# MALARIA PREVALENCE AND HAEMATOLOGICAL STATUS OF INDIVIDUALS INLAFIAGYIBADEGI COMMUNITY, KATCHA LOCAL GOVERNMENT AREA, NIGER, NIGERIA

**FUNMILOLA SHERIFAT ADEFOLALU[1,2], BERNARD, USMAN LANKO[1], IFEANYI FAMOUS OSSAMULU[1,2], MAUREEN NNWAMAKA ODU[1] AND MARY UCHENNA OGUNSANYA[1]**

[1]Department of Biochemistry Federal University Technology, Minna, Nigeria
[2]African Centre of Excellence for Mycotoxin and Food safety, Federal University Technology, Minna, Nigeria
Tel: +2348034512717 Email: funadefolalu@futminna.edu.ng

## ABSTRACT

Malaria transmitted by *Plasmodium* infected female *Anopheles* mosquito is a severe public health challenge that causes significant morbidity and mortality worldwide, particularly in sub-Saharan Africa. A survey of malaria and hematological status of individuals in Lafiagyi Badegi community, Katcha Local Government area of Niger state North Central Nigeria was conducted in January, 2023. Questionnaires were administered to a total population of 60 individuals of varying ages and weights. The blood samples of the subjects was collected into Ethylenediamine Tetraacetic Acid (EDTA) bottles for malaria rapid diagnostic test, haematocrit and haemoglobin assays. The results showed 29.9 % of the total population tested positive for malaria. The prevalence of malaria (16.67 %) was higher in the male population than in female while on the basis of age,10-17 years showed higher malaria prevalence (10 %). Malaria-positive individuals had significantly ($p<0.05$) lower levels of haemoglobin but higher levels of packed cell volume compared to malaria-negative individuals. There were fluctuations in bodyweight for age groups and malaria status, mean weight for age group 10-17 years positive for malaria was 28.4 kg while for malaria negative was 25 kg. Also 51.8 kg and 57.85 kg for age group 18-25 years positive and negative to malaria respectively. The battle to eradicate malaria is yet to be won therefore, regular malaria prevalence surveys are to be carried out and malaria and mosquito control strategies should be improved upon and sustained to further reduce malaria prevalence.

**Keywords**: Malaria, Haematocrit, Haemoglobin, Age, Weight

## Introduction

Malaria is an acute febrile illness caused by *Plasmodium* (*P*) parasites, which are spread to people through the bites of infected female Anopheles mosquitoes. There are five parasite species that cause malaria in humans, and two of these species; *P. falciparum* and *P. vivax* pose the greatest threat (Escalante *et al.,* 2022). *P. falciparum* is the deadliest malaria parasite and the most prevalent on the African continent while *P. vivax* is the dominant malaria parasite in most countries outside of sub-Saharan Africa (WHO, 2022).Early symptoms are characterized by fever, headache and chills which usually appear 10–15 days after the infective mosquito bite. It may be mild and difficult

to recognize as malaria and if left untreated, *P. falciparum* malaria can progress to severe illness and death within a period of 24 hours (Del Prado *et al.,* 2014; WHO, 2022).

In 2021, nearly half of the world's population was at risk of malaria (The Guardian Newspaper, 2022). Some population groups' infants, children under 5 years of age, pregnant women and patients with HIV/AIDS, as well as people with low immunity are considered to be at higher risk of contracting malaria and developing severe diseases (WHO, 2023). According to the latest World malaria report, there were 247 million cases of malaria in 2021 compared to 245 million cases in 2020. The estimated number of malaria deaths stood at 619 000 in 2021 compared to 625 000 in 2020 (WHO, 2022; Buki, 2023). Over the two peak years of the pandemic (2020–2021), COVID-related disruptions led to about 13 million more malaria cases and 63, 000 more malaria deaths globally (WHO, 2023). The WHO African Region continues to carry a disproportionately high share of the global malaria burden. In 2021 the Region was home to about 95 % of all malaria cases and 96 % of deaths. Children under 5 years of age accounted for about 80 % of all malaria deaths in the Region. Four African countries accounted for just over half of all malaria deaths worldwide: Nigeria (31.3 %), the Democratic Republic of the Congo (12.6 %), United Republic of Tanzania (4.1 %) and Niger (3.9 %) (Angupale*et al.,* 2023).

Malaria is transmitted throughout Nigeria, with 97 % of the population at risk of malaria. The duration of the transmission season ranges from year-round transmission in the South to three months or less in the North. Nigeria had the highest number of global malaria cases (27 % of global malaria cases) and the highest number of deaths (32 % of global malaria deaths) in 2020 (Daily Post, 2023). The country accounted for an estimated 55.2 % of malaria cases in West Africa in 2020 (WHO,2021). The primary vector across most of the country is *Anopheles (An.) gambiae s.s.*, accounting for 67.1 % of all the *An. gambiae s.s*. collected, with *An. funestus* as a secondary vector in some areas of Nigeria (Kahamba *et al.,*2022).

There are significant regional, rural-urban, and socioeconomic differences in the prevalence malaria whichrange from 16 % in the South-South and South East Zones to 34 % in the North West Zone. Malaria is a public health problem in Niger state according to report by the National Malaria Elimination Program (NMEP, 2020) Niger State has a high burden of malaria with a prevalence rate of 27.3 % among children under 5 and 34.6 % among pregnant women (NMEP, 2020). Malaria was found to be a leading cause of admissions in hospitals and death among children under five in Niger state (Okafor *et al.*, 2017; Oresanya*et al.,* 2019). A study by Ahmed *et al*. in 2019 reported that the prevalence of malaria in Niger state was significantly associated with factors such as age, gender, educational level and occupation of the head of the household (Ahmed *et al*, 2019).

In terms of Malaria control efforts, the NMEP has implemented various interventions in Niger state such as distribution of Insecticide-Treated Nets (ITNs), indoor residual spray (IRS), and provision of artemisinin-based combination therapy (ACT) for treatment (Monroe, 2020). However, challenges such as inadequate funding, poor health infrastructure, and resistance to anti-malarial drugs and insecticides continue to hinder the control and elimination of malaria in the state (NMEP, 2020).

The study of Omarine Nlinwe and Nange (2020) assessed some hematological changes and their diagnostic values in malaria infected patients North West Region of Cameroun found out that hemoglobin levels, white blood cell counts, and platelet counts were significantly reduced among the malaria positive individuals. A cross-sectional study on the impact of malaria on haematological parameters of urban, peri-urban and rural residents in the Ashanti region of Ghana was studied (Mutala et al., 2019). The authors identified, haemoglobin level and plateletcrit as being significantly inversely associated with malaria positivity.Eledo and Izah, (2018) investigated the haematological status of malaria parasite infected patients attending outpatient clinic at Federal Medical Centre Yenagoa,Bayelsa state, Nigeria. They reported a significant reduction in neutrophil, lymphocytes, monocytes, haemoglobin and packed cell volume, and increase in erythrocyte sedimentation rate and white blood cell counts among patients when compared with the control subjects suggesting the possible risk of anaemia in patients. Unlike other studies, the present study seeks to evaluate the prevalence of malaria and haematological status on the basis of certain demographic parameters among different groups of individuals in LafiagyiBadegi Community, Katcha Local Government Area, Niger, Nigeria

## Material and Methods

### Study Area

This study was carried out in Niger state. Niger is a state in the North Central region of Nigeria and largest state by land mass in the country with an area of 76,363 sq km (26,484 sq mi). The State has Twenty-FiveLocal Government Areas with a population of about 6,783,300 people (population estimation of 2022). Study area selected was a rural village called LafiagyiBaddeggi in Katcha Local government. A local government area with a population of about 207,400. It is located at Latitude 9°09'N and Longitude 6°14'E. The major inhabitants of the region are mostly Nupe and Gbagyi, who are primarily farmers.

### Study Population and Sample

The study population consisted of a pool of men, women and children, ranging from ages 5 – 57 years. A total of 60 volunteers were used for this survey comprising 20 children, 20 women and 20 men.

### Survey Technique

A group of people (60) from different households who consented to take part in this survey were selected at random and a series of questionnaires were administered pertaining to their health conditions and medical history in the month of January, 2023. The age, sex, weight and temperature were also recorded.

### Collection of Blood Samples

Two (2) ml of blood were obtained from each subject by vein puncture technique. A soft rubber tubing tourniquet was fastened to the upper arm of the subject to enable the index finger feel for the appropriate vein. The puncture site was then sterilized by applying Denatured alcohol (methylated spirit) and vein puncture was made with a 2ml syringe. The blood was transferred into an ethylenediamine tetra-acetic disodium acid (EDTA) vacutainers to avoid clotting and ensure preservation of the samples (Elmo, 2014).

### Malaria Rapid Diagnostic Test (RDT)

A drop of blood was placed in a square hole of the sample well using a dipstick. Two (2) drops of buffer solution was added to the developer well. The reading was taken after 20 minutes based on manufacturers instruction.

### Haematocrit (Packed Cell Volume) Test

Two milliliters (2ml) of blood was collected and mixed gently in an EDTA anticoagulant bottle. The blood sample was inverted gently sixtimes and thoroughly mixed to re-suspend the red blood cells. A micro haematocrit tube was used to collect the blood sample. Capillary tube was dipped and slightly slanted into the collected blood sample and fill to 2/3. The capillary tube was then sealed with plasticineand placed in a micro haematocrit centrifuge and spun for four (4) minutes at 9,000 rpm.Using Hawksley's micro haematocrit reader, the haematocrit was determined (Ajwad, 2021).

### Heamoglobin (Hb) Count

Haemoglobin was analyzed based on the cyanide-free sodium lauryl sulphate (SLS) haemoglobin determination method using Sysmex KX 4000i haematology analyzer (Sysmex Corporation, Kobe, Japan).

### Data Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 25. The obtained data were subjected to descriptive statistics using percentages and averages as well as Analysis of variance (ANOVA) where the values are represented as the Mean±SD (standard deviation). The Duncan's Multiple Range Test was used to deduce which mean values were significantly different at $p<0.05$ among the group means.

## Results

The percentage malaria infections amongst sampled individuals in relation to demographic characteristics (sex and age group) are presented in Tables 1 and 2. The results showed that 29.9 % of the total sampled populations were positive for malaria, while 70.1 % were negative. The male had the highest malaria prevalence of 16.67 % while the prevalence in female was 7.99 %. Young males within the age group of 5-17 years (11.67 %) were most prone to malaria infection while, young females were the least prone group (3.33 %) to malaria infection in Lafiagyi Badegi Community (Table 1). Age groups 10-17 years had the highest prevalence of malaria (12.9 %) followed by 18-25 years (10.3 %) and the least prevalence in >40 years, where no malaria infection was detected (Table 2).

**Table 1: Percentage Malaria Infection according to Gender of Individuals in LafiagyiBadegi Community of Niger State**

| Variables | Number of samples (n= 60) | Percentage population (%) | Mean age ± SD (years) | Number positive (%) | Number of Negative (%) | Prevalence (%) |
|---|---|---|---|---|---|---|
| Male | 31 | 51.66 | 24.90±13.26 | 10 (16.66) | 21 (35) | 16.67 |
| YM | 11 | 18.33 | 10.73±2.37 | 7 (11.66) | 4 (6.67) | 11.66 |
| OM | 20 | 33.33 | 31.75±11.13 | 3 (5) | 17 (28.33) | 5 |
| Female | 29 | 48.33 | 24.07±12.69 | 8 (13.33) | 21 (35) | 7.99 |
| YF | 9 | 15 | 9.88±2.47 | 2 (3.33) | 7 (11.66) | 3.33 |
| OF | 20 | 33.33 | 29.6±11.38 | 6 (10) | 14 (23.33) | 10 |
| Total | 60 | 100 | 23.9±13.33 | 18 (29.9) | 42 (70.1) | 29.9 |

YM= Young Male, OM= Older Male, YF= Young Female, OF= Older Female

**Table 2: Percentage of Malaria Infection according to Age of Sampled Individuals Blood in Lafiagyi Badegi Community of Niger State**

| Age (years) | Male (%) (n=31) | Female (%) (n=29) | Positive Male (%) | Positive Female (%) | Negative Male (%) | Negative Female (%) |
|---|---|---|---|---|---|---|
| ≤9 | 4 (12.9) | 4 (13.8) | 3 (9.7) | * | 1 (3.2) | 4 (13.8) |
| 10-17 | 7 (22.6) | 5 (17.2) | 4 (12.9) | 2 (6.9) | 3 (9.7) | 3 (10.3) |
| 18-25 | 6 (19.4) | 10 (34.5) | 2 (6.5) | 3 (10.3) | 4 (12.9) | 8 (25.8) |
| 26-40 | 8 (25.8) | 5 (17.2) | 1 (3.2) | 1 (3.5) | 7 (22.6) | 4 (13.8) |
| >40 | 6 (19.4) | 3 (10.3) | * | * | * | * |

*No malaria detected

Table 3, shows the haematological parameters (PCV and haemoglobin) of positive and negative individuals for malaria (men, women and children) accessed in Lafiagyi Badegi community. It was observed that the mean PCV and haemoglobin was higher in men (39.55 % and 13.18 g/dl respectively) than in other groups. The PCV and Hb of women and children were not significantly ($p > 0.05$) different. In Table 4, the PCV and haemoglobin count in positive subjects were not significantly ($p > 0.05$) different from each other. However, the haemoglobin count and PCV were within the standard values in all the groups.

**Table 3: Mean Hematological Parameters of Sampled Individuals Blood for Malaria in Lafiagyi Badegi Community in Niger State**

| Groups | Mean PCV (%) | Mean HB (g/dl) | *Standard PCV Range (%) | *Standard HB range (g/dl) |
|---|---|---|---|---|
| All Individuals | 36.50 ± 5.89a | 12.17 ± 1.97ab | 23-57 | 10-18 |
| Men | 39.55 ± 3.75b | 13.18 ± 1.25b | 38-52 | 13.5-17.5 |
| Women | 35.10 ± 4.06a | 11.76 ± 1.36a | 34-48 | 12-15.5 |
| Children | 34.85 ± 7.91a | 11.62 ± 2.64a | 23-48 | 10-15 |

*Standard Value Virgil and Ayalew (2000).

**Table 4: Mean Haematological Parameters of individuals Blood Sampled for Malaria in Lafiagyi Badegi Community in Niger State**

| Malaria Status (Number) | HB (g/dl) | PCV (%) | Number (%) | *Standard HB (g/dl) | *Standard PCV (%) |
|---|---|---|---|---|---|
| Positive (18) | 12.11±1.88[a] | 36.57±5.65[a] | 18 (29.9) | 9.8 | 29.4 |
| Negative (42) | 12.19±2.02[a] | 36.33±6.07[a] | 42 (70.1) | 12-13 | 36-41 |
| Total (60) | 12.16±1.97[a] | 36.50±5.89[a] | 60 (100) | 12-13 | 36-41 |

*Standard obtained from Inam *et al*. (2018) and WHO (2020)

**Table 5: Mean Weight of Individuals Blood Sampled for Malaria in Lafiagyi Badegi Community in Niger State**

| Weight (kg) | Mean weight (kg) | Number of sample (%) | Positive Number (%) | Mean weight in Positive (kg) | Mean weight in Negative (kg) | Prevalence (%) |
|---|---|---|---|---|---|---|
| 18-25 | 22 | 13 (21.67) | 5 (38.46) | 23.3 | 21.9 | 8.33 |
| 26-35 | 30.07 | 7 (11.67) | 4 (57.14) | 30.87 | 29 | 6.67 |
| 36-55 | 49.9 | 13 (21.67) | 5 (38.46) | 48.8 | 50.6 | 8.33 |
| 56-65 | 62.3 | 13 (21.67) | - | - | 62.3 | - |
| 66-82 | 71.14 | 14 (23.33) | 4 (28.57) | 73 | 70.4 | 6.67 |

Table 5 depicts the prevalence of malaria according to weight distribution of the sampled subjects. A prevalence of 8.33 % was observed in weight range of 18-25 kg and 36 – 55 kg. Subjects within the weight range of 56 - 65 kg did not test positive for malaria. Table 6 showed the prevalence of malaria on the basis of temperature. Malaria was more prevalent at temperatures ≤ 36.6 ºC (23.33 %) than at temperatures ≥ 36.7 ºC (6.67 %).

**Table 6: Mean Temperature of Individuals Sampled for Malaria in Lafiagyi Badegi Community in Niger State**

| Temperature (ºC) | Mean Temp. (ºC) | Number of sample (%) | Positive Number (%) | Mean Temp. in Positive (ºC) | Mean Temp. in Negative (ºC) | Prevalence (%) |
|---|---|---|---|---|---|---|
| ≤36.6 | 36.5 | 40 (66.67) | 14 (35) | 36.5 | 36.5 | 23.33 |
| ≥36.7 | 36.8 | 20 (33.33) | 4 (20) | 36.8 | 36.8 | 6.67 |

## Discussion

The prevalence of malaria parasites in this study was higher than that of a reported by Racheal *et al*.(2020) who recorded a prevalence of 23 % in Minna, Niger State among blood obtained from blood donors at General Hospital Minna. Similarly, Hannah *et al.* (2011) recorded a prevalence rate of 27.3 % among blood donors at the University of Ilorin Teaching Hospital. Agboola*et al*. (2019) also recorded a prevalence of 28 % among the blood donors at the University Teaching Hospital, Lagos. The higher prevalence could be attributed to several factors such as lack of awareness and education on malaria, absence of proper health care systems in the rural community of LafiagyiBadegi in Niger State. Despite the Study being carried out in the month of January when the transmission of malaria is relatively low in this part of the country due to the climatic condition, the prevalence of malaria is considered to be higher than other studies carried out in urban regions (University hospitals) in the South.

The high malaria prevalence observed in Males in the present study corresponds with the report of Afolabi *et al*. (2020) who found out in a study conducted in Nigeria that the incidence of malaria was higher in men compared to women. This may be attributed to the fact that men are more involved in outdoor activities and being also in the North children and women wear clothes that cover their entire body preventing and reducing the frequency of exposure to mosquito bites. Men also tend to sacrifice their meager income in the rural areas to cater for the children and women thus they may not adhere to treatment as such are less likely to use malaria preventative measures. Similarly, the case may be for younger males who in this study were more prevalent than younger females. Younger females in contrast to male may be more yielded to parent instruction and care. From observation, the community being primarily into agriculture sees a large number of the males (10-40 years of age) usually tends their farm lands which leave them at risk and more exposed to malaria. *Human stress sometimes induces falciparum recrudescence* of an otherwise asymptomatic infection (Shanks, 2015). The high prevalence of malaria observed in older women could be due to the fact that women within child bearing ages may have reduced immunity to malaria due to immunosuppressive effects of pregnancy (Brabin, 1983; Azeez and Akinbo, 2022). The study further showed that amongst age groups 10-17 years was the most prevalent (10

%) and age group ≤9 years being the least prevalent (5 %). However, none of the participants above the age of 40 years were positive.

The higher values of mean packed cell volume and haemoglobin count in men compared to women and children, may be due to several physiological differences such as hormonal, genetic and environmental factors. Men produce testosterone which stimulates the production of erythropoietin, a hormone which increases red blood cell production (Spivak, 2012). The author also revealed that men have higher red blood cell count than women and children because of difference in size of RBCs. As such men require more oxygen to fuel larger bodies and therefore produce more RBCs to meet the demand (Spivak, 2012).

Thehigh PCV count in positive individuals than negative individuals as observed in the present study, may due to the fact that in malaria infected individuals, have an increased destruction of red blood cells by the parasite. This leads to a decrease in total number of red blood cells in circulation. However, the remaining red blood cells become denser and more compact leading to an increase in PCV as observed in a study by George *et al*. (2013) which showed that individuals positive to malaria had higher PCV levels compared to negative individuals.

It is generally believed that patients with malaria would lose weight than those who are not, however, the effect of malaria on the weight of individuals in this present study contradicts this except for subjects 26-55 kg who had a decrease in mean weight. The reduction in mean weight may be due to the loss of appetite, due to fever leading to loss in body mass. The higher prevalence of malaria noticed at temperatures ≤36.6 ºC seems to be in contrast with what is known of malaria being a febrile illness. It is expected that higher prevalence would be observed at temperature greater or equal to 36.6 ºC for individuals in Lafiagyi Badegi community in Niger state. Fisher, (2021) explained that during defervescence (when the central thermostat begins to reset) stage of malaria, patients would experience drenching sweats, which rapidly reduce the body temperature. It may be that most of the sampled patients were tested during this stage as such at ≤ 36.6 ºC, malaria was observed in them causing a higher prevalence.

## Conclusion

Malaria prevalence of individuals in Lafiagyi Badegi community area in Niger State was 29.9 %, which is on the high side. Males were more prone to malaria in this survey study (16.6 %). In addition younger males of ages 10-17 years showed higher malaria prevalence of 12.9 %. Higher values of Packed Cell Volume and haemoglobin count (39.55 % and 13.18 g/dl respectively) occurred also in male. There was an inconsistent variation in weight and temperature of the individuals that were positive to malaria and those that were negative. Therefore, regular monitoring of malaria and haemotological status of individuals in malaria endemic areas is a necessity for a sustainable health and well-being of the individuals in the community.

## Acknowledgements

We sincerely thank all the individuals of Lafiagyi Badegi community in Niger State, Nigeriathat volunteered to be part of this study.

## References

Afolabi, B. M., Sofola, O. T., Fatunmbi, B. S., Komakech, W., Okoh, F., Saliu, O. B., &Fawole O. I. (2020). Knowledge and use of insecticide-treated bed nets among pregnant women attending antenatal clinic in primary health care centers in Kwara State, North Central Nigeria. *BMC Public Health*, 201(1), 1-10.

Agboola, P. M., Peter, E., Alexander, P., Koggie, A. Z., Maikenti, J. I. (2019). The prevalence of malaria among blood donors in Lagos University Teaching Hospital Lagos Nigeria. *Journal Health Science*, 5, 47-51.

Ahmed, M. A., Jibril, I. A., Ibrahim, M. T. O, & Bako I. A. (2019). Prevalence of malaria and its Association with socio-demographic factors among children under 5 years in Niger state, Nigeria. *Annals of Nigerian Medicine*, 13(1), 23-28. https://doi.org/10.4103/anm.anm_31_18.

Ajwad A. A. (2021). Determination of Packed Cell Volume*. University of Diyala. p. 10* http://medicine.uodiyala.edu.iq/uploads/AMA%20Files/Lectures/2/Physiology/Dr.%20Asmaa%20Abbass/Course%201/PCV.pdf

Angupale, J. R., Tusiimire, J., &Ngwuluka, N. C. (2023). A review of efficacy and safety of Ugandan anti-malarial plants with application of RITAM score. *Malaria Journal*, *22*(1), 1-19.

Azeez, M. M., &Akinbo, F. O. (2022). "Asymptomatic" plasmodium falciparum parasitemia and micronutrient deficiencies among pregnant women in Oyo State. *Biomedical and Biotechnology Research Journal (BBRJ)*, *6*(2), 185.

Brabin B. J. (1983). An analysis of malaria in pregnancy in Africa. *Bull World Health Organ*, 61(6),1005-1016.

Burki, T. (2023). A new Director for the Global Malaria Programme. *The Lancet Infectious Diseases*, *23*(5), 536-537.

Daily Post Nigeria (2023). Malaria a major cause of morbidity, mortality in Nigeria – PECAN by SeunOpejobi. Accessed from https://dailypost.ng/2023/04/25/malaria-a-major-cause-of-morbidity-mortality-in-nigeria-pecan/ on the 23rd April, 2023

Del Prado, G. R. L., García, C. H., Cea, L. M., Espinilla, V. F., Moreno, M. F. M., Márquez, A. D., ... & García, I. A. (2014). Malaria in developing countries. *The Journal of Infection in Developing Countries*, *8*(01), 001-004.

Eledo, B. O., &Izah, S. C. (2018). Studies on some haematological parameters among malaria infected patients attending a tertiary hospital in Nigeria. *Open Access Blood Research & Transfusion Journal*, *2*(3), 48-52.

Escalante, A. A., Cepeda, A. S., & Pacheco, M. A. (2022). Why *Plasmodium vivax* and *Plasmodium falciparum* are so different? A tale of two clades and their species diversities. *Malaria Journal*, *21*(1), 1-19.

Fisher, J. F. (2021). The clinical signs and symptoms of malaria. Accessed from https://www.medmastery.com/guides/malaria-clinical-guide/clinical-signs-and-symptoms-malaria

George, S., Abiodun, G., Yakubu, O., & Abdulrahman, Y. (2013). The effect of malaria on packed cell volume (PCV) of patients in Ilorin, Nigeria. *Annals of African medicine*. 12 (2): 95-99.

Hannah, R. S., Olofin, E. A., Nabegu, A. B., &Dambazau, A. M. (2011). The prevalence of malaria among blood donors in University of Ilorin Teaching Hospital Kwara Nigeria. *Journal of Health Science*, 2, 76-83.

Inam U, Muhammed U. A, Saeed A, Ahmed R, Zeeshan S, & Sana H. (2018) Hematological profile of patients having malaria-positive Peripheral Blood smears: A Cross Sectional Study at a Diagnostic Research Center in Khyber Pakhtunkwa, Pakistan. *Cureus*. 10(9): e3376. Doi: 10.7759/cureus.3376.

Kahamba, N. F., Finda, M., Ngowo, H. S., Msugupakulya, B. J., Baldini, F., Koekemoer, L. L., ... & Okumu, F. O. (2022). Using ecological observations to improve malaria control in areas where *Anopheles funestus* is the dominant vector. *Malaria Journal*, *21*(1), 1-15.

Monroe, A. (2020). Closing the Malaria Prevention Gap: Measuring and Characterizing Human Behavioral Drivers of Persistent Malaria Transmission in Sub-Saharan Africa (Doctoral dissertation, University_of_Basel).

Mutala, A. H., Badu, K., Owusu, C., Agordzo, S. K., Tweneboah, A., Abbas, D. A., & Addo, M. G. (2019). Impact of malaria on haematological parameters of urban, peri-urban and rural residents in the Ashanti region of Ghana: a cross-sectional study. *AAS Open Research*, *2*, 27. doi: 10.12688/aasopenres.12979.3

National Malaria Elimination Program (NMEP) (2020). Nigeria Malaria Indicator Survey 2020: Key Indicators. Abuja Nigeria: Federal Ministry of Health.

*Okafor C. I, Nweke N. O, Okeke O. C, & Anyanwu O. G. (2017). Malaria morbidity and mortality among under-five children in Niger state, Nigeria. Annals of African Medicine. 16(4), 166-171. https://doi.org/10.4103/aam.aam_43_17*

OmarineNlinwe, N., &Nange, T. B. (2020). Assessment of hematological parameters in malaria, among adult patients attending the Bamenda Regional Hospital. *Anemia*, *2020*, 1-8.

Oresanya, O., Counihan, H., Nndaliman, I., Alegbeleye, A., Jiya, J., Adesoro, O., ... & Maxwell, K. (2019). Effect of community-based intervention on improving access to treatment for sick under-five children in hard-to-reach communities in Niger State, Nigeria. *Journal of global health*, *9*(1).

Racheal A. A, Aishat R. S, Kabiru A. (2020). Prevalence of malaria parasites and associated factors among blood donors attending General Hospital Minna, Niger state, Nigeria. *Equity Journal of Science and Technology*, 7(2), 77-82. ISSN 2354-1814; E-ISSN 2683-5961.

Shanks, G. D. (2015). Historical review: does stress provoke Plasmodium falciparum recrudescence?. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *109*(6), 360-365.

Spivak J. L. (2012). Anemia in the elderly: a consequence of ageing? *Hematology Am Soc Hermatol Educational Program*. 2012:1-8. Doi: 10.118.

The Guardian Newspaper (2022). Nigeria, three other African countries account for over half of global malaria deaths in 2021 by Onyedika-Ugoeze, N, Abuja 22nd December, 2022. https://guardian.ng/news/nigeria-3-other-african-countries-account-for-over-half-of-global-malaria-deaths-in-2021/

Virgil, F. F., &Ayalew, T. (2000). Normal ranges of packed cell volume and Haemoglobin concentration. European *Journal of Haematology*, 65(5), 285-96. Doi: 10.1034/j.1600-0609.2000.065005285.x.

World Health Organization (2021). *World Malaria Report 2021*. Switzerland: World Health Organization. ISBN 978-92-4-004049-6.

World Health Organization (2022). *World Malaria Report 2022*. Switzerland: World Health Organization. ISBN 978-92-4-006489-8.

World Health Organization (2023). Malaria. World Health Organization, https://www.who.int/news-room/fact-sheets/detail/malaria retrieved March 9th, 2023