Eagle International Journal of Research, Innovation and Health Sciences

An International Peer Reviewed Journal
Volume 1 | Issue 2 | May 2026
Website: https://eijrihs.com

PREVALENCE OF MALARIA PARASITEMIA AMONG PATIENTS ATTENDING UKE GENERAL HOSPITAL, KARU LOCAL GOVERNMENT AREA, NASARAWA STATE, NIGERIA

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ABSTRACT

Malaria persists as major public health concern in Nigeria. Malaria, an infectious disease spread by mosquitoes, is caused by plasmodium protist. Nigeria accounts for 27% of the global malaria burden and 32% of malaria deaths globally (FRN, 2022). Malaria poses a risk of about 97% to the Nigerian population and contributes about 11% of maternal mortality. This study sought to establish the prevalence of malaria parasitemia among patients attending Uke General Hospital, Karu Local Government Area, Nasarawa State, Nigeria. the study was structured around three key objectives: To determine the malaria prevention practices among the patients visiting the hospital, to identify some socio-cultural factors that can be included in the education of people for effective control programme and to compare the prevalence of malaria parasite infection caused by plasmodium falciparum among patients attending Uke General Hospital Karu Local Government Nasarawa State. A quantitative research design was adopted, Using rapid diagnostic tests (RDT) kits, 120 patients of different ages and genders were screened for malaria. Analysis of collected Capillary blood samples showed that 65 individuals were positive, giving prevalence rate of 54.2%. Children aged 1-10years showed the highest prevalence, and males were generally more affected than females. Although light microscopy is regarded as the gold standard for malaria diagnosis, RDTs were used in this study due to their speed, ease of use, and availability in the hospital setting. These findings demonstrate the ongoing burden of malaria in the study area and the need to reinforce prevention and control strategies. There should be intensive public awareness campaigns on malaria transmission, symptoms, prevention, and the importance of seeking timely treatment. These campaigns should be targeted especially at the uneducated population through the use of local languages and visual aids

Keywords : Malaria, *Plasmodium falciparum,* Protist, Public health, Nigeria

1.0 INTRODUCTION

Malaria remains a major public health concern in many nations, including Nigeria **(**Adikwu *et al.,* 2024; Oyerogba *et al.,* 2023). humans contract the disease from the bites of an infected female anopheles' mosquitoes [(Adikwu *et al.,* 2024;]. The genus *Plasmodium* contains five species of parasites that cause malaria, with *Plasmodium falciparum* being the most common (Belay, *et al.,* 2021). In 2021, there were 247million malaria cases and 619,000 deaths reported globally (CDC 2022). However, just 15 countries, mostly of them in Africa, accounted for approximately 80% of all malaria-related deaths (WHO,2024). World Health Organization (WHO) reported that 48% of the world's population is still at danger of malaria despite frantic efforts and interventions aimed at its eradication (WHO, 2022). This rate is substantially greater than commonly reported 40%.

Malaria account for the highest number of hospital admissions and outpatient visits in Africa (Omoya *et al.,* 2020). Variations in sociodemographic, environmental, and climatic factors may contribute to the variation in the prevalence of malaria infection among patients, even within the same nation (Ngum, *et al.,* 2023). Previous studies have reported a Malaria prevalence of 66.7% (Omoya *et al.,* 2020), 64.0% (Oyerogba *et al.,* 2023). Nigeria remains the highest- burden malaria country globally, accounting for over 30% of malaria deaths (WHO, 2024). Malaria is responsible for 60% of outpatient visits to health facilities, 30% of childhood deaths, 25% of deaths in children under one year, and 11% of maternal deaths in Nigeria (WHO, 2020).

In urban and peri-urban areas, socio-demographic factors like age, gender, education, occupation, and income have been well-reported to have a direct impact on human exposure and treatment. Climate factors like temperature, humidity, and rainfall have also been shown to facilitate mosquito vector development and rapid growth (Ngum, *et al.,* 2023). In African, Malaria transmission occurs more frequently in rural areas than urban areas, possibly due to higher vector density, subpar housing conditions, and inadequate drainage infrastructure (WHO, 2022).

Parasite-based diagnosis prior to antimalarial treatment is recommended by the World Health Organization [WHO, 2022]. However, due to the alleged high prevalence of malaria, empirical treatment and over prescription of antimalarial medications continue to be a common place in Nigerian households and clinical settings (Umaru, *et al.,* 2015). This is made worse by a lack of knowledge on the precision of malaria diagnosis [CDC, 2023]. Since the advent of expensive antimalarials (artemisinin-based treatments), it has become necessary to develop reliable diagnostic instruments for tracking the efficacy of the fight against malaria (Njila, *et al.,* 2022). The gold standard for diagnosing malaria and the accepted procedure for laboratory confirmation of the disease is still conventional light microscopy of a blood smear, which has a threshold sensitivity of 5 to 50 parasite/ÉL (depending on the microscopist expertise) (Sultana, *et al.,* 2017). In cases of severe malaria, it helps with the assessment of the parasitological

response to chemotherapy and the determination of parasite densities and their circulatory stages.

Drug resistance to the currently available antimalarial medications, which are expensive, and the progression of malaria after therapy have been connected to the indiscriminate treatment of non-malaria feverish individuals without parasitological diagnosis (Ebadan, *et al.,* 2017). This study was carried to assess prevalence of malaria among patience attending the Uke General Hospital Nasarawa State Nigeria. It would also attempt to establish the prevalence of *P.* falciparum infection among different age groups of consenting participants in order to provide information useful to relevant government agencies involved in the control of malaria towards the development of suitable policies for maximum efficiency

2.0 LITERATURE REVIEW

Malaria Epidemiology

In Nigeria, malaria is still a major public health problem responsible for a large proportion of the global disease burden. As of October 2023, Nigeria accounts for approximately 27% and 31% of the global burden of malaria cases and deaths respectively, making it still the highest malaria burden country in the world (WHO,2024). Malaria accounts for approximately 60% of outpatient hospital admissions in Nigeria, (Malaria Consortium,2024). Malaria is the second cause of death in sub-Saharan African Children behind pneumonia and diarrheal disease (CDC, 2014) and kills one child every 30 seconds.

In 2010, there were an estimated 219 million cases of malaria (of which approximately 81% occurred in Africa) and an estimated 660 000 deaths due to malaria (91% in Africa). This burden is felt the hardest in the WHO African Region where an estimated 90% of all malaria deaths occur, and in children aged under-5 years, accounting for 78% of all deaths (WHO, 2015). Malaria is a global health concern with 90% of deaths from malaria occurring in thirty countries in Sub-Saharan Africa. Half of all deaths in the world occur just in Nigeria, Democratic Republic of Congo (DRC), Ethiopia and Uganda. Malaria continues to be among the top five killers and diseases of childhood on our continent, killing a child every two minutes. Nigeria retains one of the highest malarial burdens in the world (Global Burden of Disease,2025).

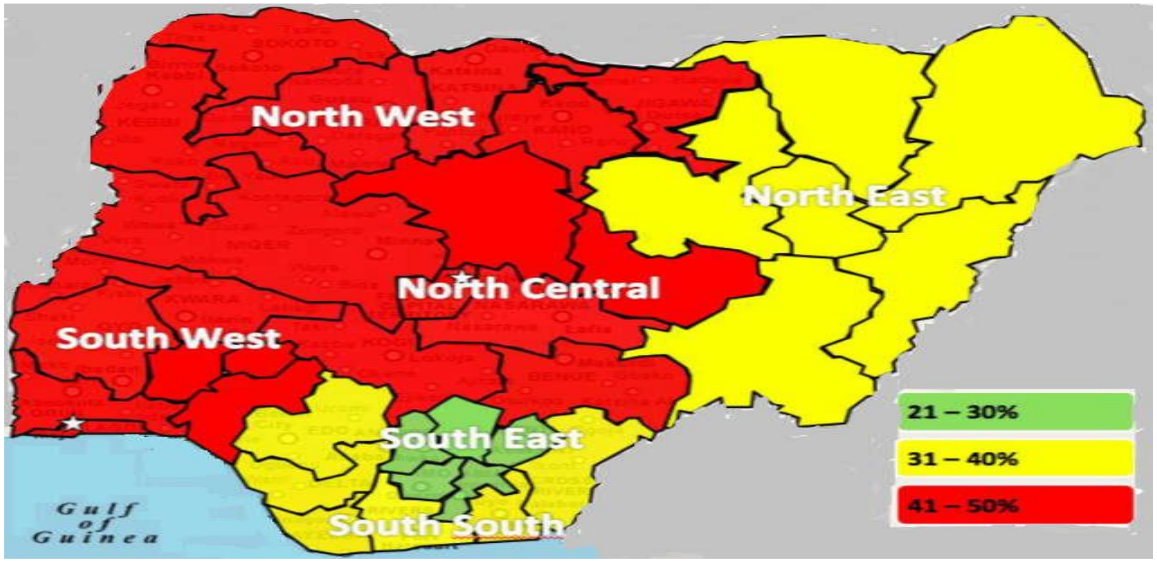

Figure 1: Geographical distribution of malaria prevalence in children 659 months by microscopy in Nigeria Source: Nigeria Malaria Indicator Survey, 2012.

Malaria contributes to an estimated 11% of maternal mortality, 60% of outpatient visits and 30% of hospitalizations among children under five years of age in Nigeria. Malaria has the greatest prevalence, close to 50%, in children age 659 months in the South West, North Central, and North West regions (Fig. 1). Malaria has the least prevalence, 27.6 %, in children age 6 to 59 months in the South East region (Ugochukwu et *al*., 2010). Malaria impedes human development and thus having social consequences and heavy burden on economic development with Nigeria losing over 132 billion ($694.7 million) from cost of treatment and absenteeism from work, school and farm (Onwujekwe *et al*., 2013).

Life Cycle of Human Malaria

The life cycle of human malaria has two stages, a sexual stage and an asexual stage (Figure 2). The sexual stage occurs in female *Anopheles* mosquito (definitive host), while the asexual

stage occurs in human (intermediate host) (CDC, 2006). The sexual stage, also known as the sporogonic cycle, begins when a female *Anopheles* mosquito feeds on a human infected with *Plasmodium*. The red blood cells which the mosquito ingests contain male and female gametocytes. In the mosquito, the male gametocytes or microgametocyte undergo flagellation to form mature male gametes, while the female

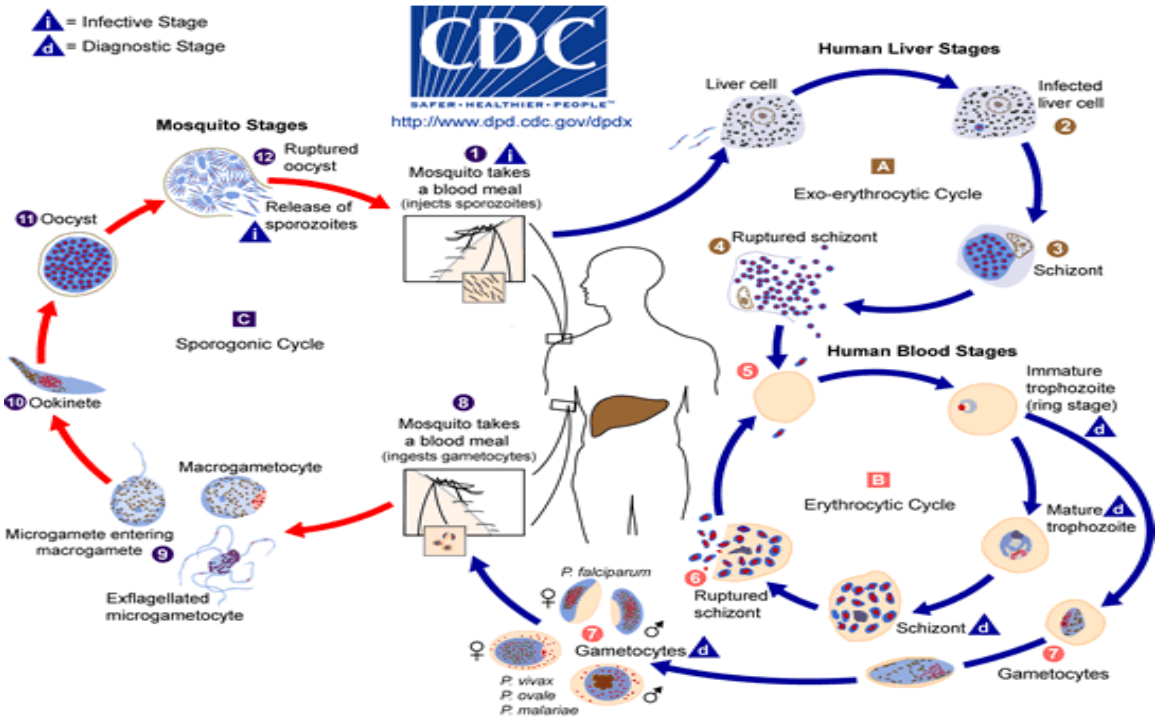

Figure 2: Human malaria life cycle.

Source: CDC 2006.

Gametocytes shed the red blood cell becoming female gametes. The male gametes penetrate the female gametes forming a zygote (Bloland, 2001; CDC, 2006). The zygote elongates into an ookinete, which infiltrates the stomach of the mosquito and attaches to the outer lining of the stomach. As the ookinetic enlarges it transform into an oocyst, the oocyst rapidly divides into sporoblasts. Once the sporoblasts develop a defined nucleus and break away from the stomach lining, they become sporozoites. The sporozoites migrate and invade the salivary gland of the mosquito, which normally takes 10 to 18 days after the intake of gametocytes. This ends the sexual stage of the life cycle (Bloland, 2001; CDC, 2006).

The asexual stage begins when the sporozoites are transferred to a human host when the infected mosquito feeds. The asexual stage can be further divided into exoerythrocytic stage and the erythrocyte stage (Bloland, 2001). The exoerythrocytic stage occurs first, because the sporozoites travel to the liver of the human host and invade the hepatocytes (Bloland, 2001). In the hepatocytes, the sporozoites mature into schizonts. After five to sixteen days, the schizonts rupture, they release merozoites, the haploid form of *Plasmodium* (CDC, 2006). *Plasmodium vivax*and *Plasmodium oval* can remain in the hepatocyte in a dormant stage. The merozoites in the dormant phase are called hypnozoites. The merozoites exit the hepatocytes and enter the blood stream. Once the merozoites enter the blood stream, they penetrate the red blood cells of the human host. This begins the erythrocyte stage (CDC, 2006).

In the erythrocyte stage, the merozoites join together to form ringed trophozoites in the red blood cells. The parasite consumes the hemoglobin through its food vacuole. The hemoglobin is metabolized into heme, which is toxic to the parasite. The parasite uses polymerase to detoxify heme into crystals of hemozoin pigment (Bloland, 2001). The trophozoites mature into schizonts or into gametocytes. The schizont phase will rupture into merozoites and repeat the erythrocyte stage. The gametocytes are crescent shaped and mature very slowly (around 10 days). The gametocytes are eventually ingested by the female *Anopheles* mosquitoes starting the sexual stage (CDC, 2006).

A successful sporozoite can produce from 10,000 to more than 30,000 daughter merozoites in 6 8 days within the hepatocyte (White *et al*., 2014). An asexual cycle in the blood takes roughly 48 h for *P falciparum*, *P vivax*, and *P ovale*, 72 h for *P malariae*, and 24 h only for *P knowlesi*. In a susceptible individual, the parasite population expands by between six times and 20 times per cycle (Simpson *et al*., 2002). After 6 8 days of emerging from the liver, when parasite densities have reached roughly 50/µl of blood (roughly 100 million parasites in the blood), they become detectable by microscopy or rapid diagnostic tests and the symptomatic stage of infection begins.

The incubation period is therefore usually 12 14 days from the infecting bite. In *falciparum* malaria, the sexual cycle is delayed eventually after several asexual cycles, some merozoites invade red cells and there develop into either male or female gametocytes. Initially these resemble trophozoite forms, and they are sequestered. They mature in the small capillaries and venules and they are then released into the circulation. This sexual stage is responsible for infecting the Anopheline mosquito and thus transmission of the infection. As gamete fusion and thus meiosis takes place in the mosquito's mid gut.

Malaria Transmission

The malaria parasite is mostly transmitted to people through the bites of infected female mosquitoes, which injects Plasmodium parasites into the human blood stream. Although less common blood transfusion and contaminated needles may also transmit malaria. (WHO, 2024).

A newly emerging concern is the spread of Anopheles stephensi, a mosquito species capable of surviving in urban environments and breeding in artificial water containers (CDC, 2024).

Climate change, urbanization, and human behavioral patterns (such as poor housing and lack of protective measures) also influence malaria transmission dynamics, prolonging transmission seasons and expanding mosquito habitats (WHO,2024). Resistance remains a major challenge in the fight against malaria transmission. Insecticide resistance among Anopheles mosquitoes reduces the effectiveness of core malaria prevention strategies such as insecticides-treated nets (ITN) and indoor residual spraying (IRS), leading to higher survival rates of mosquitoes and sustained transmission. (CDC, 2024).

Host Factor

Host factors play a vital role in determining an individual's risk of malaria infection, the severity of the disease, and their potential contribution to ongoing transmission. Among these factors, age and immunity are particularly important. Children under five years of age remains the most vulnerable to malaria due to their immature systems, with studies showing that children between one and two years have nearly double the risk of infection compared to older children (Isiko et al.,2024). Overtime, repeated exposure to malaria in endemic regions helps older children and adults develop partial immunity, resulting in milder or even asymptomatic infection (CDC,2024., WHO,2024).

Genetic factors also play a significant role., individuals with sickle cell traits (HbAS) have been shown to have natural protection against severe Plasmodium falciparum malaria, while conditions such as G6PD deficiency and thalassemia similarly affects susceptible and disease progression (Band et al., 2022).Pregnant women have high - risk group due to immunological changes during pregnancy and the vulnerability of the placenta to parasite sequestration .Malaria in Pregnancy is associated with maternal anemia, low birth weight, miscarriage ,and still birth (Chua et al., 2021., Minwuyelet et al.,2025).

Nutritional status further influences malaria outcomes, as malnourished children are at higher risk of severe infection due to weakened immune responses (Gebreegziabher et al.,2023). Behavioral and socioeconomic factors, including poverty, poor housing, sleeping without insecticide-treated nets and limited access to healthcare significantly influence exposure and the ability to prevent or treat malaria. (CDC, 2024., WHO, 2024).

Mixed Species

Accurate malaria diagnosis in endemic areas remains complicated by the presence of multiple Plasmodium species within the host, a situation often missed by conventional diagnostic method such as microscopy. Infections commonly involve the combinations of Plasmodium falciparum with P. malariae, P ovale, or P, vivax, the occurrence of such infection was previously underestimated due to diagnostic limitations; however, molecular techniques such as PCR have revealed that mixed infections are more widespread than previously assumed. (Oboh Imafidon et al.,2020). A study conducted in Niger revealed that over 38% of symptomatic individuals harbored mixed infections when examined using sensitive diagnostic tools. (Garba et al., 2024).

Individuals co-infected with P. falciparum and P. vivax had an increased risk of severe malaria compared to those with single-species infections. The presence of mixed-species infections poses significant challenges in malaria control and treatment efforts' co-infection may contributes to chronic parasitemia, complicate clinical symptoms, and increase the likelihood of treatment failure when non-falciparum species are not adequately diagnosed. (Diagne et al.,2024).

Types Of Malaria

Uncomplicated Malaria

Accurate diagnosis of uncomplicated malaria is essential, particularly in endemic regions where symptoms overlap with many other febrile illnesses. Clinical features of uncomplicated malaria typically include fever, chills, headache, muscle and joint pain, nausea, vomiting, and general malaise. These symptoms arise from the release of toxic byproduct from lysed red blood cells, which trigger cytokine production. (CDC, 2024). In Nigeria and other parts of Africa, nearly all cases of uncomplicated malaria are caused by Plasmodium falciparum, while infections with P. vivax, P. malariae, or P. ovale occur less frequently but present similarly. (WHO, 2024).

Severe Malaria

Severe malaria is associated with high morbidity and mortality especially among young children, pregnant women and immunocompromised individual in endemic region like Nigeria. It happens when malaria progresses beyond uncomplicated disease, resulting in deadly complications from a combination of massive red blood cell destruction, extreme inflammation, and organ failure. Plasmodium falciparum is the leading African cause of lethal malaria and accounts for the vast majority of malaria mortality worldwide (WHO,2024).

The clinical presentation of severe malaria ranges six (severe anemia, respiratory distress, acute kidney injury, hypoglycemia,, metabolic acidosis hyper parasitemia shock and multiorgan failure) to three systems (cerebral malaria associate with seizure, confusion or coma). Recurrent seizures and a deep coma are often the most commonly recognized features in children; whereas, renal failure and acute respiratory distress syndrome are more frequent findings in adults. (CDC,2024)

Pathogenesis and Pathology of Malaria

The pathogenesis of malaria begins when an infected female Anopheles mosquito injects sporozoites into the human bloodstream during feeding. These sporozoites migrate to the liver, where they invade hepatocytes and multiple during the asymptomatic liver stage. Following the rupture of the infected hepatocytes, merozoites are released into the bloodstream, initiating the erythrocytic stage responsible for the clinical symptoms of malaria. (WHO,2024; CDC,2024). Recent studies have further highlighted the role of endothelial activation and microvascular dysfunction in the pathology of severe malaria. (Piccaluga. &Ignatius,2023).

The immune response plays a significant role in malaria pathology. Parasite toxins, particularly glycosylphosphatidylinositols (GOLs) and hemozoin cells, leading to the

production of pro-inflammatory cytokines such as TNF-a, IFN-Y, and IL-6. Although these response are essential for controlling parasitemia, their excessive release contributes to systematic inflammation, metabolic acidosis, hypoglycemia, and in severe cases multi-organ failure. (Glineur et al., 2022., CDC,2024). Overall, the pathogenesis and pathology of malaria results from the complex interaction between parasite factors, host immune responses, endothelial function, and coagulation disturbances. These factors together determine whether the infection manifests as mild, severe, or fatal malaria. (Gallego-Delgado,2023., WHO, 2024).

Factors Influencing Malaria Outcome

Malaria parasites influence disease outcome of malaria infection, determing whether it presents as mild, severe, or fatal. These include host related factors, parasite characteristics, environmental conditions, healthcare accessibility, and socioeconomic status. Host factors such as age, immunity, pregnancy, genetic traits like sickle cell trait, G6PD deficiency and malnutrition significantly affect disease severity. Young children, pregnant women, and non-immune individuals are mostly at risk. (WHO,2024).

Malaria Complications

Cerebral malaria

Cerebral malaria is the most severe neurological complication of infection by plasmodium falciparum and continues to be a main cause of mortality and long-term neurological disability among sub-Saharan African children aged under five. (WHO,2024., CDC, 2024). We have already mentioned that the pathophysiology of cerebral malaria includes not only mechanical obstruction from sequestered erythrocytes but, also they are driven mostly by inflammatory mechanisms including cytokines like TNF-A and IL-1 which further exacerbate endothelial activation, vascular leakage and brain swelling (Glineur et al., 2022). It is now recognized that disruption of the blood-brain barrier has an ongoing role in the evolution of cerebral sequelae. (de lima et al., 2025).

Cerebral malaria diagnosis is clinical but should be aided by confirmed P. falciparum parasitemia and exclusion of any other cause of coma. Serious supportive care is required urgently, including intravenous artesunate—first-line treatment for cerebral malaria—and management of complications like seizures, hypoglycemia and cerebral edema. (WHO, 2024). Cerebral malaria still represents one of the deadliest forms of malaria owing to high mortality and continuing long-term neurological sequelae in survivors, including cognitive impairment, epilepsy and behavioral disorders, despite major advances in treatment. (WHO, 2024; Gallego et al.,2023).

Malaria in pregnancy

In high transmission area, such as Sub-Saharan Africa, malaria during pregnancy remains a serious cause of maternal and neonatal complications, in the Democratic Republic of the Congo, reported that pregnant women who received intermittent preventive treatment with sulfadoxine-pyrimethamine (IPTp-SP) and used insecticide-treated nets (ITNs) had significantly reduced risks of malaria infection, maternal anemia, and low birth weight. (Tshionogo et al.,2024). The consistant use of these preventive measures contributed to the reductions in the maternal anemia, neonatal mortality, and low birth weight over a ten-year period in Ghana. (Ampofo et al., 2022). In Nigeria, these challenges are furthered supported by findings which show that poor antenatal care attendance, poverty, and low education continue to limit pregnant women's access to IPTp-SP. (Kalu et al.,2023). Similar findings in Bukna Faso, where malaria infection during pregnancy was linked to adverse outcomes such as anemia, stillbirth, and low birth weight. (Ouedraogo et al.,2023).

Placental Malaria

Placenta malaria is a condition that occurs when Plasmodium falciparum-infected erythrocytes accumulate in the placenta during pregnancy, leading to inflammation and blockage of normal placental function. This is mediated by the parasites VAR2CSA protein, which allows infected red blood cells to blind specifically to chondroitin sulfate A (CSA) receptors in the placenta. (WHO,2024., CDC, 2024). This sequestration of parasites disrupts the placental circulation, causing reduced nutrient and oxygen delivery to the fetus and triggering an immune response characterized by the infiltration of monocytes and macrophages into the placental intervillous space. (Tshiongo et al., 2024).

Diagnosis of Malaria

The accurate diagnosis of malaria before prompt treatment is critical to preventing complications, classical methods for diagnosing malaria are microscopy and rapid diagnostic test (RDTs), whereas molecular techniques such as polymerase chain reaction (PCR). For malaria diagnosis microscopy is still the gold standard. Microscopy is the most reliable and it requires training personnel or laboratory infrastructure well (WHO,2024), it involves Giemsa-stained thick and thin blood smears under the microscopy.

Rapid diagnostic tests (RDT) are often used either where microscopy is unavailable, or in resource limited circumstances and so play an important role in the context of malaria diagnosis. RDTs detect Plasmodium antigens, particularly histidine-rich protein 2 (HRP-2) for P. falciparum and lactate dehydrogenase (pLDH) for other species. It is easy to use, fast and needs very little basic training but it does not quantify parasitemia or invariably show a positive result in low parasitemia (in the case of HRP-2 gene deletion). (CDC, 2024).

As the most sensitive and specific diagnostic tests for malaria, molecular methods such as polymerase chain reaction (PCR) can detect low-level parasitemia and mixed infections. Nevertheless, PCR is expensive and laborious and has mainly restricted to the research or confirmation of rather than the routine diagnosis. (Ampofo et al., 2022). Recent advances in tools include high-sensitivity RDTs (hsRDTs) targeting low parasite densities and lower complexity assays such as loop-mediated isothermal amplification (LAMP), more conducive for field testing, which offer higher sensitivity than microscopy. (WHO, 2024; CDC, 2024).

Clinical Diagnosis of Malaria

Clinical diagnosis of malaria is often based on recognizing common symptoms such as fever, chills, headache, body pains, vomiting, and general weakness. However, these symptoms are not specific to malaria and can resemble other diseases like typhoid fever or viral infections. Therefore, relying solely on symptoms may lead to misdiagnosis, especially in areas where multiple febrile illnesses are common. (WHO,2024; CDC,2024). Depending solely on clinical symptoms without laboratory confirmation can result in missed malaria cases, particularly when parasite densities are low, Subclinical infections those with no obvious symptoms are also common in endemic areas and often go undetected if clinicians rely only on patient's presentation. (Opoku et al., 2023; Reynder et al., 2024).

Laboratory Diagnosis Of Malaria

In the laboratory, malaria diagnoses can be done using different techniques, which include microscopic diagnosis by staining thin and thick peripheral blood smears, rapid diagnostic tests and molecular diagnostic methods such as PCR.

Microscopic diagnosis

Microscopy remains the gold standard for diagnosing malaria, especially where skilled laboratory personnel are available by examine Giemsia-stained thick and thin blood smears, microscopies can identify the presence of parasites, determine the plasmodium species and estimate parasite density important information that guides treatment decision. (WHO, 2024). Thick films concentrate red blood cells and offer greater sensitivity, while thin films preserve cellular morphology for accurate speciation crucial when P. vivax or P. malariae coexist with P. falciparum. A recent study in Ghana reported a sensitivity of just 42.5% (95% Cl: 38.1 – 6.9%) compared with highly sensitive PCR methods, although specifically remained high at 97.8% (95% Cl: 96.5-98.7%). (Opoku et al.,2023).

Serological Tests

Serological testing such as enzymes linked immunosorbent assays (ELISA), multiplex bead arrays, and immunofluorescence assays detects antibodies against malaria antigens, making it valuable for understanding past exposure, but not suitable for diagnosing active infection (WHO, 2024). A study in southwestern Ethiopia found that serological markers targeting both P. falciparum and P. vivax accurately reflected exposure history and were instrumental in identifying areas of continued transmission, even at low levels. (Jeang et al., 2023).

These findings confirm that serological assays can map out hotspots of malaria exposure and monitor changes over time in both moderate and low transmission settings. However, antibody persistence means serology cannot distinguish new infections from past ones. (Kartel et al., 2023).

Molecular Diagnostic Method

Polymerase Chain Reaction (PCR)

Polymerase Chain Reaction (PCR) remains the most sensitive technique for detecting malaria, with the ability to identify infections even when parasite levels are extremely low levels often missed by conventional diagnostic methods, A recent 2024 cross-sectional study conducted in Ethiopia compared the performance pf nested 18S PCR, microscopy, and rapid diagnostic tests (RDTs) among both symptomatic and asymptomatic participants, 20.3% tested positive for malaria using PCR, whereas microscopy and RDT detected only 6.3% and 3.9%. respectively. Similarly, among symptomatic individuals, PCR identified 27.2% of cases, compared to 13.9% detected by microscopy and 12.9% by RDTs, clearly demonstrating the superior sensitivity of PCR in detecting malaria infections. (BMS Infectious Diseases 2024).

However, PCR is more expensive and requires specialized laboratory infrastructure, it remains highly valuable for research purposes and malaria elimination programs, particularly for identifying hidden or subclinical infections that other diagnostic methods may fail to detect. (WHO, 2024).

Loop-Mediated Isothermal Amplification (LAMP) technique

The loop mediated isothermal amplification (LAMP) technique has emerged as a widely accepted molecular diagnostic techniques for the detection of malaria parasite due to its high specificity, rapid amplification time, and simplicity. Unlike conventional PCR, which requires thermal cycling equipment, LAMP operates under a constant temperature (typically 60-65C), utilizing a strand displacement DNA polymerase and four to six specially designed primers targeting a specific region of the parasite genome. (Yang et al., 2024).

Microarrays

Microarrays represent an advanced molecular diagnostic technique used primarily in research settings to analyze malaria at the genomic and transcriptomic levels. This technology allows for the simultaneous detection and qualification of thousand of genes or specific malaria biomarkers, offering insights into parasite gene expression, rug resistance markers and the host immune response. (WHO, 2024). Unlike microscopy or PCR, which are focused on identifying the presence of malaria parasites, microarrays are mainly applied to investigate the genetic variations of plasmodium species and how the human host responds during infection.

Recent studies have demonstrated the relevance of microarrays in monitoring malaria drug resistance and transmission patterns. (Wang et al., 2023).

Strategies for Integrated Malaria Control

Malaria control requires an integrated approach combining different methods to reduce malaria transmission and prevent complications. These strategies include vector control, chemoprevention, early diagnosis and treatment, health education, and surveillance. Vector control remains the most effective method of preventing malaria transmission. The use of long-lasting insecticidal nets (LLINS) and indoor residual spraying (IRS) has been shown to significantly reduce mosquito population and limit human contact with mosquitoes, (WHO,2024).

Chemoprevention is another important strategy, especially for vulnerable groups such as pregnant women, children. These includes intermittent preventive treatment in pregnancy (IPTp), intermittent preventive treatment in infants (IPTi), and seasonal malaria chemo preventive (SMC) to reduce the risk of infection, severe complications. (Tshiongo et al., 2024).

Transmission Control

Transmission control is very important in reducing malaria cases. The use of long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) are the most common method for preventing malaria transmission. LLINs protects people from mosquitos' bites during sleeping hours, while IRS kills mosquitoes that rest on the walls inside houses. These methods help to reduce the number of mosquitoes and also stop the spread of malaria from infected people to others (WHO,2024). Recent studies have shown that combining different transmission control method alone. Combining LLINs with house screening, which prevents mosquitoes from entering houses, has also found to reduce malaria transmission. (Belay et al., 2025)

Malaria Eradication

Malaria eradication refers to the complete and permanent removal of malaria from all parts of the world, ensuring no further transmission occurs. In Africa, efforts towards malaria eradication have focused on key strategies such as the use of long-lasting insecticide-treated nets (LLINs), indoor residual spraying (IRS), rapid diagnostic testing, seasonal chemoprevention for children, and treatment with artemisinin-based combination therapies (ACTs). Although these strategies have led to major improvements reducing malaria incidence by 40% and death's around 60% in Africa since 2000 complete eradication remains difficult. (Li et al., 2024).

Malaria Vaccines

The development of malaria vaccines has advanced with the approval of RTS, S/AS01 by the World Health Organization (WHO) in 2021, marking a significant achievement in the fight against malaria. This vaccine provides moderate protection, reducing sever malaria cases among children but requiring four doses for effectiveness. Due to its limited protection, experts recommend combining it with other malaria prevention strategies, such as insecticide-treated nets, vector control, and antimalarial medicine. (Moamly et al., 2023).

Further studies have highlighted the practical challenges in vaccine implementation. Issues such as cost, weak health systems, difficulties delivering multiple doses, and vaccine hesitancy remain barriers in malaria-endemic regions. Newer vaccine candidates, including RH5.1/MATRIX-M and the next-generation technologies like mRNA vaccines, are being developed to provide stronger long-lasting protection. However, it has been recommended that vaccines should be used alongside existing malaria control measures for greater success. (Sallam et al., 2025).

Transmission blocking vaccines (TBVs)

Transmission blocking vaccines (TBVs) are being developed to prevent the malaria parasite from moving from human to mosquitoes by targeting the parasite sexual stages inside the mosquito. One key focus is the protein Pfs47, which allows Plasmodium falciparum to survive within the mosquitoes. Studies have shown that antibodies against domain of Pfs47 can stop the parasites development in mosquitoes, even without the support from the human immune system. Virus like particles (VLPs) displaying Pfs47 domain 2 have been created to strengthen this immune response, offering a promising method to block transmission and support malaria elimination efforts. (Molina et al.,2022).

Pre-erythrocytic vaccines

RTS, S/AS01 and R21/Matrix-M are the most advanced pre-erythrocytic malaria vaccines currently recommended for use. Both vaccines target the circumsporozoite protein (CSP) of Plasmodium falciparum to stop the parasite at the liver stage before it

enters the bloodstream. These vaccines provide protection by generating antibodies and T cell responses against the early stages of infection, reducing the risk of malaria illness and dealth. It has also focused on PfSPZ vaccines, which use weakened whole sporozoites to stimulate stronger and longer-lasting immunity. Other developments include virus like particle (VLP) technologies, which aim to improve immune responses and increase the durability of protection. (Hammer et al., 2024).

Blood-stage vaccines

Blood- stage vaccines are designed to protect individuals from malaria by targeting the stages of the parasites life cycle when it invades red blood cells and causes the clinical symptoms of the disease. The primary aim of this vaccine is to prevent the parasite from entering the red blood cell to reduce its multiplication inside them, thereby reducing parasite density, preventing severe complications, and limiting transmission. One of the most promising blood-stage vaccine candidates is the RH5.1/Matrix-M vaccine, which targets the reticulocyte-binding proteins homolog 5 (RH5) of Plasmodium falciparum. (Natama et al., 2025).

Adjuvants and delivery systems for malaria vaccines

Adjuvants and delivery system are very important in malaria vaccine development because they help to make the immune response stronger and last longer. Without adjuvants, most malaria vaccines would not work effectively.

The RTS, S/AS01 vaccine (Mosquuirix) uses adjuvant called ASO1, which contains monophosphorylate lipid A (MPL) and QS-21. These helps the body produce both antibodies and T-cell to fight malaria. The R221/Matrix-M vaccine uses Matrix-M, a newer adjuvant made from plant extracts (saponin), which helps increase antibody production and improve protection. (Bonam et al.,2021).

3.0 METHODOLOGY

Study Area.

This study was carried out at Uke General Hospital, located in Uke town, Karu Local Government Area, Nasarawa State, Nigeria. The hospital is situated at coordinates 8°53’44.9” N and 7°42’40.0” E. It serves a large population from Uke and nearby communities, providing primary and secondary healthcare services. The area has a tropical climate with a rainy season from April to October and a dry season from November to March. These conditions encourage mosquito breeding and contribute to the spread of malaria. Malaria is common in the area, especially during the rainy season, making it a suitable location for this study.

Study Population and Sample

The study population consisted of a pool of men, women and children, ranging from ages 1 – 41 years and above. A total of 120 volunteers were used for this survey comprising, 70 female and 50 male.

Survey Technique

A group of people (120) 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 May to October, 2025. The age, sex, education, treatment, protection, and Healthcare Behavior 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 (Funmilola *et al.,*2022).

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 manufacturer's instruction.

4.0 RESULTS

Table 1: Age and Gender Distribution of Patients Malaria Blood Samples from Uke General Hospital

Age Groups	No. of Samples Examined (%)	No. of Positive Samples (%)	No. of Male Samples (%)	No. of Positive Male Samples (%)	No. of Female Samples (%)	No. of Positive Female Samples (%)
1–10	30 (25.0%)	19 (29.2%)	18 (36.6%)	12 (38.7%)	12 (17.1%)	7 (20.6%)
11-20	30 (25.0%)	18 (27.7%)	15 (30.0%)	10 (32.3%)	15 (21.4%)	8 (23.5%)
21–30	20 (16.7%)	10 (15.4%)	10 (20.0%)	6 (19.4%)	10 (14.3%)	4 (11.8%)
31–40	20 (16.7%)	10 (15.4%)	4 (8.0%)	2 (6.5%)	16 (22.9%)	8 (23.5%)
41 & Above	20 (16.7%)	8 (12.3%)	3 (6.0%)	1 (3.2%)	17 (24.3%)	7 (20.6%)
Total	120 (100%)	65 (100%)	50 (100%)	31 (100%)	70 (100%)	3 (100%)

Table 2: Distribution of Malaria Parasite According to Education Status in Uke General Hospital

Educational Status	No. Examined	No. Infected
Educated	40 (33.3%)	10 (15.4%)
Semi Educated	40 (33.3%)	20 (30.8%)
Uneducated	40 (33.3%)	35 (53.8%)
No Response	0 (0.0%)	0 (0.0%)
Total	120 (100%)	65 (100%)

Table 3: Distribution of Malaria Parasite in Patient Based on Treatment Used at UKE Hospital

Treatment Used	No. Examined	No. Infected
Medication	45 (37.3%)	15 (46.9%)
Herbs	35 (29.2%)	5 (15.6%)
No treatment	25 (20.8%)	7 (21.9%)
No Response	15 (12.5%)	5 (15.6%)
Total	120 (100%)	32 (100%)

Table 4: Distribution of Malaria Parasite in Patient Based on Means of Protection

Treatment Used	No. Examined	No. Infected
Insecticide	25 (20.8%)	10 (15.4%)
Mosquito Net	40 (33.3%)	15 (23.1%)
None	55 (45.8%)	40 (61.5%)
Total	120 (100%)	65 (100%)

Table 5: Distribution of Malaria Parasite in Patients Based on Healthcare Behavior

Healthcare Behavior	No. Examined	No. of Males	No. of Females
Prompt healthcare visit	50 (41.7%)	20 (40.0%)	30 (42.9%)
Delayed healthcare visit	70 (58.3%)	30 (60.0%)	40 (57.1%)
Total	120 (100%)	50 (100%)	70 (100%)

Discussion of findings

This study examined the prevalence of malaria parasitemia among patients that visited UKE General Hospital, Karu Local Government Area of Nasarawa State. Patient data were assessed based on a variety of factors, including age, sex, educational status, prior treatment history, prevention behaviors and healthcare seeking practices in 120 subjects. The results give a thorough insight into the impact of socio-demographics and behavioral characteristics on malaria transmission levels in the study area.

The results showed that malaria was widely distributed among all ages with a high incidence in the age group 1–10 years.Hand, foot and mouth disease (HFMD) is an infectious viral disease in children characterized by a febrile illness followed by vesicular lesions usually on hands, feet and mouth. Males aged ≥18 years accounted for 25% of the total sample binary population with representing an eligible male being identified by the surrogate data as a malaria positive parasite case (29.2%). This concurs with international and countrywide research, which has consistently recognized that children who are all the way down to five years of age are specifically vulnerable to malaria due to their immature immune systems and expanded exposure time to mosquitoes (World Health Organization, 2021).

In addition, the analysis revealed that amongst most age groups, males presented at a higher percentage with malaria positivity as compared to females. In the most recent cohort (1–10 years), 12 of 18 males were positive, and 7 of 12 females were positive. This trend may relate to behavioral and lifestyle differences, where males, especially young boys, may be more likely to spend time outdoors during peak mosquito feeding times. This result agrees with the study from Bello et al. (2022) reported a higher malaria burden among children below 15 years in Lafia, Nasarawa State. Likewise, Ogunyemi and Adeyemi (2023) in the study conducted in Ekiti State also stated that men were more prone to infection than women probably due to higher rate of exposure.

It also found that the prevalence of malaria was closely related to education level. Out of patients with no formal education, high prevalence was recorded when examining positive malaria cases, whereby 35 out of the 40 (53.8%) subjects were found to be infected with Plasmodium. In comparison, just 10 of the 40 (15.4%) educated people were the infected ones. Those who were semi-educated occupied an intermediate position, 20 of 40 cases testing positive.

Such pattern suggests better knowledge and higher adoption of malaria prevention measures like insecticide-treated nets use, prompt treatment-seeking behaviour and environmental sanitation among those with formal education. This supports the findings made by Chukwu et al. A study by Ambabi and Nwaneri (2021) shows there was a drastic decline of malaria prevalence among literate people in Enugu State, ascribed to improved health awareness and practices.

The study categorized which therapies have been used by patients preceding their hospital visit, and how often these therapies correlate with positive cases of malarial

infection. Malaria was investigated in 45 respondents (11/30 using conventional and herbal medicine versus nine who used only the latter. Only 5 of the 35 people who received herbal treatments tested forcibly positive, compared to an infection rate of at least 1 in 8 among unmedicated controls. In contrast, 7/25 had positive by virtue of not using any type of treatment.

Although the beneficiaries of herbal medicine seemed to have a lower infection rate, this ought to be interpreted with caution. Individuals who used herbs may well have self-treated with incomplete treatment or had herbal remedies on top of pre-existing therapy after symptoms had improved. Also, the inability to standardize herbal therapy on a scientific basis makes it impossible to determine its actual efficacy. Umar et al. noted similar concerns (2020) which showed self-medication and dependence on unregulated herbal medicines were correlated with suboptimal parasite clearance as well as promoting drug resistance in Kaduna State.

The analysis on malaria prevention showed that people who did not use any preventive means were reporting the highest infection rates. In particular, 72.7% (40 out of 55) of the infected without the previous use of insecticides or mosquito nets tested positive. In contrast, the incidence of infections was lower among people who used insecticides or mosquito nets. For example, among 25 insecticide users only 10 tested positive and among the those using mosquito nets, 15 out of 40 tested positives.

These results illustrate the role of vector control as a primary prevention tool against malaria transmission. This finding corroborates earlier investigations such as the one conducted by Adetunji et al (2024), who reported on a 65% decrease among individuals using insecticide-treated nets consistently in Osun State. The role of insecticide use and indoor residual spraying as primary malaria control strategies is once again endorsed by the World Health Organization (2023).

Another key issue the study explored was healthcare-seeking behavior. In a sample of 120 respondents, the highest number of individuals were among those who delayed their hospital visits (58.3%) and most of these had malaria infections as well. In contrast, there were fewer infections (41.7%) among those who visited the hospital and received treatment promptly.

This suggests that early diagnosis and treatment may be a key actor in limiting only the severity or the spread of malaria infection. It further stresses the need for public awareness about the need to seek prompt medical attention. Eze et al. further corroborate this observation and also aggravated the malaria diseases and delayed healthcare visits were significantly associated with severe malaria cases in Enugu State (2022). Also, the World Health Organization (2022) also emphasizes that early case detection followed by rapid treatment is an essential pillar to attaining malaria control and elimination.

The results from this study is consistent with many other current studies done in Nigeria between 2020 and 2025 where malaria prevalence, demographic associated risk factors, malaria treatment practices and prevention measures were found.

In the first place, with respect to age-related prevalence, this study identified children 1–10 years as the most affected group representing 63.3% positive for malaria parasitemia. This trend is quite similar to that of the results from Bello et al (2022) in Lafia, Nasarawa State characterized that with % of positive cases and children aged years (age group later reported different prevalence ranging from 45%). Similarly, Chukwu et al. (2021) in Enugu found 0–10 years as the most vulnerable age group, Adetunji et al. (2024) Peak prevalence among ages 5–14 years in Osun State. These findings together suggest that younger age groups are highly susceptible to malaria infection, likely due to weaker or developing immune responses and increased exposure to mosquito bites.

The current study observed a marginally higher prevalence in males than females regarding the risk based on gender. Bello et al provide similarly supporting evidence for this trend (2020), in Lafia, also observed a similar male bias in infection. Adetunji et al. (2024) achieved equally pronounced male bias for with only at less than a well-respected name. In contrast, Chukwu et al. According to (2021), while male gender is a known risk factor for HIV infection globally, in Enugu State of Nigeria a more balanced infection rate between sexes was seen and they postulated that local cultural, occupational and environmental factors might also influence gender based vulnerability.

Regarding educational status, the current study showed that the infection rates among uneducated individuals (87.5%) were found significantly higher than educated individuals. The same inverse correlation between education and malaria infection shown in Bello et al. In Lafia, the most affected demographic were illiterate persons (Amisigo et al. 2022). Chukwu et al. Enugu (2021) also recorded a common trend in Enugu that found an association between low literacy levels and malaria risk susceptibility. Although Adetunji et al. Although their study found education to be a weak predictor of malaria in Osun (2024), they also demonstrated the protective impact of basic health literacy and access to information.

It also investigated the application of herbal medicine as a maltreatment tool for malaria. In this study, 14.3% of herbal remedy users were positive for malaria. While Bello et al. Although herb usage was not investigated in detail by the study of Chukwu et al. (2022) It was referenced without specific data but only briefly in Clynes et al. However, Adetunji et al. (2024) found 20% clearance in subjects from a group who took locally prepared herbal combination, suggesting a placebo benefit. These mixed results highlight the requirement for further scientific evaluation and incorporation of herbal therapies into standardised malaria treatment protocols.

The results of this study illustrated the benefits of mosquito control tools in relation to preventive measures. An astonishing 72·7% of individuals did not protect themselves with insecticides or bed nets and developed malaria. This is in line with the 65% infections rate among non-users reported by Bello et al. (2022). Similarly, Chukwu et al. Ordinary Least Squares Regression: Adetunji (2021) highlighted the need for ITNs and indoor spraying; and Adetunji (†). Researchers have reported that consistent use of ITNs reduces incidence by 65% (2024). These studies validate vector control as a key intervention for reducing malaria transmission.

Finally, healthcare-seeking behavior results indicated that 58.3% of respondents delayed seeking care which is consistent with the higher presentation rates. This is consistent with the results of Bello et al. who observed a similar delays in malaria patients Lafia. Adetunji et al. This problem was also noted by (2024), who found that late presentation frequently resulted in poorer health outcomes. However, Chukwu et al. (2021) reported that early enrolment to health facilities in Enugu reduced malaria associated complications. Taken together, these observations emphasize the importance of timely access to healthcare in the management and control of malaria infections.

To conclude, a comparative analysis of findings from this study and studies in related literature across Nigeria from 2020–2025 attests to a core set of recurring themes. This abundance includes the high susceptibility of children to malaria, a marginal male excess in risk, the protective role of formal education, the partial dependence on unqualified herbal medicines and proven effectiveness of preventive interventions such mosquito nets and insecticides as well as the negative effect of delayed health seeking behavior. The convergence of these trends highlights the need for more comprehensive strategies that combine public information campaigns about malaria with preventive interventions and improvements in access to health care services.

Conclusion

In conclusion, the data from UKE General Hospital underscore the multifactorial nature of malaria prevalence. Children under 10 remain the most vulnerable, likely due to underdeveloped immunity, while educational level, use of preventive measures, treatment behavior, and timely healthcare engagement are all strongly associated with infection rates. The hospital-based data not only reflect clinical burden but also provide critical clues for shaping public health education, intervention targeting, and resource allocation. The findings indicate that children between the ages of 1 and 10 years and uneducated individuals are the most affected groups. Also, delayed hospital visits and the failure to use preventive measures like insecticide-treated nets significantly contribute to higher malaria infection rates. Therefore, improving public awareness, enhancing access to preventive tools, and strengthening healthcare infrastructure are crucial to reducing the malaria burden in the area.

Ethics approval and consent to participate: Ethical clearance was obtained from Federal Ministry of Health Lafia.

Competing interests: The authors have no competing interest.

Acknowledgements: We wish to express our profound gratitude to the management of Ave Maria University Piyanko, FCT Abuja for their unreserved support toward this research work, as well as the Staff of Microbiology Department in Ave Maria University and Nasarawa State University Keffi for their support rendered.

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