PREVALENCE OF *PLASMODIUM FALCIPARUM* MALARIA AND HAEMATOLOGICAL PROFILING AMONG CHILDREN IN ILORIN, KWARA STATE, NIGERIA

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Received: 1st Jan., 2024 **Accepted**: 28th Feb., 2024 **Published:** 1st June, 2024

ABSTRACT

Background: Malaria is one of the most severe global public health problems worldwide, particularly in Africa, where Nigeria was ranked among the countries with the highest numbers of malaria cases. This community-based study was designed to investigate the prevalence and risk factors of malaria and to evaluate the knowledge, attitudes, and practices (KAP) and Haematological profile regarding malaria among children in Ilorin North-Central Nigeria.

Methods: A cross-sectional community-based study was conducted on 354 participants from three local government areas in Ilorin Kwara Central Senatorial districts of Kwara State. Blood samples were collected and examined for the presence of *Plasmodium* species by rapid diagnostic test (RDT), and Giemsa-stained (thin and thick blood films). Detail information on demographic, socioeconomic, and environmental data using a pre-tested questionnaire designed with the standard knowledge, attitudes and practices were collected.

Results: A total of 279 (78.8%) participants were found positive for *Plasmodium falciparum*. The prevalence differed significantly by age group ($p < 0.01$), but not by gender or location. Also, studies underscore distinct age-associated variations in Haematological parameters, with notable differences in haemoglobin concentration, hematocrit levels, and white blood cell counts among the different age groups. Multivariate analysis showed that malaria was associated significantly with aged, a low household family income, not using insecticide-treated nets (ITNs). Overall, 78.8% of the respondents had prior knowledge about malaria, and 64.5, 33.0 and 69.2% knew about its transmission, symptoms, and prevention respectively. Findings also showed that 71.7% of the respondents considered malaria a serious disease. Although 83.3% of the respondents had at least one ITN in their household, utilization rate of ITNs was 72.3%. Significant associations between the respondents' knowledge concerning malaria and their age, gender, education, and household monthly income were reported.

Conclusion: Malaria is still highly prevalent among rural communities in Ilorin, Kwara State Nigeria. Despite high levels of knowledge and attitudes in the study area, significant gaps persist in appropriate preventive practices, particularly the use of ITNs. Innovative and Integrated control measures to reduce the burden of malaria should be identified and implemented in these communities. Community mobilization and health education regarding the importance of using ITNs to prevent malaria and save lives should be considered.

Keywords: Parasitemia; Malaria; *Plasmodium falciparum*; Haematological profiling; Erythrocytes

Citation: Ahmmed, B. O. and Nassar, S. A. (2024): Prevalence of *Plasmodium falciparum* Malaria and Haematological Profiling among Children in Ilorin, Kwara State, Nigeria *BJMLS 9(1):53 - 71*

INTRODUCTION

Malaria is caused by *Plasmodium falciparum*, and the mosquitoes *Anopheles gambiae*, *Anopheles funestus*, *Anopheles arabiensis*, and *Anopheles moucheti* are the major vectors that cause year-round transmission; artemether-lumefantrine (AL) or artesunate + amodiaquine (AS + AQ) is the treatment regime adopted in 2004 (WHO, 2015: Kar *et al*., 2014). This devastating disease affects the country's economic productivity, resulting in an estimated monetary loss of approximately 132 billion Naira (~700 million USD), in treatment costs, prevention, and other indirect costs (WHO, 2012: FMH, 2012).

Malaria continues to be a major public health problem in 97 countries and territories in the tropics and subtropics. Globally, approximately 214 million cases of malaria occur annually and 3.2 billion people are at risk of infection (WHO, 2015). Approximately 438,000 deaths were attributed to malaria in 2015, particularly in sub-Saharan Africa, where an estimated 90% of all malaria deaths occur (WHO, 2015). As a critical target of the Millennium Development Goals, in 2005, the World Health Assembly established a goal of reducing malaria cases and deaths by 75% between 2005 and 2015 (WHO, 2016). Hence, over the past decade, there has been greatly renewed interest in research and innovations in diagnostic methods, drugs and vaccines, and the development of control measures to eradicate malaria (Korenromp *et al*., 2013). As a result, between 2000 and 2013, the incidence rates of malaria fell by 30% globally, and by 34 % in Africa (Murray *et al*., 2013).

Nigeria suffers the world's greatest malaria burden, with approximately 51 million cases and 207,000 deaths reported annually (approximately 30% of the total malaria burden in Africa), while 97% of the total population (approximately 173 million) is at risk of infection (WHO, 2014). Moreover, malaria accounts for 60% of outpatient visits to hospitals and leads to approximately 11% maternal mortality and 30% child mortality, especially among children less than 5 years (WHO, 2014: FMH, 2009).

Malaria remains a significant public health challenge in Nigeria, with an estimated 53 million cases and over 80,000 deaths reported annually (WHO, 2020). Children under the age of five are particularly vulnerable to severe malaria caused by *Plasmodium falciparum*, the deadliest species of malaria. Severe malaria can lead to life-threatening complications such as cerebral malaria, severe anaemia, and respiratory distress. The prevalence and risk factors associated with severe malaria among children in Nigeria vary across different regions of the country, and understanding these factors is crucial for developing effective malaria control strategies (Dawaki *et al*., 2016)

Moreover, malaria is endemic, and its burden is highest in the northern part of the country, where about 97% of the population is at risk of the disease (NMEP, 2013). The country accounts for about 25% of the global malaria burden and the disease remains a significant contributor to morbidity and mortality among children under the age of five (WHO, 2020). Despite significant progress made in malaria control efforts in Nigeria, severe malaria caused by *P. falciparum* remains a major public health challenge, particularly among children under the age of five (Dasgupta *et al.*, 2022)

Since 2008, the National Malaria Control Programme (NMCP) in Nigeria has adopted a specific plan, the goal of which is to reduce 50% of the malaria burden by 2013 by achieving at least 80% coverage of long-lasting impregnated mosquito nets (LLINs), together with other measures, such as 20% of houses in targeted areas receiving indoor residual spraying (IRS), and treatment with two doses of intermittent preventative therapy (IPT) for 100% of pregnant women who visit antenatal care clinics (Adigun *et al*., 2015: USAID, 2013: Ye *et al*., 2012).

Because of these measures, the percentage of households with at least one LLIN increased to over 70% by 2010, compared to only 5% in 2008 (Garley *et al*., 2013: Oyeyemi *et al*., 2010: WHO, 2010). Although previous studies have documented a high prevalence of malaria throughout Nigeria (Onyiri, 2015: Nmadu *et al*., 2015: Noland *et al*., 2014: Oche and Aminu, 2012: Gajida *et al*., 2010: Ibekwe *et al*., 2009), there remains a paucity of research on people's knowledge, attitudes, and practices (KAP) towards malaria in the majority of the federation, particularly in Northern Nigeria, including Kwara State. This information is imperative in order to identify and implement effective control measures, and plan for the participation of the targeted communities in the control, which is one of the cardinal tools for the success and sustainability of disease control programmes (Salam *et al*., 2014: Govere *et al*., 2000) The North Central region of Nigeria, including Kwara State, is endemic for malaria, and the prevalence and risk factors associated with severe malaria in this region are not well understood (Babamale and Ugbomoiko, 2016) According to the Nigeria Malaria Indicator Survey (NMIS) 2015, the prevalence of malaria among children under the age of five in Kwara State was 36.8%, which is higher than the national average of 27.5% (NPC, 2016). Severe malaria caused by *P. falciparum* is a major cause of morbidity and mortality in this population, with high rates of hospitalization and death reported (Choutos *et al*., 2023).

The burden of malaria in Nigeria is further complicated by the emergence of drug-resistant strains of *P. falciparum* especially the emergence of an artemisinin-resistant malarial strains **(**Sankineni *et al.*, 2023), this has made the treatment of severe malaria more challenging, and there is a need for alternative treatment options to be developed. In addition, the burden of malaria is compounded by poverty, poor health infrastructure, and inadequate resources for malaria control efforts. These factors contribute to the high morbidity and mortality rates associated with severe malaria in Nigeria (Uzochukwu *et al*., 2010) Understanding the prevalence and risk factors associated with severe malaria caused by *P. falciparum* among children in Nigeria is crucial for developing targeted interventions to reduce the burden of malaria in the region (Desai *et al*., 2007). Risk factors for severe malaria may include host factors such as age, nutritional status, and immune status, as well as environmental factors such as mosquito density and malaria transmission intensity (Mensah *et al*., 2021). Identifying these risk factors can help to target interventions to those who are most at risk and improve the overall effectiveness of malaria control efforts in Nigeria.

Nigeria accounts for about one-quarter of the global malaria burden, and the country's success in reducing the incidence of malaria will have a significant impact on the global effort to eliminate the disease (Nwanosike *et al.,* 2015).

The aim of this study is to investigate the current prevalence, Haematological profile and to evaluate the people's Knowledge attitude and practice (KAP) regarding malaria in Ilorin Kwara State, North Central Nigeria

MATERIALS AND METHODS

Study Area

Kwara State is located in the North Central region of Nigeria and is endemic to malaria (Kolawole *et al*., 2016). Despite efforts to control the disease, malaria remains a major public health problem in the state, with an estimated prevalence of 37% among children under five years old. Severe malaria caused by *P. falciparum* is a major cause of morbidity and mortality in this population, with high rates of hospitalization and death reported ((Dini *et al*., 2020; Kamau *et al*., 2020).

Therefore, the research was conducted in Ilorin, the capital city of Kwara State in Nigeria. Ilorin is a densely populated urban centre equipped with a range of facilities and amenities, encompassing healthcare institutions such as Hospitals. The study specifically centred on designated Hospitals within this city, among which Ajikobi Cottage Hospital served as the WHO sentinel Center for Malaria as shown in Fig.1

Study Design: An unmatched case-control study was conducted among children with uncomplicated severe malaria patients as cases and asymptomatic malaria controls in Ilorin, North-Central Nigeria.

Ethical Consideration: Ethical approval was sought from the Kwara State Ethical Research Review Committee, Ministry of Health, Ilorin. Additionally, oral and written informed consents were obtained from individual parents/guardians after providing a clear explanation of the study's objectives and potential benefits, along with obtaining their children's assent. Approval I.D is **ERC/MOH/2022/03/021**

Sample Size Calculation

The sample size was determined by the formula described by Sumari (2017)

$$N = \frac{Z^2 \times P(1-P)}{d^2}$$

Where, N = Minimum sample size

P = Prevalence of Malaria in Nigeria = 0.64 (64%) (Olarewaju *et al*., 2018)

d = Desired level of significance = 0.05 (5%),

Z = Confidence interval = 1.96 (95% confidence interval)

$$N = \frac{1.96^2 \times 0.64(1-0.64)}{0.05^2}$$

= 0.8416 x 0.2340/0.0025 = 354

For the study, a total of 354 children was needed

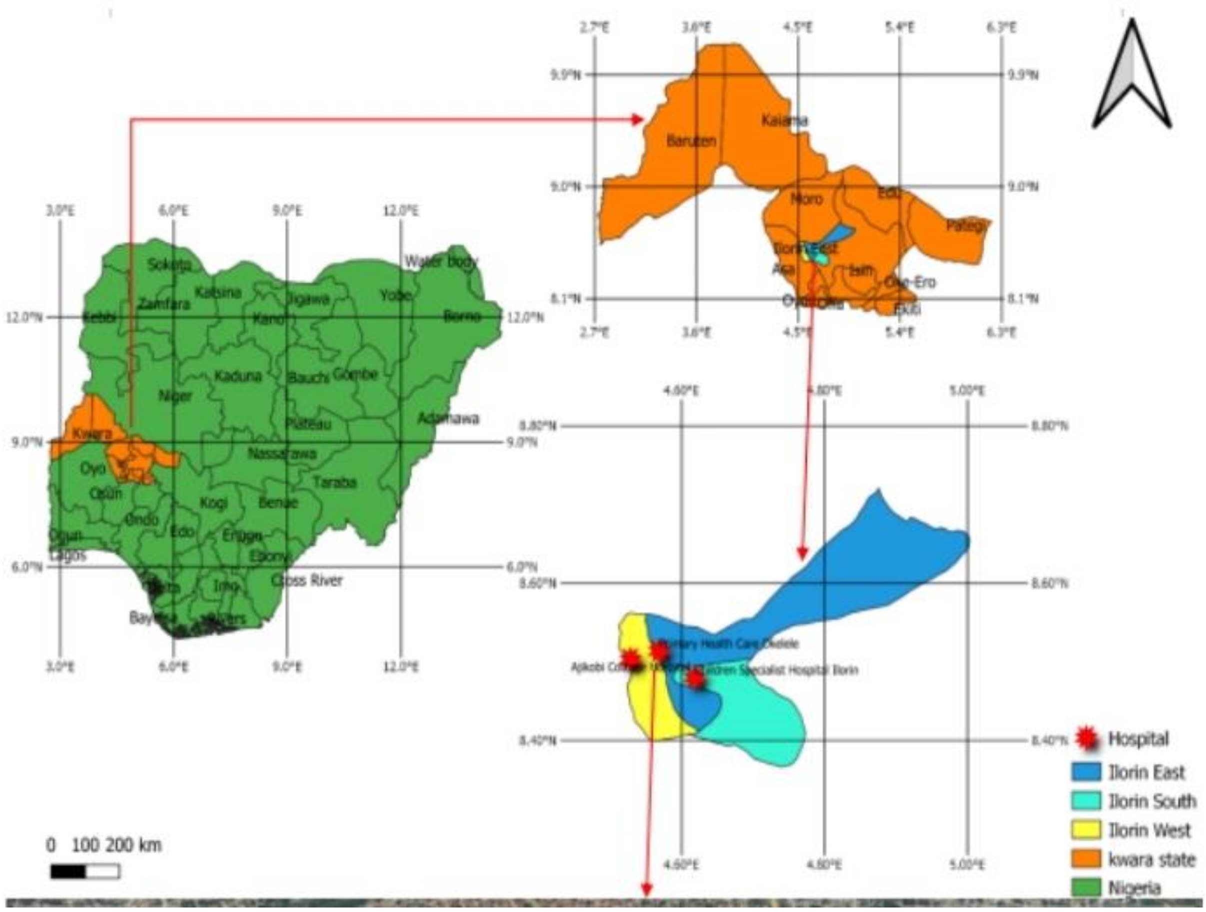

Fig. 1: Map of the study area

Study Population

A total of 354 children age range (1years-14years), Case group (uncomplicated and severe malaria) and Control group (asymptomatic malaria) 3ml of blood samples were collected from children from the study area.

Temperature Measurement

Axillary thermometer (Domotherm® Germany, 0.2˚C sensitivity). The tip of the thermometer was placed at the apex of the axilla and held in place with the upper limb adducted till a beep was heard. The displayed reading, in centigrade to one decimal place was taken as the child's temperature. Children 1-14 years of age and Children having axillary temperature ≥37.5ºC. with malaria infection were included in the study, while children below age 1year and above age 14 years was excluded from this study.

Sampling Technique: A systematic random sampling technique was used, recruiting every 3rd sample with a confirmed malaria status from children within the specified age range (1-14 years) for the study.

Data Collection Techniques:

A pre-tested questionnaire was administered to the participants in order to collect information on their demographic, socioeconomic, and environmental factors, and their health status, as well as their KAP towards malaria. Information was collected from the respondents via face-to-face interviews conducted by trained research assistants. Both assistants were aware of the purpose of the study and how to administer the questionnaire.

The survey gathered information offered both spontaneously and in response to specific questions that addressed their knowledge about malaria. Questions about knowledge were open-ended to avoid guessing about the answers to multiple-choice questions, which might give a false impression concerning the participants' knowledge. However, questions about practices were multiple-choice to assess the frequency with which participants performed the various activities and actions.

At the end of each interview, the interviewers probed for further knowledge related to malaria that the respondents did not mention spontaneously. However, this was done only for selected variables, specifically their source(s) of information about the disease, history, and reasons for previous visits to clinics or hospitals, as well as the availability, condition, and use of ITNs. During the survey, direct observations were made concerning the use of ITNs, as well as housing conditions and cleanliness (including the availability of functioning toilets, indoor plumbing, water containers, and cisterns), and the status of windows.

Laboratory Investigations:

Sample Collection / Transport and Processing: Approximately 3mls of blood samples were collected into EDTA bottles and transported to the laboratory for the determination of parasitemia. Moreover, 2–3 drops were collected on 3MM Whatman® filter paper (Whatman International Ltd., Maidstone, England) and kept in individually sealed plastic bags at room temperature until use.

Rapid Diagnostic Test (RDT): A drop of blood was utilized with an RDT kit to diagnose malaria parasites, following the method outlined by Endeshaw *et al*. (2008).

All the laboratory scientists who assisted in this study were blinded to the history and examination findings of the children. Three millilitres of blood were collected from each child and put in an ethylene diamine tetra acetic acid (EDTA) bottle, maintaining aseptic and universal safety precautions all through. A code number was assigned to each EDTA bottle. The blood collected was subjected to tests within 24 hours of collection. Two slides were prepared for each sample; each slide had a measured volume of 6µl for the thick film and 2 µl for the thin film.

Three per cent working Giemsa stain was prepared with a stock of Giemsa staining solution and working Giemsa buffer with pH of 7.2. The thin and thick blood films were stained for 45 to 60 mins with working Giemsa stain after fixing with absolute methanol. The entire film was screened at a low magnification (10X x 40X objective lens) to detect suitable fields with an even distribution of white blood cells (WHO, 2016). The film was then examined using X100 oil immersion. At least 100 high-power fields were examined before a thick film was said to be negative. Quantification was achieved by determining the parasite density (per µl of blood) as the number of parasites counted against 100 White blood (100) Cells x number of leucocytes (WBC) counted divided by 100.

Parasites/µL blood = Number of parasites counted x 8000 white cells/µL
No. of white cells counted

Parasite density class ≤ and > 5,000/µl were regarded as light and heavy parasitemia respectively. Thin films were examined to identify the parasite species. The blood film was said to be positive when a concordant result was produced by the two microscopists.

Statistical analysis

Data were double entered by two different researchers for accuracy and created a single dataset for analysis into spreadsheets of SPSS, v. 20 (IBM Corporation, NY, USA). The demographic, socioeconomic, environmental, and behavioural characteristics of the respondents, as well as the KAP variables, were treated as categorical variables and presented as frequencies and percentages. Pearson's Chi-squared test and Fisher's exact test were used to test the associations between malaria prevalence and KAP items as the dependent variables, with the demographic (age, gender, and family size) and socioeconomic factors (educational and employment status, household monthly income, living near water sources, presence of functioning toilet in the house, housing conditions, using ITNs and insecticide, history of infection, and presence of domestic animals in the households) as the explanatory variables. Odds ratios (OR) and 95 % confidence intervals (CI) were also computed for the explanatory variables. Moreover, participants were categorized into three age groups (<5, 6–10, and 11- 14 years) for analysis of the KAP variables. ORs at 95% CIs were also computed. Multivariable logistic regression was conducted to identify the risk factors associated significantly with infection. To retain all possible significant associations, all variables that showed an association with $p \leq 0.25$ were used in the multiple logistic regression model, as $p < 0.05$ was considered statistically significant.

RESULTS

Malaria Diagnosis by age group with Microscopy and RDT positive (+ve) cases of the respondent with the Gender

This study included 279 subjects who met the inclusion and exclusion criteria. A Giemsa's stained peripheral smear shows many Red cells infected with trophozoites, rings form and gametocytes of *P. falciparum* (Plate 1). The subjects were categorized into the following groups < 5 years, 5–10 years and > 10 years. The percentage distribution of males and females varies across different age groups, indicating the sex distribution among children with malaria cases. The male population percentages across the ages < 5 years, 5–10 years and > 10 years were 39.1%, 40.4%, and 33.9% respectively with a combined male percentage of 38.6%. The female population percentages across the three age groups of < 5 years, 5–10 years and > 10 years were 60.9%, 59.6%, and 66.1% respectively, with a combined female percentage of 61.6% as shown in Table 1

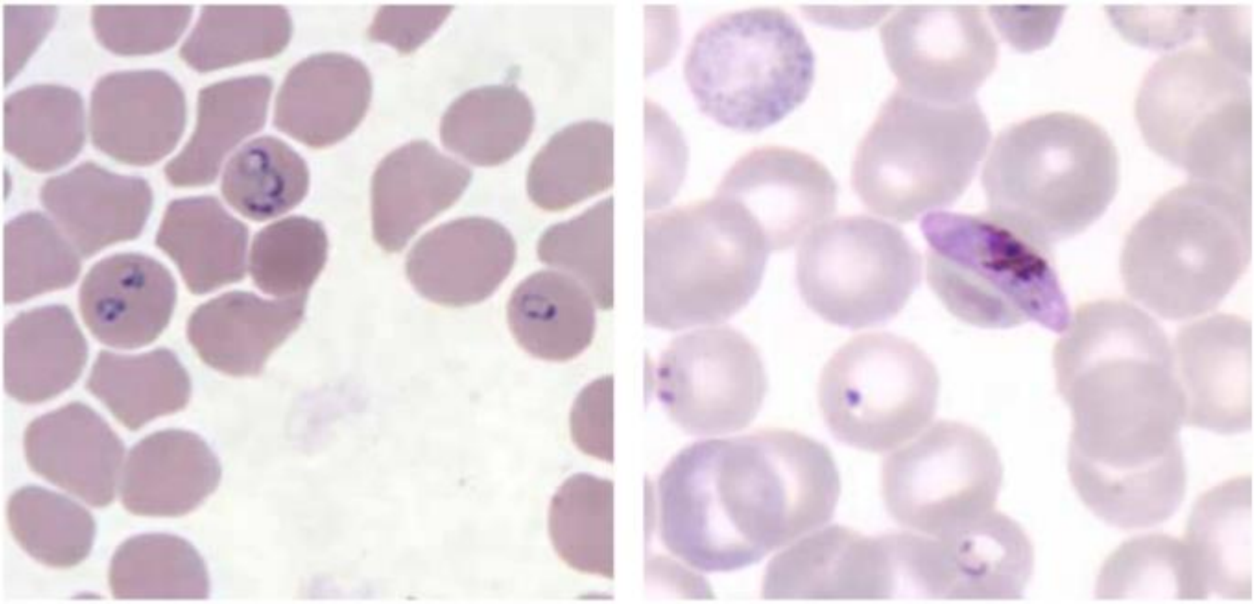

Plate 1: Rings forms and Gametocytes of *P.falciparum* in peripheral blood film(x1000)

When the positive and negative cases are combined, a total of 279 children are found to have participated in the study (180 positives + 99 negative). The ratio of malaria to non-malaria cases in children in Ilorin North Central is stated to be approximately 2:1. This indicates that for every two children who tested positive for malaria, approximately one child tested negative for malaria.

Table 1: Malaria Diagnosis by Age Group with Microscopy +ve cases of the respondent with the Gender

Sex	n=128 < 5 years	n=89 5–10 years	n=62 > 10 years	n=279	p-value
Male	50(39.1%)	36 (40.4 %)	21 (33.9%)	107 (38.6 %)	0.3201
Female	78(60.9%)	53 (59.6 %)	41 (66.1%)	172(61.6)	

Correlation Matrix: Relationships between Different Variables from malaria-infested patients.

The correlation matrix provides information about the relationships between different variables. Correlation generally means the degree of linear relationships or association between two or more random terms (variables). It ranges from -1 to +1, -1 means a strong negative relationship between the two variables, as it tends to move to zero the relationship gets weak, 0 means there is no relationship between the two variables, and +1 means a strong relationship between two variables.

Table 2, below shows a very weak linear relationship between parasite count and PCV (-0.029), also a very weak or no linear relationship between parasite count and WBC, and there is significant but not strong linear relationships between parasite count and temperature of the individual child as depicted in Table 2.

Table 2: Correlation Matrix: Relationships between Different Variables from malaria-infested patients.

	Parasite count	PCV	WBC	Temperature
Parasite count	1	-0.029	0.0094	0.33
PCV	-0.029	1	-0.056	0.025
WBC	0.0094	-0.056	1	0.1
Temperature	0.33	0.025	0.1	1

Correlation between Parasite Count, PCV, and Temperature in Children

Parasite count exhibits a correlation of -0.03 with PCV, indicating that an increase in parasite count corresponds to a decrease in PCV. In other words, children with higher parasite counts are likely to have lower PCV levels. Furthermore, parasite count shows a correlation of +0.33 with temperature, suggesting that higher parasite counts are associated with elevated temperatures. In summary, children with higher parasite counts are more likely to experience increased body temperature as shown in Fig.3

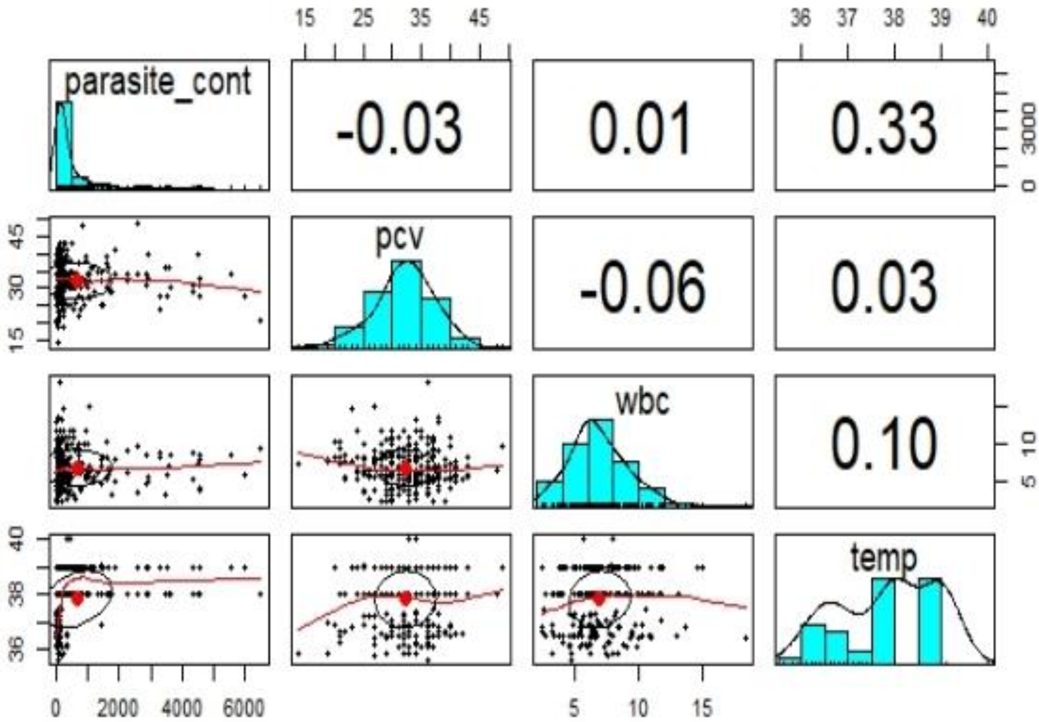

Figure 3: Correlation between Parasite Count, PCV, and Temperature in Children

Hypothesis Test Results for Prevalence of Malaria among Children in Ilorin North-Central, Nigeria.

The given results represent a hypothesis test conducted to determine the level of prevalence of malaria among children in Ilorin North-Central, Nigeria. The test is performed using a Chi-square test, and the results are presented in Table 3. Based on the results, the p-value was 1.258×10^{-11}, which is an extremely small value and much smaller than the significance level of 0.05. It indicates strong evidence against the null hypothesis. Therefore, there is enough data evidence to reject the null hypothesis, and the conclusion is that the level of prevalence of malaria among children in Ilorin North-Central is high.

Table 3: Hypothesis Test Results for Prevalence of Malaria among Children in Ilorin North-Central, Nigeria.

Chi-square	Df	P-value	Proportion +ve	Proportion -ve
45.878	1	1.258×10^{-11}	0.64516	0.35484

*df: degree of freedom

Principal Component Analysis of the Malaria Indicator Patterns

Fig 4, shows the PC1 and PC2 account for a total of 33.75% + 26.15% = 59.9% of the variance in the data. The remaining variance (100% - 59.9% = 40.1%) is captured by other principal components (not shown in the plot), but they contribute less to the overall variability in the data.

The 2D PCA plot of the malarial indicator dataset reveals that a child is considered positive for malaria when there is a high parasite count of over 500 in the body, a significantly reduced PCV level, and a relatively elevated body temperature. Additionally, the white blood cell count (WBC) tends to be closer to zero in such cases. Conversely, if these conditions are not met, the child is categorized as malaria-negative. The malaria variable was explained by PCA 1 and PCA 2, accounting for more than 59% of the total variance, which is deemed statistically acceptable.

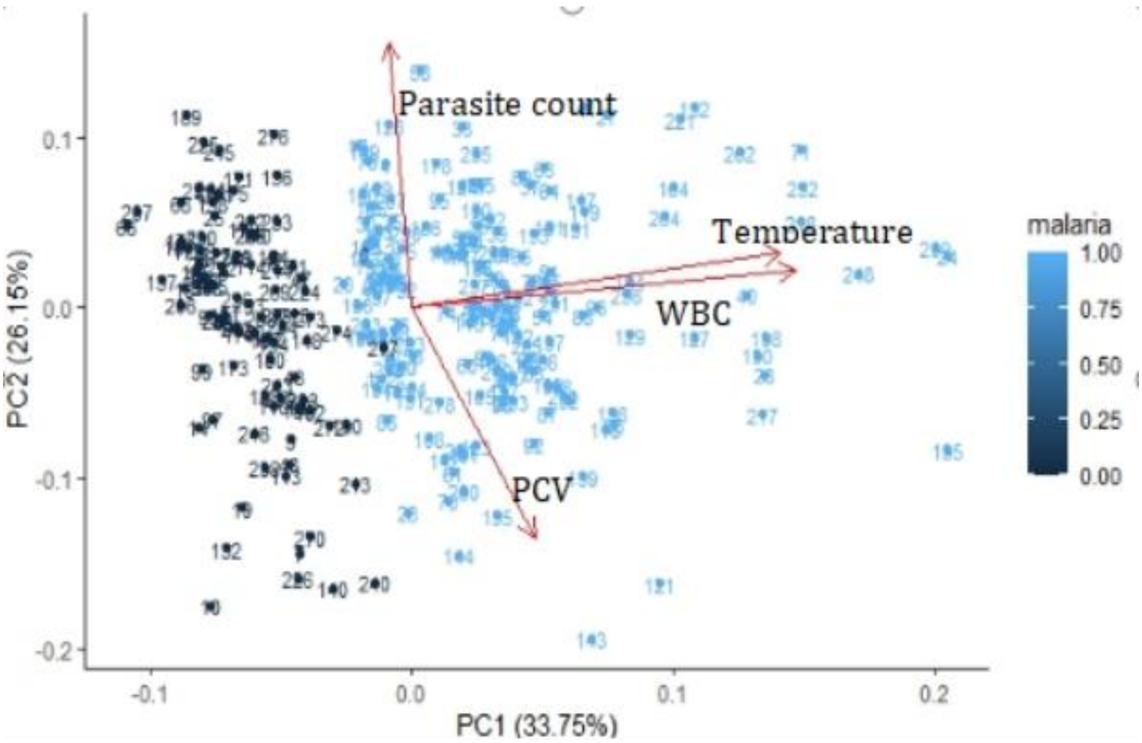

Fig 4: Principal Component Analysis of the Malaria Indicator Patterns

Effects of Malaria on some Haematological Parameters with Various Characteristics of Subjects in Ilorin.

Table 4, presents findings from this study involving 279 subjects, highlighting the distribution of various characteristics within the studied population, including gender. Of the total subjects, 159 (57%) were male and 120 (43%) were female. Notably, a majority of the subjects were male (57%), and the age group with the highest representation was children under five years of age (128, 45.9%).

Analysis of haemoglobin concentration (HGB) in malaria-infected children revealed a predominant range of 5.1–10 gr/dL, accounting for 135 cases (48.4%). Additionally, the highest proportion of detected leucocyte values in infected children fell within the range of 6000–11,000, encompassing 127 cases (45.5%). A substantial number of subjects, approximately 196 (70.3%), exhibited a platelet count of 100,000. Regarding anaemia, 217 subjects (77.8%) were found to be anaemic. The study investigated haematological profiles based on subjects' age groups. Among the diagnostic criteria, five predictors demonstrated significant associations, namely haemoglobin, haematocrit, leukocytes, platelets, and monocytes ($p < 0.05$). The study also identified specific medical conditions associated with these predictors, including Leucopenia (37 subjects, 13.3%), Monocytosis (93 subjects, 33.3%), Lymphocytopenia (215 subjects, 77.1%), and Thrombocytopenia (178 subjects, 63.8%).

Table 4: Effects of Malaria on some Haematological Parameters in Children in Ilorin Characteristics and Hematological Profile of Subjects with Malaria

Characteristic	n = 279	
Sex, n (%)	Male **159 (57)** Female **120 (43)**	
Age group (Years)		
> 10	62 (22.2)	
5–10	89 (31.9)	
< 5	128 (45.9)	
Haemoglobin, n (%)		
> 10 gr/dL	80 (28.7)	
5–10 gr/dL	135 (48.4)	
≤ 5 gr/dL	64 (22.9)	
Leukocytes, n (%)		
> 11,000	69 (24.7)	
6000–11,000	127 (45.5)	
< 6000	83 (29.7)	
Platelets, n (%)		
> 100.000	196 (70.3)	
≤ 100.000	83 (29.7)	
Anemia, n (%)		
Yes	217 (77.8)	
No	62 (22.2)	
Leucopenia, n (%)		Total Lymphocyte
Yes	37 (13.3)	Count < 3.0 × 10^9/L
No	242 (86.7	
Monocytosis, n (%)		White Blood Cells
Yes	93 (33.3)	(WBCs) < 4 ×10^3/μl
No	186 (66.7)	
Lymphocytopenia, n (%)		Monocyte
Yes	215 (77.1)	count > 3 × 10^3/μl
No	64 (22.9)	
Thrombocytopenia, n (%)		Platelet
Yes	178 (63.8)	count < 150 × 10^3/μl
No	85 (36.2)	

Knowledge, attitudes, and practices regarding malaria

Knowledge of the cause, transmission, symptoms, and prevention of malaria, as well as the perception of its seriousness, is presented in Table 5. Generally, the respondents were well informed about malaria; 279 (78.3 %) knew about malaria (excluding children less than 10 years; thus n=354). Knowledge about malaria was obtained primarily through personal/relatives' experiences (43.0%) or the media (35.1%). Approximately one-fifth of the respondents (7.2%) did not know the cause of malaria, but the majority (64.5%) attributed it to mosquitoes. Approximately three-quarters (33.0%) of the respondents mentioned fever and slightly less than half mentioned weakness (27.2%) as symptoms of malaria. Moreover, 69.2% of the respondents indicated that they avoided mosquitoes by using bed nets or insecticide, while only 3.5% replied that they did not know how to prevent malaria.

With respect to attitudes, most subjects (71.7%) regarded malaria as a serious infection. The distribution of ITNs was high in the study area, and 83.3% of the respondents had at least one ITN in their homes. However, only 72.3% of the 354 respondents used ITNs, and only one-third (52.8%) of the respondents used insecticide. With regard to treatment-seeking behaviour, a considerable number of the respondents (279, 67.2%) mentioned that they went to hospitals or clinics when they had an episode of fever, while 27.2 % of the respondents self-medicated as a first-line of treatment for fever; 5.0% of the respondents did not treat malaria infection.

Table 5; Knowledge, attitude and practices of respondents with regards to malaria infections in Ilorin, Kwara State, North-Central, Nigeria

Variables	**n(%)**
Knowledge (n=354)	
Known malaria	279(78.8)
Source of information(n=279)	
Media (TV, Radio, newspaper)	98(35.1)
Awareness campaign	41(14.7)
Through family and friends	120(43.0)
Don't know	20(7.2)
Causes of malaria (n=279)	
Mosquito bites	180(64.5)
Stagnant water	7(2.5)
Poor personal hygiene	5(1.8)
Don't know	87(31.2)
Signs and symptom of malaria (n=279)	
Fever	92(33.0)
Headache	37(4.3)
Weakness of the body	76(27.2)
Don't know	74(23.3)
Prevention of malaria(n=279)	
Using bed net/insecticide	193(69.2)
Improved personal hygiene	50(18.0)
Use of Medication	26(9.3)
Don't know	10(3,5)
Attitude toward malaria infection(n=279)	
Serious disease	200(71.6)
Not serious disease	63(22.6)
Don't know	16(5.7)
Practice(n=354)	
Having ITNs	295(83.3)
Using ITNs	256(72.3)
Using insecticides	187(52.8)
Living near stagnant water	297(33.9)
Living in a house with wood/zinc roof	289(83.3)

DISCUSSION

The prevalence of peripheral malaria infection in this study was 78.8%. This was higher when compared with findings from other studies on malaria in Nigeria, the study was not in agreement with other studies conducted in the South-Eastern part of Nigeria a prevalence rate of 23.3% by Nwaneli *et al*. (2020). The difference in this prevalence rate in malaria studies could be due to the seasonal variation as well as geographic location in Nigeria, where *P. falciparum* was the commonest species of the parasite in the infected. This is not unconnected to poor knowledge of malaria and its transmission, and this may be probably because they were more exposed to mosquito bites due to poor environmental conditions and lifestyles. Female children had the highest prevalence of 61.6% while male children had a low prevalence of 38.6.% which agrees with Johnson *et al*. (2020) affirming that the prevalence of malaria varies significantly across age groups and sexes. This study also emphasized the importance of gender-based analysis in research to uncover potential variations in disease susceptibility, progression, and treatment response and it is in agreement with the study of Gadi *et al*. (2020). The observed higher prevalence of malaria in females within this study could potentially be linked to these gender-related disparities, warranting further investigation into the underlying mechanisms.

P. falciparum was the only parasite species encountered in this study which is similar to reports from other studies among hospitalized children in Maiduguri (Ezeudu *et al*., 2015: Elechi *et al*., 2015: Umaru and Uyaiabasi, 2015). This supports the fact that *P. falciparum* is the most prevalent plasmodium species in Nigeria and is mostly responsible for childhood morbidity. Since this species of malaria parasite which is known to cause significant morbidity is highly prevalent in Nigeria, it is not surprising that malaria is still a significant cause of childhood mortality in Ilorin, Kwara State and perhaps in Nigeria. It was observed in this study that the majority of children had heavy parasitemia (parasite density ≥ 5,000/µl). This may be a result of the fact that the study was conducted during the rainy season which is a high transmission season and also because this study focused primarily on sick children. A similar report of heavy parasitemia in the rainy season and among symptomatic patients who present to health facilities has previously been reported by (Olasehinde *et al*., 2010: Ben-Edet *et al*., 2004). Parasite density ranged from as low as 494/µl to as high as 5,622,102/µl in this study, demonstrating the ability of *P. falciparum* to parasitize the RBCs at different stages of maturation resulting in hyper-parasitemia. This supports the report that parasite density at all levels can lead to clinical illness (WHO, 2009). It was found in this study that the age of a child was an independent predictor of a child's malaria status.

Haematological changes have been associated with malaria infection and these have been found to involve red blood cells, leukocytes, and thrombocytes (Maina *et al*., 2010). However, limited information on these changes is available in Ilorin, Kwara State. Nigeria. In this study, significantly lower values of PCV and haemoglobin concentration were observed in malaria-infected children compared to the controls, and these findings are in agreement with previous reports of George and Ewelike-Ezeani, (2011), Ogbodo *et al*., (2010) and Maina *et al*., (2010). This was consistent with reports from several sub-Saharan African countries which indicated that the prevalence of anaemia was consistently higher among children infected with malaria than those uninfected, also this study aligns with prior research that has identified alterations in hematocrit and red blood cell indices as indicators of malarial pathogenesis (Abdulhameed *et al*., 2021). Mid-cell (monocytes, eosinophils, and basophils) counts in this study showed no significant difference in malaria-infected children compared to the control subjects.

Thrombocytopaenia has been observed in malaria-infected children in this study, which is consistent with earlier reports (George and Ewelike-Ezeani, 2011: Maina *et al*., 2010). However, thrombocytopaenia in malaria infection has also been associated with sequestration and pooling of the platelets in the spleen, immune-mediated destruction of circulating platelets, and platelets mediating the clumping of *P. falciparum* infected erythrocytes, leading to pseudo-thrombocytopenia (George and Ewelike-Ezeani, 2011: Maina *et al*., 2010: Pain *et al*., 2001). There were no significant differences associated with the values of haematocrit, total white blood cell count, platelet count, granulocyte count, and lymphocyte count in relation to sex in both malaria-infected and control subjects. These findings are consistent with previous reports on haematological values that showed no significant gender variation (Dapper *et al*., 2009: El-Hazmi and Warsy, 2001).

With respect to respondents' KAP, the current study indicated that general awareness of malaria was high among various communities in Kwara State and almost all of them (95.6 %) had heard about malaria. This is expected, as malaria is considered the primary health problem in various communities (Kimbi *et al*., 2014: Adedotun *et al*., 2010: Isah *et al*., 2007). Most of the respondents in the present study were well knowledgeable about malaria symptoms, and 33.0% of them recognized fever as the sign and symptom of malaria. Moreover, these findings showed that the majority of the respondents had received information about malaria prevention, and using bed nets/insecticide, improving personal hygiene, and taking medication were the three main preventive measures they cited. This agrees with previous studies in other parts of Nigeria (Singh *et al*., 2014: Erhun *et al*., 2005), and other malaria-endemic countries (Kimbi *et al*., 2014: Al-Adhroey *et al*., 2010: Isah *et al*., 2007). Similarly, a previous study among rural farming communities in Oyo State, Southwestern Nigeria, reported that only 12.4% of respondents were aware of the role of mosquito bites in transmitting the disease and less than half (46.7%) were able to state at least one symptom of malaria(Oladepo *et al*., 2010). Recent studies from Southwest Nigeria also revealed that knowledge of malaria remains low among caregivers of children aged less than five, pregnant women and mothers(Adebayo *et al*., 2015: Bello and Rehal, 2014). The present study showed that the majority of the respondents (71.7%) indicated that malaria is a serious disease, which is consistent with previous studies in Nigeria and other countries (Singh *et al*., 2014: Adedotun *et al*., 2010: Isah *et al*., 2007). Moreover, this study showed that only a very few percentage (22.6%) believed that malaria is not harmful. They claimed, "Malaria is not so serious because everyone has it, and cannot be cured." Some said, "It sometimes causes fever, when one takes medication the fever goes away but the malaria does not, we are born with it." Others stated, "Malaria cannot be cured, it always goes and comes back," and "Malaria is in our blood, it is always there, just avoid going down with fever by avoiding stress and always eating good food." A few were indifferent, and believed that mosquito noise when asleep and bites are simply a nuisance; it is good if they can be avoided, but otherwise they have no consequences. However, the findings of the current study contradicted those of a recent study in Osun State, Southwest Nigeria, which demonstrated that the majority of the mothers believed that malaria is a simple disease for which they can comfortably apply home remedies (Bello and Rehal, 2014). Another hospital-based study about awareness of ITN use in Abeokuta State, Southwest Nigeria reported low awareness among the pregnant women interviewed (Runsewe-Abiodun *et al*., 2012). Notwithstanding the high prevalence of attitudes that the disease is serious, approximately 27.2% of the respondents tended to begin treatment at home and sought help from professionals only when it failed.

Home treatment usually involves self-medication or unqualified prescription by family members, friends, and unauthorized shops. This behaviour was not different with malaria fever, wherein people began treatment with analgesics and then anti-malarial drugs if symptoms persisted. The same behaviour has been reported elsewhere in Nigeria (Oladipo *et al*., 2015: Adedotun *et al*., 2010: Okeke and Okeibunor, 2010: Idowu *et al*., 2008), and from other parts of Africa (Deressa *et al*., 2003: Thera *et al*., 2000). Intriguingly, a previous study in Oyo state, Southwest Nigeria, showed that approximately 90% of suspected malaria cases were self-treated first at home with traditional herbs or drugs purchased from medicine stores (Adedotun *et al*., 2010). Moreover, a significant difference in treatment-seeking behaviour was reported between rural and urban mothers in Southeast Nigeria, in that two-thirds of urban mothers preferred private/government health facilities, while two-thirds of their rural counterparts preferred self-treatment with drugs bought over-the-counter from patent medicine vendors (Okeke and Okeibunor, 2010).

CONCLUSION

In Conclusion, our study comprehensively elucidates the intricate effects of malaria infection on a wide range of haematological parameters in pediatric patients. These findings contribute significantly to our understanding of the haematological consequences of malaria infection, offering potential avenues for enhanced diagnostic and management strategies. The changes in some haematological values in malaria-infected children in this study are associated with anaemia and thrombocytopenia, irrespective of sex. It is also evident that platelet count determination, among other tests, may be useful in monitoring the response of the patient to therapy, more so as the platelet count decreases when malaria parasite density increases. Moreover, the distribution of respondents across various age groups and genders plays a pivotal role in contextualizing our findings, providing valuable insights into potential demographic influences on haematological differences. The correlation matrix further enriches our understanding by revealing the intricate relationships between parasite count, haematological parameters, and temperature.

Recommendations

Based on the comprehensive investigation conducted in this study, we recommend the following actions and considerations to enhance clinical management and research on malaria infection and its impact on haematological parameters in pediatric patients:

1. The observed alterations in haematological parameters, such as PCV, haemoglobin levels, WBC count, and platelet count, highlight the importance of early diagnosis of malaria infection in pediatric patients.
2. Timely diagnosis allows for prompt initiation of appropriate treatment, potentially mitigating the risk of severe haematological complications.
3. Close monitoring of haematological parameters, especially in pediatric patients with confirmed malaria infection will be an added advantage regular assessment of PCV, haemoglobin levels, WBC count, and platelet count can aid in identifying early signs of anaemia, immunosuppression, and thrombocytopenia, which will enable targeted interventions and patient-specific management.
4. Administering appropriate therapies and monitoring the response to treatment are essential for preventing complications related to these conditions.

For future research, there is a need to access the genetic polymorphism CYP2B6 gene involved in the metabolism of the drug use in the treatment of malaria from our community, since it varies from different populations and ethnicity.

Acknowledgements. We thank all the patients from, Ajikobi Cottage Hospital, Children Specialist Hospital, Centre Igboro and Sobi Specialist Hospital all in Ilorin metropli for their willingness to participate in the study and all member of Medical Laboratory staff of Ajikobi Cottage Hospital for their support in collecting human blood samples. We also thank, Prof. Nuhu Abdulrazak, Dr Ajao, A.T, Dr Aborisade, W. T for their comments on the manuscript. This study was supported by a grant from Tertiary Education Trustfund (TETFUND) from Kwara State University, Directorate of Institutional Research unit.

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