracy of the RDT against the Microscopy in the Diagnosis of Malaria among Under-five Children in Nigeria.*Malaria Journal,* 18(1):46. doi:10.1186/s12936-019-2678-1.

Adepeju, I. S. (2017). Prevalence of Malaria Parasite among Asymptomatic and Symptomatic Students of Federal University of Technology, Akure, Ondo State. *British Journal of Research*, 4: 5.

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.

Atah, S. A., Lucien, H., F., K., Longdoh, A., N. (2022). Relationships between blood cell counts and the density of Malaria parasites among patients at the regional hospital, in Cameroon. *African Journal of Clinical and experimental Microbiology*, 11(2) 120: 120-127.

Antwi-Baffour, Menseh, B. T., Johnson, G., Okailey A. N. D., Ali-Mustapha, S. & Annison, L. (2023). Haematological parameters and their correlation with the degree of malaria parasitemia among outpatients attending a polyclinic. *Malaria Journal,* 23(22): 281. https://doi.org/10.1186/s12936-023-04710-3.

Alshamrani, M., Alsamti, S. S. A., Alshareef, H. B., Huraysi, N. A., Althaqafi, A. A. F., Saad, E. A.....Amalki, M. F. A. (2022). Prevalence of Malaria and Risk Factors among Patients visiting the Primary Health Care at Saudi Arabia 2022. Annals of the Romanian Society for Cell Biology, 26(01), 4551-4565. Retieved from http://www.annalsofrscb.ro/index.php/journal/article/view/11738.

Awosolu, O. B., & Agboaja, C. K. (2021). Pattern of malaria parasitemia in a high transmission setting of Oba- Ile, South-Western Nigeria. *Animal Research International,* 2021 18(1): 3947-3954.

Ayanlade A, Adeoye N. O. & Babatimehin O. (2010). Climate Change /Variability and Malaria Transmission in Sub-Saharan Africa: A case of Nigeria. Report of the Royal Norwegian Society of sciences and Letters 250 anniversary Conference, June 21-24, 2010 Trondheim, Norway. 2010.

Boundenga, L., Ollomo, B., Rougeron, V., Mouele, L. Y., Mve-Ondo, B., Diamella, M. N.....Prugnolle, F. (2015). Diversity of malaria parasites in great apes in Gabon. *Malaria Journal*, 14(1):1–8.

Centers for Disease Control and Prevention (2016). Global Health, Division of Parasitic Diseases and Malaria, CDC, 2016.

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

Coban C. (2020). The host targeting effect of chloroquine in malaria. *Current Opinion in Immunology*, 66:98–107.

Enosolease M. E, Awodu O. A. (2003). Seasonal Variation of Malaria Parasitaemia in an Urban Tropical City Nigeria. Journal of Clinical Practice2003, 6(1):30–33. [Google Scholar].

Fassinou, A. J. Y., Koukpo, C. Z., Osse, R. A., Agossa, F. R., Assogba, B. S., Sidick, A., Sewade, T. W., Akogbeto, M. C. & Sezonlin, M. (2019). Genetic structure of *Anopheles gambiae ss* populations following the use of insecticides on several consecutive years in southern Benin. *Tropical Medicine and Health*, 47(1):10.

Federal Ministry of Health (1991). Malaria in Nigeria Epidemiology and Control. Nigeria Bulletin of Epidemiology, 1991;1(3):1–19. [Google Scholar]

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.

Gosselle, O. N., Onwuliri, C. O. N & Onwuliri V. A (2007). Malaria and the Effect of Malaria Parasitemia on Albumin Level among HIV/AIDS patients in Jos Nigeria. *Journal of Medical Science,* 7 (7):1187-1191.

Ibrahim, O. R., Lugga, A. S., Ibrahim, N., Aladesua, O., Lawal, M. I., & Suleiman, B. A. (2021). Impact of climatic variables on childhood severe malaria in a tertiary health facility in northern Nigeria.*Sudan Journal of Paediatrics*, 21(2),173–181.

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.

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.

Kumar, D. S., Andimuthu, R., Rajan, R. & Venkatesan, M. S. (2014). Spatial Trend, Environmental and Socioeconomic factors associated with malaria prevalence in Chennai. *Malaria Journal*, 13(1), 1-9.

Lalremruata, A., Jeyaraj, S., Engleitner, T., Joanny, F., Lang, A., Belard, S., Mombo-Ngoma, G., Ramharter, M., Kremsner, G. P., Benjamin, M. & Held, J. (2017). Species and genotype diversity of *Plasmodium* in malaria patients from Gabon analysed by next generation sequencing. *Malaria Journal,* 16, 398 (2017). https://doi.org/10.1186/s12936-017-2044-0. https://doi.org/10.1186/s12936-017-2044-0.

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).

Nas, F. S., Yahaya, A. & Ali M. (2017): Prevalence of Malaria with Respect to Age, Gender and Socio-economic Status of Fever Related Patients in Kano city, Nigeria. *Greener Journal of Epidemiology and Public Health,* 5(5):44-49.

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.

Oesterholt, M. J. A. M., Bousema, J. T., Mwerinde, O. K., Harris, C., Lushino, P., Masokoto, A., & Drakely, C. J. (2006). Spatial and Temporal variation in Malaria Transmission in a low endemicity area in Northern Tanzania. *Malaria Journal*, 5(1), 1-7.

Ogunfowokan, O., Ogunfowokan, B. A. & Nwajei, A. I. (2020). Sensitivity and specificity of malaria rapid diagnostic test (mRDT CareStatTM) compared with microscopy amongst under five children attending a primary care clinic in southern Nigeria. *African Journal of Primary Health Care and Family Medicine,* 17;12(1):e1-e8. doi: 10.4102/phcfm.v12i1.2212. PMID: 32634015; PMCID: PMC7380062.

Ojurongbe, O., Adegbosin, O. & Taiwo, S. (2013). Assessing of Clinical Diagnosis, Microscopy, Rapid Diagnostic Tests and Polymerase Chain Reaction in the Diagnosis of *Plasmodium falciparum* in Nigeria". *Malaria Research and Treatment*. 5: 308069.

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.

Okopu Afriyie, S., Kwame, T. A., Gebre, Y., Mutala, A., Baako, K. A., Ackom, D. A., Agyapong, K. A., Tweneboah, A., Kwame, N. A., Koepfli, C. & badu, K. (2023). Accuracy of diagnosis among clinical malaria patients: comparing microscopy, RDT and a highly sensitive quatitative PCR looking at the implications for submicroscopic infections. *Malaria journal*, 2023, 22-76. https://doi.org/10.1186/s12936-023-04506-5.

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.

Pembele, G. N., Rivero, L. R. & Fraga, J. (2015). Detection and Species Identification of Malaria Parasites by nested-PCR: Comparison with Light Microscopy and with SD BIOLINE malaria Ag test in Luanda, Angola. *International Journal of Tropical Disease and Health.* 10(1):1-13

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

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.

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.

Simon-Oke, I.A., Awosolu, O.B., & Odeyemi, O. (2023). Prevalence of Malaria and COVID-19 Infection in Akure NorthLocal Government Area of Ondo State, Nigeria.*Journal of Parasitology Research,* Pp 2-7.

Thomson, M. C, Connor, S. J & Phindela, T. (2005). Rainfall and Seasurface Temperature Monitoring for Malaria Early Warning in Botswana. American Journal of Tropical Medicine and Hygiene. 2005;73:214–221. http://dx.doi.org/10.1186/1475-2875-3-37 [PubMed] [Google Scholar]

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.

Tolulope, S. A., Bukunlola, J. B., Olumuyiwa, O.O. & Adetutu, M. A., (2021). Comparative Analysis of Malaria using Microscopy and Rapid Diagnostic Test (RDT) in Ijebu-Igbo North Local Government, Southwest Nigeria.*UMYU Journal of Microbiology Research*, 6 (2), 21. https://doi.org/10.47430/ujmr.2162.008.

Wogu, M. N. & Nduka, F. O (2018). Evaluating Malaria Prevalence Using Clinical Diagnosis Compared with Microscopy and Rapid Diagnostic Tests in a Tertiary Healthcare Facility in Rivers State, Nigeria.*Journal of Tropical Medicine*, 2018 Apr 22:2018:3954717.doi: 10.1155/2018/3954717. eCollection 2018.

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 (1998): *Quality Assurance in Haematology*. World Health Organization, Geneva, WHO/LAB/98.4,10.

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 (2016). *Malaria Fact sheet* N°94". Retrieved 2 February 2016.

World Health Organization (2017). *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.

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.