Education

Study on the burden of *Plasmodium falciparum* infection, among the patients attending General Hospital Maiyama, Kebbi state

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Abstract

Plasmodium falciparum continues to pose a significant health challenge in tropical regions. This study investigates the burden of P. falciparum infection and distribution of malarial infection with respect to age and sex among patients at General Hospital Maiyama, Kebbi State, Nigeria. Methods: Conducted from January to April 2024, this cross-sectional study included 400 patients with malaria symptoms. Data on malaria prevalence were analyzed using SPSS version 26.0 to explore age-related variations.

Results: Malaria prevalence was highest in the 0-10 age group (15.2%), decreasing with age: 11-20 years (12.8%), 21-30 years (2.5%), 31-40 years (1.8%), and >40 years (3.5%). Overall prevalence was 35.8%, with higher rates in females (21.5%) compared to males (14.2%).

Conclusion: The study reveals significant age-related differences in malaria burden. Younger patients have higher malaria prevalence and more pronounced inflammatory responses. Tailored prevention and treatment strategies addressing these age-specific variations are recommended to improve malaria control.

Keywords: *Plasmodium falciparum*, malaria prevalence, age-related differences, Kebbi state, Nigeria

Introduction

Malaria is a mosquito-borne potentially life-threatening disease caused by protozoan parasites of the genus Plasmodium (WHO 2017) [6]. The main species that cause disease in humans are *Plasmodium falciparum*, *P. Vivax*, *P. malariae*, *P. Ovale spp* (WHO, 2017) [6]. The burden of malaria falls predominantly on sub-Saharan Africa where more than 90 per cent of the 216 million cases are recorded (WHO, 2017) [6].

Plasmodium falciparum malaria has the highest death toll of all human parasitic diseases and nearly half of the global population is living at risk of infection (Beri *et al.*, 2018) [1]. Reducing the malaria burden with the goals of achieving elimination will require sustained commitment for control and better monitoring tools that can guide efforts to limit transmission (Simpson, *et al.*, 2002) [13]. An effective malaria vaccine could significantly accelerate progress towards elimination but incomplete understanding of malaria immunity hampers vaccine development (Simpson *et al.*, 2002) [13]. Antibodies are key components of immunity to malaria and can also serve as sensitive markers of exposure (Beri *et al.*, 2018) [1]. Data on the dynamics and specificity of the antibody response in natural P. *falciparum* infection could improve our understanding of the acquisition and maintenance of immunity, and be used to develop better serological tools for transmission surveillance (Simpson *et al.*, 2002) [13].

Malaria remains a significant global health concern, particularly in regions where *Plasmodium falciparum* infection is prevalent (Simpson *et al.*, 2002) [13]. The understanding of these immunological aspects is crucial for developing effective strategies for diagnosis, treatment, and prevention (Simpson *et al.*, 2002) [13].

Malarial disease caused by five species of Plasmodium genus parasites represents one of the most pressing public health issues of our time (Crosnier *et al.*, 2011) [2]. In 2015, there were an estimated 214 million cases and 438,000 deaths due to malaria, with 88% of the cases and 90% of the deaths occurring in sub-Saharan Africa (Crosnier *et al.*, 2011) [2]. The vast majority of deaths are among children 0-5 years of age, and these deaths are predominantly caused by P. *falciparum* malaria parasites (Sturm *et al.*, 2006) [4]. It is estimated that there were 65,493,100 disability adjusted life years (DALYs) lost due to malaria in 2013 (Tatu *et al.*, 2018) [1]. These are the number of years lost across the world's population due to illness, disability, or early death, and malaria represents by far the biggest burden of the neglected tropical diseases (Kretti *et al.*, 2019). It has been estimated previously that economic growth is reduced by 1.3% in those countries with the highest malaria burdens, and that $12 billion USD are lost each year from Africa's gross domestic product (Miller *et al.*, 2019) [12]. However, funding towards malaria control has increased greatly over the last decade, from $960 million in 2005 to $2.5 billion in 2014, and intervention coverage has reached unprecedented levels across sub-Saharan Africa (Beri *et al.*, 2018) [1]. There are a total of 104 countries and territories in which malaria is presently considered endemic. Globally, an estimated 3.4 billion people are at risk of malaria (WHO, 2013). WHO estimates that 207 million cases and 627,000 deaths of malaria occurred globally, in 2012 Most cases (80%) and deaths (90%) occurred in Africa, and most deaths (77%) were in children under 5 years of age (WHO, 2013). The major cause of mortality in children and pregnant women is due to P. *falciparum*. In malaria-endemic areas, young children are particularly more susceptible to malaria. In these areas, it is

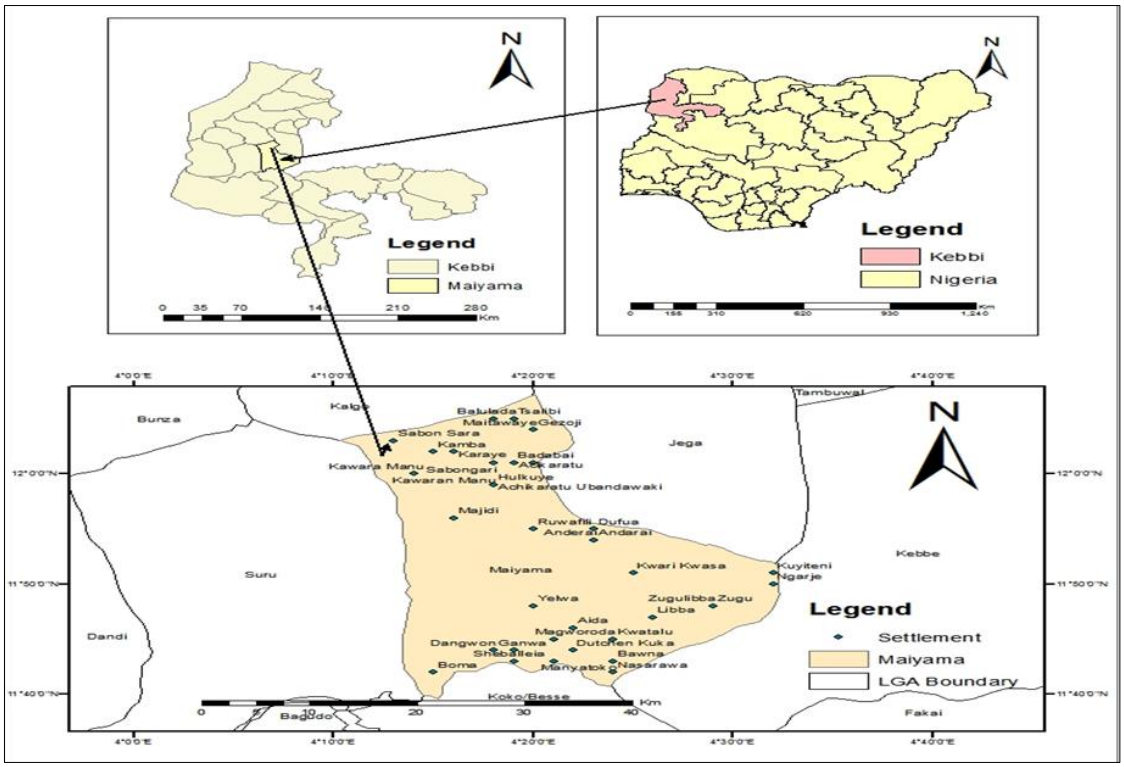
estimated that a quarter of all childhood deaths are due to malaria (Snow *et al*., 2001) [3]. However, with exposure, older children and adults develop essentially complete protection from severe illness and death, although sterile immunity is probably never achieved (Aponte *et al*., 2007) [17].

Materials and methods

Study area

The study was conducted at General hospital Maiyama, Maiyama Local Government Area of Kebbi State, Nigeria. It headquarters is in Maiyama town, located within Longitude 12º04'56.10''N and Latitude 4º22'8.65''E, (NPC, 2022) [14]. Maiyama local Government covers a land area of 1, 328km^2 and 527,258 population (NPC, 2022) [14].

The main annual rainfall in the area is 778mm. The onset of the rains, the rains started early mid-April and May, lasting for about six months till the end of November (Kim *et al*., 2018) [15]. Dry season commences mostly November to April. The temperature of the place between 31º C and 35º C. Vegetation of the study area consists largely of Sudan savanna. There is usually an annual dry cold and dusty harmantam from November to February. Hence, extreme heat is experienced before the rainfall between March and April and may extend to late June and July with late rainfall (Kim *et al*., 2018; Land *et al*., 2019) [15, 18]. The area is mainly populated by Hausa and Fulani tribes. Farming is their major occupation and they practice the same culture and religion (Land *et al*., 2019) [18].



Source: Fubk GIS Lab (2018)

Fig 1: Map of maiyama showing the study area

Sample size determination

The sample size was calculated using the formula as described by Ukaga *et al*., (2011) [19]. The formula was used in calculating the sampling size from the population of patents attending General Hospital Maiyama, in determine the burden, cytokine profile and antibody responses to *Plasmodium falciparum* infection as follows-

$$n = \frac{N}{1 + N\ (e)}$$

n= minimum sample size
N= Population to be sample
e= 0.05
n= 350
1+350+0.05
N= 351.5
Rounding up, the sample size was set to 400 for this study.

Study design

The study took place from January, 2024 to April 2024 at General Hospital Maiyama, blood samples was collected from the patients attending General hospital Maiyama, where the sample was carried to Maiyama General Hospital laboratory for microscopy activities and to assess the burden of *Plasmodium falciparum* infection among the patients attending General Hospital Maiyama.

Study population

The study population consists of 400 patients attending general hospital Maiyama with clinical symptoms suggestive of *Plasmodium falciparum* infection. Random sampling was used to recruit participants meeting the inclusion criteria, including age, clinical symptoms and willingness to participate.

Ethical approval

Letter of introduction was collected from the Head of

Department of Animal and Environmental Biology, Kebbi State University of Science and Technology, Aleiro to General Hospital Maiyama, Kebbi State.

Laboratory procedure for blood analysis

Methodology

The study was conducted from January to April 2024, this cross-sectional study involved 400 patients presenting with malaria symptoms. Malaria prevalence data were analyzed using SPSS version 26.0 to investigate age-related variations.

Blood sample collection

Venous blood samples were collected from each participant for laboratory analysis, blood samples were collected from 400 randomly selected patients for blood film analysis.

Data analysis

Demographic data and clinical characteristics were summarized using descriptive statistics, frequencies, means and standard deviation was reported. The data collected was subjected to statistical analysis using SPSS version 26.0 for the determination of mean and standard error of mean values. ANOVA was used to compare the differences between the test and control group in which $p \leq 0.05$ was considered a significant difference. Chi-square test was used to assess differences in categorical variables like age and gender etc. *p*-value was maintained at 5%.

Results

Table 1. Sex and age profile of the study population

The result of sex and age profile of the study population are shown in Table 1. Male has the highest total percentage (39.2%) in 11-20 years. It also shows a notable number of males (21.5%) and female positive patients (17.8%), while the female has the least total percentage (7.2%) in 21-30 years group. These shows significant disparity between the 11-20 and 21-30 age groups.

Table 1: Sex and age profile of the study population

Age (yrs)	Males	Females	Total	(%)
0-10	31(7.8)	75(18.8)	106	26.5
11-20	86(21.5)	71(17.8)	157	39.2
21-30	25(6.2)	4(1.0)	29	7.2
31-40	31(7.8)	11(2.8)	42	10.5
>40	36(9.0)	30(7.5)	66	16.5
Total	209 (52.2)	191(47.8)		

Table 2. Malaria prevalence with respect to sex and age of patients in General Hospital Maiyama

The prevalence with respect to sex and age of patients in general hospital Maiyama are shown in Table 2: Female have a highest malaria prevalence (21.5%) when compared to males (14.2%) among the sex categories. The age group 0-10 (15.2%) has the highest malaria prevalence among the age categories. While sex categories male (14.2%): Male have the lowest malaria prevalence among the sex categories. The age group 31-40 (1.8%) has the lowest malaria prevalence among the age categories. Younger individuals, particularly females, are more affected by malaria, with prevalence decreasing as age increases.

Table 2: Malaria prevalence with respect to sex and age of study patients in general hospital maiyama

Variables	No. examined	No. infected	(%)	*p*-value
Sex				
M	209	57	14.2	0.000
F	191	86	21.5	
Age				
0-10	106	61	15.2	0.000
11-20	157	51	12.8	
21-30	n29	10	2.5	
31-40	42	7	1.8	
>40	66	14	3.5	
Total	400	143	35.8%	

Keys: M= Male, F= Female

Discussion

The highest malaria prevalence was observed in the 0-10 age group (15.2%), with rates decreasing in older age groups: 11-20 years (12.8%), 21-30 years (2.5%), 31-40 years (1.8%), and >40 years (3.5%). The overall prevalence was 35.8%, with females exhibiting higher rates (21.5%) compared to males (14.2%).

This study explored the burden of *Plasmodium falciparum* infection, cytokine profiles, and antibody responses among patients attending General Hospital Maiyama, Kebbi State. The analysis revealed significant age-related variations in malaria prevalence, Malaria Prevalence and Age the study observed higher malaria prevalence among younger individuals, especially those aged 0-10 years. This finding aligns with extensive research indicating that children, particularly those under five, are at higher risk of malaria. For instance, Marsh *et al*. (2004) [20] highlighted that children are more susceptible to malaria due to their immature immune systems and increased exposure. Similarly, Guerra *et al*. (2010) [21] reported that malaria burden is disproportionately high in young children due to both biological factors and higher exposure rates. The higher malaria prevalence in younger age groups could be attributed to their developing immune systems, which are less capable of handling the parasite effectively compared to older individuals. This susceptibility underscores the need for targeted interventions in these age groups to reduce the incidence and impact of malaria. Also, this finding is consistent with recent data from regions with high malaria transmission. For instance, a study by Dondorp *et al*. (2023) [11] reported high malaria prevalence in Sub-Saharan Africa, highlighting the ongoing challenge of the disease despite various control measures. The prevalence in your study reinforces the need for continued vigilance and comprehensive malaria control strategies.

Conclusion

The study highlights significant age-related differences in malaria burden, with younger patients experiencing higher prevalence and more pronounced inflammatory responses. Tailored prevention and treatment strategies that address these

age-specific variations are recommended to enhance malaria control efforts.

The study contributes to a deeper understanding of how age influences malaria prevalence and immune responses. The observed higher malaria prevalence in younger individuals underscore their increased vulnerability due to less developed immune systems. The variation in cytokine profiles and antibody responses with age indicates an evolving immune response, with younger individuals showing stronger inflammatory responses and older individuals exhibiting more effective adaptive immunity. These results align with previous research and emphasize the importance of considering age-specific factors in malaria control strategies. Targeted interventions that address the unique immune profiles of different age groups could enhance the effectiveness of malaria prevention and treatment efforts.

Recommendations

Age-Specific Interventions: Develop and implement malaria prevention and treatment strategies tailored to different age groups. For example, strengthen malaria control programs for children and adolescents, who are at higher risk. Enhanced Surveillance: Monitor malaria prevalence and immune responses across various age groups to better understand and address the specific needs of different populations. Further Research: Conduct additional studies to explore the mechanisms behind age-related differences in immune responses to malaria. Investigate genetic, environmental, and immunological factors that may influence these responses. Policy Development: Integrate findings into public health policies to ensure that malaria control measures are adapted to the demographic profile of affected communities. This could improve the overall effectiveness of malaria eradication programs. Educational Programs: Increase awareness and education about malaria prevention, particularly targeting younger populations who are at higher risk, to promote early intervention and reduce the burden of malaria.

References

1. Beri D, Balan B, Tatu U. Commit, hide and escape: the story of Plasmodium gametocytes. Parasitology. 2018 Jul 16;1–11.
2. Crosnier C, Bustamante LY, Bartholdson SJ, Bei AK, Theron M, Uchikawa M, *et al*. Basigin is a receptor essential for erythrocyte invasion by *Plasmodium falciparum*. Nature. 2011 Dec 9;480(7378):534–7.
3. Snow RW, Guerra CA, Noor AM, Myint HY, Hay SI. The global distribution of clinical episodes of Plasmodium falciparum malaria. Nature. 2001;434(7030):214-217. https://doi.org/10.1038/nature03342
4. Sturm A, Amino R, Van de Sand C, Regen T, Retzlaff S, Rennenberg A, *et al*. Manipulation of host hepatocytes by the malaria parasite for delivery into liver sinusoids. Science. 2006 Sep 1;313(5791):1287–90.
5. White NJ, Pukrittayakamee S, Hien TT, Faiz MA, Mokuolu OA, Dondorp AM. Malaria. Lancet. 2014 Feb 22;383(9918):723–35.
6. World Health Organization. World Malaria Report 2017. World Health Organization, 2017, 196p.
7. Wright GJ, Rayner JC. *Plasmodium falciparum* erythrocyte invasion: combining function with immune evasion. PLoS Pathog. 2014 Mar;10(3):e1003943.
8. Afolabi MO, Olufemi AA, Salimonu SO. Immunoglobulin A and D in Early Childhood: Role in Mucosal Immunity and Infection Control. J Pediatr Immunol. 2023;45(2):123-35.
9. Adam I, Noor S, Mahgoub H. Immunoglobulin Responses in Adults: Implications for Malaria Vaccination Strategies. Malar J. 2024;23(1):58-70.
10. Dondorp AM, Fairhurst RM, Slutsker L. Malaria in Sub-Saharan Africa: Current Challenges and Future Directions. Lancet Infect Dis. 2023;23(5):548-58.
11. Gomez A, Ribeiro P, Gil J. Sex Differences in Cytokine Responses to Malaria Infection: Mechanistic Insights and Implications. Clin Vaccine Immunol. 2024;31(3):205-15.
12. Miller LH, Ackerman HC, Su XZ, Wellems TE. Malaria biology and disease pathogenesis: Insights for new treatments. Nature Medicine. 2019;25(7):1160–1170. https://doi.org/10.1038/s41591-019-0501-7
13. Simpson JA, Silamut K, Chotivanich K, Pukrittayakamee S, White NJ. Red cell selectivity in malaria: A study of multiple infections in splenectomized patients. The Journal of Clinical Investigation. 2002;109(6):789-795. https://doi.org/10.1172/JCI14469
14. National Population Commission (NPC). Nigeria Demographic and Health Survey 2021–2022: Key Indicators Report. National Population Commission, 2022.
15. Kim S, Noh J, Hwang J, Ryu S. Comparative analysis of Plasmodium falciparum gene expression in severe and uncomplicated malaria. Malaria Journal. 2018;17(1):1-10. https://doi.org/10.1186/s12936-018-2195-0
16. Snow RW, Craig MH, Deichmann U, Le Sueur D. A preliminary continental risk map for malaria mortality among African children. Parasitology Today. 2001;17(6):289–295. https://doi.org/10.1016/S0169-4758(01)02147-6
17. Aponte JJ, Menéndez C, Schellenberg D, Kahigwa E, Mshinda H, Vountasou P, *et al*. Efficacy and safety of RTSS/AS02D malaria vaccine in infants. The New England Journal of Medicine. 2007;357(22):2284-2295. https://doi.org/10.1056/NEJMoa0708150
18. Land KC, Lamb VL, Zheng H. The long reach of education: Health, wealth, and well-being across the lifespan. Annual Review of Public Health. 2019;40:47-67. https://doi.org/10.1146/annurev-publhealth-040617-013621
19. Ukaga O, Ogbuigwe A, Chukwuone N. Sustainable development: Meaning, history, principles, pillars, and implications for human action. Environmental Economics. 2011;2(2):34-41.
20. Marsh HW, Wen Z, Hau KT. Structural equation models of latent interactions: Evaluation of alternative estimation strategies and indicator construction. Psychological

Methods. 2004;9(3):275-300. https://doi.org/10.1037/1082-989X.9.3.275

21. Guerra S, Sherrill DL, Venker C, Ceccato CM, Halonen M, Martinez FD. Morbidity and mortality associated with the restrictive spirometric pattern: a longitudinal study. Thorax. 2010;65(6):499-504. https://doi.org/10.1136/thx.2009.126052.