Research Article

The Prevalence of Cerebral Malaria among Children under the Age of Ten in Selected Hospitals within Zaria Metropolis, Kaduna State, Nigeria

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ABSTRACT

This study investigates the prevalence of Cerebral Malaria (CM) among children in selected hospitals within Zaria metropolis, Kaduna State, aiming to address the limited data specific to this region. It focuses on CM prevalence among children under the age of 10 in the study area. A cross-sectional study design was employed, and to ensure accurate representation of the target population and the specific condition of interest in the selected hospitals, a purposive sampling technique was adapted for this study. Data were collected through laboratory examination of participants' blood through thick and thin blood film, after which the Plasmodium Falciparum positive slides were subjected to complete blood count test, parasite density calculation and temperature measurement. A physical clinical assessment using the Blantyre Coma Scale (BCS) to determine the altered state of consciousness or coma was used, and a well-structured questionnaire, as well as a consent form, was given to the participant's parent or guardian to elicit data. Version 23 of IBM's Statistical Package for Social Sciences (IBM SPSS) software was used to conduct all statistical analyses and a probability value below 0.05 (p 0.05) was regarded as statistically significant. Among 240 samples, the findings identified an overall prevalence of CM to be 9.2% with higher prevalence of CM recorded in Hospital D **(**15.0%) compared to Hospital A, C, and B which reported a prevalence of 10.0%**,** 6.7% and 5.0% respectively.

Keywords: Cerebral Malaria; Prevalence; *Plasmodium falciparum*; Children under Ten; Zaria Nigeria; Public Health

INTRODUCTION

Malaria remains a critical health challenge in Africa, contributing significantly to mortality among vulnerable populations such as children under five years of age (Pizzol *et al.*, 2018). In 2021, the World Health Organization (WHO) estimated that there were 247 million cases of malaria globally, with the majority occurring in sub-Saharan Africa (WHO, 2021). *Plasmodium falciparum* is the most virulent malaria parasite responsible for severe and cerebral malaria, causing the highest fatality rates among all *Plasmodium* species (De Silva, 2018); Center for Disease Control and Prevention (CDC, 2019). It is estimated that 94% of malaria deaths occur among young children, particularly those residing in endemic regions (WHO, 2021). Cerebral malaria

(CM) is the most severe neurological complication of P*. falciparum* infection, characterized by a sudden onset of coma, seizures, and other neurological deficits (Idro *et al.*, 2016). It is associated with significant morbidity and mortality, especially in resource-limited settings (WHO, 2021). CM poses a unique challenge to clinicians due to its rapid progression and poor outcomes if left untreated. Most cases of CM result in death within 24 hours of hospital admission, particularly in young children (English *et al.,* 2004). Studies have indicated that up to 50% of severe malaria cases in African children may progress to CM, with a significant proportion resulting in long-term neurological complications or death (Oluwayemi *et al.,* 2013). Given the high mortality rates and the

complexity of cerebral malaria, this study seeks to assess the prevalence of CM among children under the age of 10 years in selected hospitals within Zaria metropolis. Understanding the prevalence of CM in this high-risk group is essential for shaping public health interventions, improving diagnostic protocols, and informing clinical management strategies. This study also provides valuable insights into the burden of CM in Kaduna State, Nigeria, where malaria remains endemic. The main objective of this study is to determine the prevalence of cerebral malaria in children under the age of 10 in four selected hospitals within Zaria metropolis. The specific objectives are to: Assess the overall prevalence of CM among the pediatric population and compare the prevalence of CM across the selected hospitals in relation to age and gender.

Cerebral malaria (CM) is a significant global health concern, particularly in sub-Saharan Africa, where it contributes to nearly 50% of malaria-related deaths, with young children being the most affected (Jakubowski *et al*., 2017). According to the World Health Organization (WHO), CM develops in approximately 1–2% of all malaria cases, with an estimated 575,000 preschool-aged children affected each year (Piccaluga & Ignatius, 2023).

Sub-Saharan Africa bears the highest malaria burden, with *Plasmodium falciparum* responsible for 93% of malaria-related deaths, and CM being one of the most critical complications (WHO, 2020). Research indicates that between 20% and 50% of severe malaria cases progress to CM, with a significant number of fatalities occurring within the first 24 hours of hospital admission (English *et al*., 2004). Outside Africa, although CM is less common, it remains a significant health issue in South-East Asia and India, where mortality rates range from 43% to 59%, particularly in cases involving multiple organ dysfunction (Lamas *et al*., 2022). Additionally, imported malaria cases in travelers have shown that 2.4% of these cases develop into CM, emphasizing its relevance beyond endemic areas (Postels & Birbeck, 2013).

Nigeria remains one of the countries with the highest malaria burden, accounting for approximately 27% of global malaria cases. CM prevalence varies significantly across different regions due to differences in malaria transmission rates, healthcare access, and effectiveness of control measures. Studies in northwestern Nigeria have reported CM prevalence rates between 10% and 19.8%, with children under five years of age being the most vulnerable (Oluwayemi *et al*., 2013). Despite ongoing efforts to control malaria, CM remains a major contributor to child mortality and long-term neurological complications. Many survivors experience cognitive impairments, including issues with memory, concentration, and problem-solving abilities, which can affect their education and future prospects (Boivin *et al*., 2007). Preventive strategies such as early detection, prompt treatment with antimalarials, and increased use of insecticide-treated nets (ITNs) remain crucial in combating CM (Greenwood & Alonso, 2005; WHO, 2015). However, given the limited understanding of CM's pathogenesis and risk factors, further research and targeted public health interventions are essential to reduce its impact (WHO, 2021).

The aim of this study is to assess the prevalence of cerebral malaria among children under the age of ten (10) in selected hospitals within Zaria metropolis of Kaduna State.

MATERIALS AND METHODS

Study Area

This study was conducted in Zaria metropolis, a densely populated area in Kaduna State, Nigeria. Zaria is located between latitudes 11°5' N and longitudes 7°43' E, covering an area of approximately 563 km² (Kaduna State Bureau of Statistics, 2022). The study was carried out in four hospitals: Hajiya Gambo Suwaba General Hospital (Hospital A) [11.1247°N, 7.7254°E], Muslim Specialist Hospital (Hospital B)[11°o5'N, 07°41'E], Major Ibrahim Balarabe Abdullahi Memorial Hospital (Hospital C)[11.1766°N, 7.6765°E], and Ahmadu Bello University Teaching Hospital (Hospital D)[11.176°N', 7.6048°E], representing healthcare centers within the metropolis.

Study Population

The study targeted children aged 10 years and below who presented with symptoms of severe malaria and were confirmed to have *P. falciparum* parasitemia. Participants were selected based on WHO's diagnostic criteria for CM, which includes the presence of *P. falciparum* in peripheral blood and a Blantyre Coma Scale (BCS) score of ≤ 3 (Marsh *et al*., 1995); WHO, 2021. Only children with parasite densities above 5000 parasites per microliter of blood were classified as having severe malaria, a precursor to CM (Amoako *et al.,* 2012).
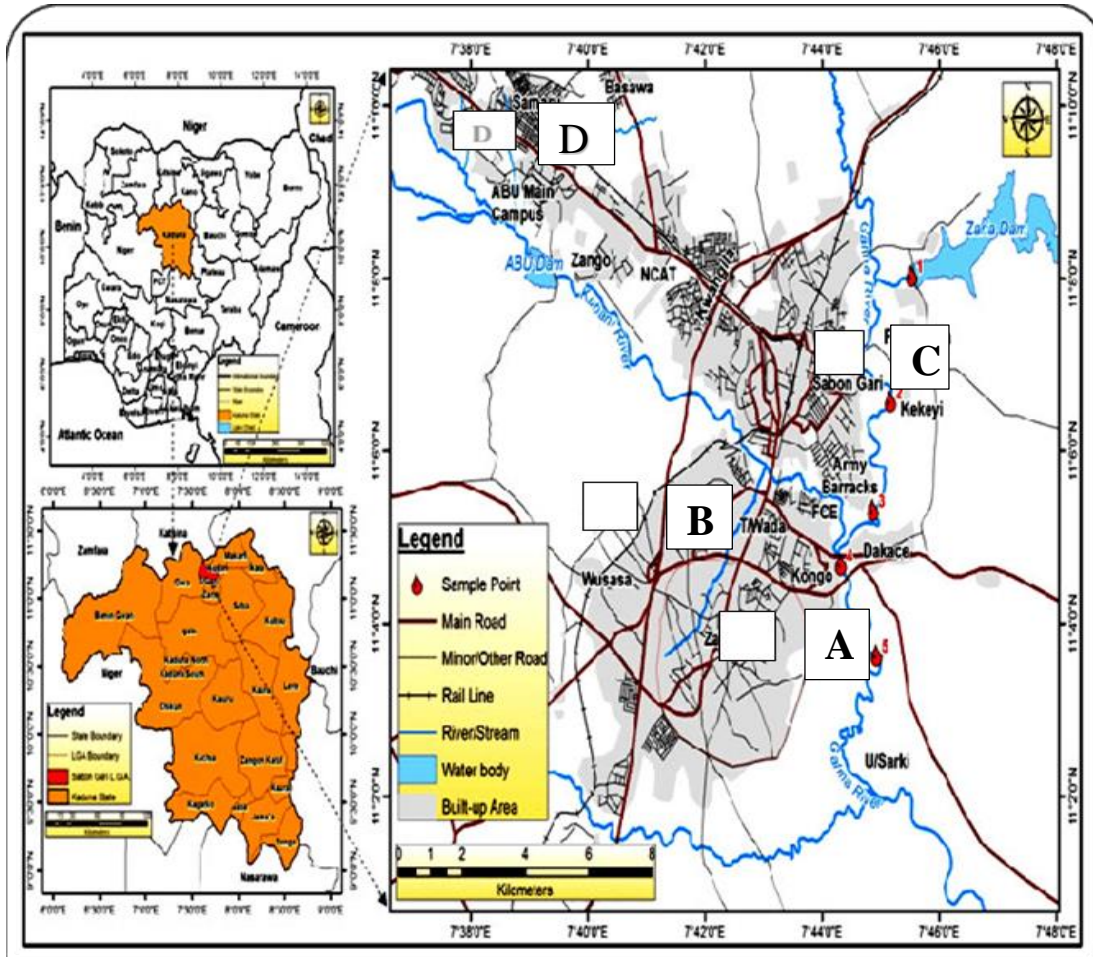
Fig 1: Map of Zaria Modified from the Administrative Map of Zaria

Study Design

A cross-sectional hospital-based study was conducted, involving the collection of clinical data, blood samples, and coma scale assessments. The data collection period spanned four months, during which 240 children were enrolled in the study. The Blantyre Coma Scale was used to assess consciousness levels, while laboratory tests were performed to determine parasite density and confirm the presence of *P. falciparum* (Taylor *et al.*, 2009).

Sampling Techniques

A purposive sampling technique was used to select children who met the study criteria. The sample size was determined using Cochran's formula, based on a previous prevalence estimate of 19.8% (Oluwayemi *et al.,* 2013). The calculated sample size was 240, and to account for incomplete responses, 260 questionnaires were administered.

Sample Size of the Study

The sample size for the study was calculated using the prevalence of 19.8% as reported by Oluwayemi *et al.* (2013) using the formula developed by Cochran (1963).

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

Where;

n = desired sample size

E = margin of error (0.05 for 5%)

p = estimated prevalence 19.8% (0.194) as prevalence for CM according to Oluwayemi *et al.* (2013)

Z = is the Z-score for 95% confidence level (approximately 1.96)

n = Desired Sample size

$$n = \frac{1.96^2 . 0.194 (1 - 0.194)}{0.05^2}$$

n = 240.275

n ≈ 240

Ethical Considerations

Before the study commenced, ethical approval was obtained from the Kaduna State Ministry of Health (NHREC/17/03/2018). Written consent was also obtained from the parents or guardians of all study participants.

Data Analysis

The version 23 of IBM's Statistical Package for Social Sciences (IBM SPSS) software was used to conduct all statistical analyses. To find any statistical differences between the variables, the chi-square test was used.

Probability values below 0.05 (p 0.05) were regarded as statistically significant and will show independent factors connected to CM.

General Characteristics of the Study Population
The study population consisted of 240 children, of which 52.9% were females and 47.1% were males. Age distribution showed that 25% of the children were under 2 years, 52.9% were aged 2–5 years, and 22.1% were between 6–10 years.

RESULT

Table 4.1a: Gender Distribution of study participants

Hospital	No. Examined	Female (%)	Male (%)
A	60	33 (55.0)	27 (45.0)
B	60	32 (53.3)	28 (46.7)
C	60	33 (55.0)	27 (45.0)
D	60	29 (48.3)	31 (51.7)
Total	240	127 (52.9)	113 (47.1)

Key; Hospital A = Hajiya Gambo Suwaba General Hospital
Hospital B= Muslim Specialist Hospital
Hospital C = Major Ibrahim Balarabe Abdullahi Memorial Hospital
Hospital D = Ahmadu Bello University Teaching Hospital

Table 4.1b: Age Distribution of Study Participants

Hospital	No. Examined	0 - 2 Yrs (%)	2 – 5 Yrs (%)	6 – 10 Yrs (%)
A	60	13 (21.7)	30 (50.0)	17 (28.3)
B	60	20 (33.3)	32 (53.3)	8 (13.3)
C	60	12 (20.0)	36 (60.0)	12 (20.0)
D	60	15 (25.0)	29 (48.3)	16 (26.7)
Total	240	60 (25.0)	127 (52.9)	53 (22.1)

Key; Hospital A = Hajiya Gambo Suwaba General Hospital
Hospital B = Muslim Specialist Hospital
Hospital C = Major Ibrahim Balarabe Abdullahi Memorial Hospital
Hospital D = Ahmadu Bello University Teaching Hospital

Overall Prevalence of Cerebral Malaria in Some Hospital in Zaria
The overall prevalence of CM from this study is 9.2% as 22 out of the total 240 study participants were positive for CM. The relative prevalence of CM by hospital indicated that the highest prevalence of CM (15.0%) was recorded at Hospital D as nine (9) out of the 60 study participants were confirmed positive for CM that was followed by the prevalence of 10% recorded at Hospital A as six (6) out of the participants drawn from that location were diagnosed for CM, while at Hospital C the prevalence was 6.7% as four (4) out of the 60 participants were CM positive; the least prevalence of CM (5.0%) was recorded at Hospital B with three (3) out of the 60 participants being positive for CM. The

difference in prevalence of CM between the four hospitals was, however, not statistically significant ($p > 0.05$).

Prevalence of CM among Participants by Gender
Overall, there was higher prevalence of CM among males than in females, however, the difference was not statistically significant ($p > 0.05$); the overall prevalence of CM in male children was 10.6% as 12 out of the 113 male wards were diagnosed with CM; in female children the overall prevalence of CM was 7.9% as 10 out of the 127 female wards were CM positive (Fig 4.2). The relative distribution of male and female wards by hospitals showed that the prevalence of CM in males (11.1%) was higher than the recorded prevalence in females (9.1%) in children enrolled at Hospital A,

however, the difference was not statistically significant ($p > 0.05$). At the Hospital B, the prevalence of CM in female wards (6.3%) was higher than that in male children (3.6%), however, the difference was not statistically significant ($p > 0.05$). The relative prevalence of CM in male children enrolled at Hospital C was higher than the prevalence in female children in the same hospital with respective prevalence of 6.1 and 7.4%, however, the difference was not statistically significant ($p > 0.05$). Similarly, the prevalence of CM in male children was higher than in female children that were enrolled at Hospital D with respective prevalence of 19.4 and 10.3%, however, the difference was not statistically significant ($p > 0.05$).

Prevalence of CM among Study Participants by Age

Out of the 60 children under 2 years, 3 (5.0%) were positive for CM, 14 (11.1%) of the 127 children that were aged 2 to 5 years were diagnosed with CM, while 2 out of the 53 children between ages 6 and 10 years were positive for CM; the difference was however, not statistically significant ($p > 0.05$). When the age related prevalence of CM among the children were compared by hospital, the results indicated there was no statistically significant difference in the prevalence of CM among the age categories of children: at Hospital A, the prevalence of CM among children under the age of 2 was 7.7%, and 10.0 and 11.8% among children between ages 2 to 5 and 6 to 10 years, respectively. At Hospital B, the prevalence of CM in children under 2 years was 11.8% while in children between ages 2 and 5 years, the prevalence was 6.3%; no case of CM was diagnosed in children between the age of 6 and 10 years in Hospital B.

Hospital C, the cases of CM were identified only among children between 2 and 5 years with a prevalence of 11.1%; no case of CM was diagnosed in children that were either under 2 years or between 6 and 10 years old. Children under the age of 2 years sampled at Hospital D had a prevalence of 6.7% for CM, while the prevalence of CM among children between 2 and 5 years at Hospital D was 17.2%; the prevalence of CM among children between ages 6 and 10 years at Hospital D was 18.8%.
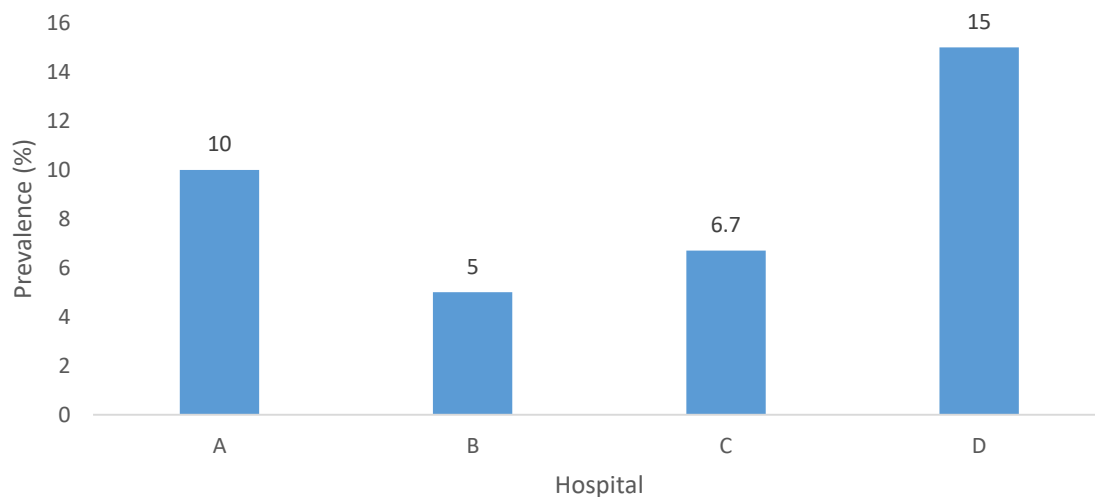

Fig 1: Prevalence of Cerebral Malaria in four Hospitals in Zaria
Hospital A = Hajiya Gambo Suwaba General Hospital; Hospital B = Muslim Specialist Hospital;
Hospital C = Major Ibrahim Balarabe Abdullahi Memorial Hospital; Hospital D = Ahmadu Bello University Teaching Hospital
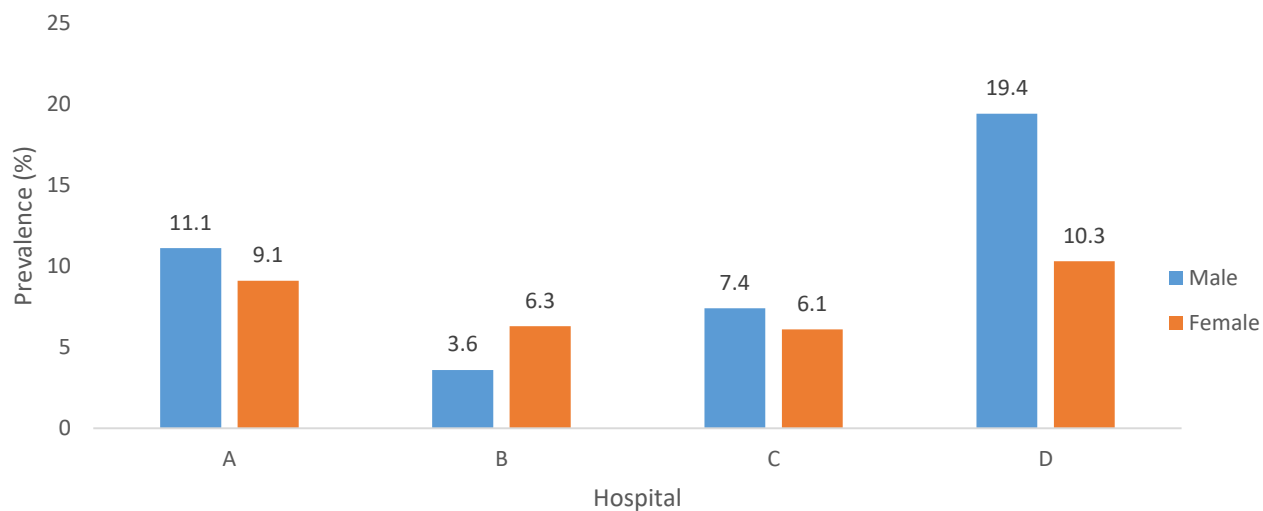
Fig. 2: Prevalence of CM among Participants by Gender
Hospital A = Hajiya Gambo Suwaba General Hospital;   Hospital B = Muslim Specialist Hospital;
Hospital C = Major Ibrahim Balarabe Abdullahi Memorial Hospital;   Hospital D = Ahmadu Bello University Teaching Hospital

Fig. 3: Prevalence of CM among Participants by Age
Hospital A = Hajiya Gambo Suwaba General Hospital; Hospital B = Muslim Specialist Hospital; Hospital C = Major Ibrahim Balarabe Abdullahi Memorial Hospital; Hospital D = Ahmadu Bello University Teaching Hospital
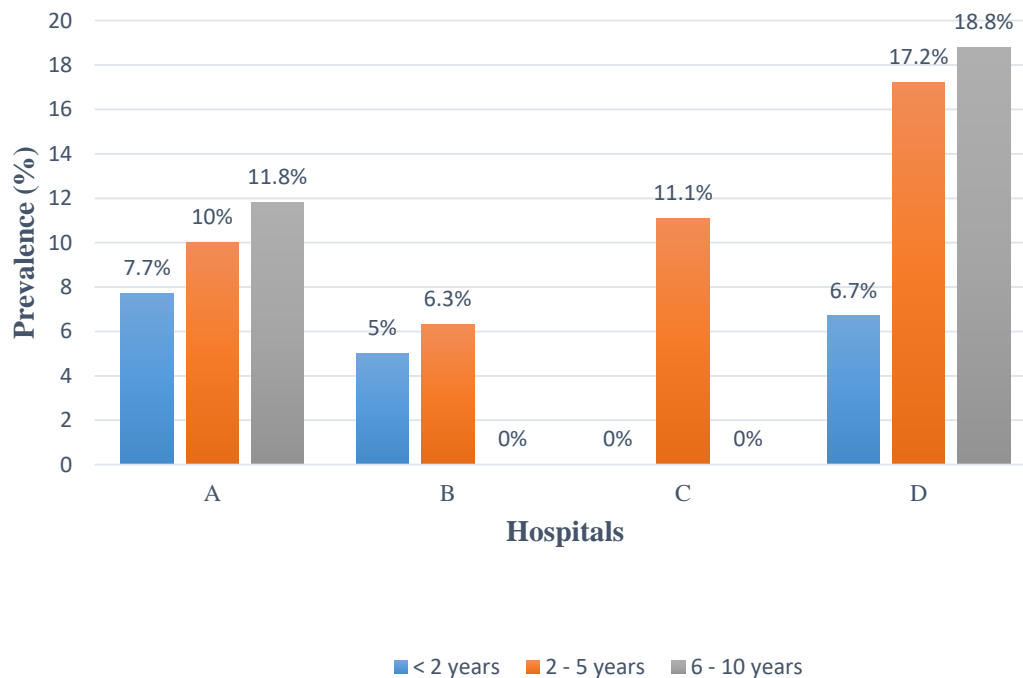
DISCUSSION

The overall prevalence of CM in this study (9.2%) is consistent with previous studies of Oladipo *et al.* (2022) and Eze *et al*. (2021) on malaria burden in Nigerian healthcare facilities and Hospital-based prevalence of malaria in Southeast Nigeria respectively. However, according to a study by Koffi *et al.* (2021) and Mboup *et al.* (2020), shows that CM prevalence in this study is lower compared to the study carried out in Ghana, where hospital-based studies reported a prevalence range of 12-18%. The highest number of cases was observed at Hospital D (15.0%) which is similar to the findings of Adetola and Oladimeji (2020) from other tertiary hospitals in South Western part of Nigeria. The elevated prevalence at Hospital D could be attributed to factors such as prompt medical care seeking, advanced diagnostic capabilities, or higher referral rates for complex cases. Hospital A (10.0%), Hospital C (6.7%), and Hospital B (5.0%) recorded lower prevalence rates. Although these variations were not statistically significant, they may reflect differences in case severity, hospital admission policies, and diagnostic capabilities.

Children below ten years of age are at the highest risk of developing CM due to their still-developing immunity. The study found that children aged 2–5 years had the highest prevalence (11.1%) which is consistent with the previous findings of Akindele *et al.* (2021) in Lagos with children under 5 years constituting the majority, reflecting their high vulnerability to infectious diseases. The sex distribution of children in the study, comprising 240 participants, revealed a higher percentage of females (52.9%) compared to males (47.1%). This trend was generally consistent across the four hospitals, with slight variations: Hospital A: Had 55.0% females and 45.0% males. Hospital B: Had 53.3% females and 46.7% males. Hospital C: Had 55.0% females and 45.0% males. Hospital D: Had 48.3% females and 51.7% males. These findings are similar to the study of Opara *et al.* (2022) who found minor differences in sex distribution.

The findings of this study highlight the continued burden of CM in pediatric populations in Nigeria. The relatively high prevalence of CM underscores the need for improved diagnostic protocols and timely treatment. Preventive measures such as the use of insecticide-treated nets must be scaled up, particularly in high-transmission areas.

CONCLUSION

Cerebral malaria remains a significant public health issue among children under the age of 10 in Zaria metropolis. The overall prevalence of 9.2% indicates a persistent disease burden, particularly in tertiary healthcare settings. This represents a higher ratio that needs public health concern given that Zaria is within a known malaria-endemic region in northern Nigeria. Male children had a higher prevalence of CM (10.6%) compared to female children (7.9%). However, males had a higher risk. Children under 2 years had a relatively low prevalence of CM at 5.0%. The prevalence peaked at 11.1% among those aged 2 to 5 years and was 9.4% for children aged 6 to 10 years. The findings of this study emphasize the need for targeted interventions, including improved diagnostic capabilities, enhanced malaria control measures, and public health education campaigns aimed at reducing the incidence of CM.

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