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Determining the Trends of Different *Plasmodium* Species in Children 0 - 2-Year Post Administration Sulfadoxine and Pyrimethamine in Selected Hospitals in the Metropolitan District of Sierra Leone

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Abstract

Background: Malaria is an alarming health concern, particularly in children under the age of two. Studying and understanding the trends of different *Plasmodium* species in children under the age of 2 aids in making prevention and control strategies and also prevents misdiagnosis of *plasmodium* species. This study aims to determine the prevalence and trends of different *Plasmodium* species in children 0 - 2 years in Metropolitan District in Sierra Leone post administration of S-P. Methods: This study was a cross-sectional study with One Hundred and Fifty-Five (155) participants aged 0 - 2 years who had taken Sulfadoxine-Pyrimethamine prophylaxis were recruited. Samples were collected from participants for malaria parasite test at key tertiary Hospitals in the Metropolitan District. A Rapid Diagnostic Test (RDT) kit was used and for those participants with positive results, venous blood sample was taken for Microscopic both thin and thick film. Data was analyzed using SPSS. **Results:** From the total 155 samples collected, Ola During Children's Hospital had a total of 64, Rokupa Government Hospital had a total of 47 and Kingharman Maternal and Child Health Hospital of 44. Ninety-nine (64%) of our participants are females while 56 (36%) are males. Ninety percent (90%) of the participants had *P. falciparum* infection and *P. ovale* and *P. malariae* were recorded in 1% each of the participants. **Conclusion**: Majority of the participants had *Plasmodium* infections despite the administration of Sulfadoxine-Py-

rimethamine prophylaxis. More females were infected than males in this study and children in rural areas were more infected with malaria than children in urban areas. *P. falciparum* species shows the highest distribution in all three facilities.

Keywords

Plasmodium Trends, Plasmodium Species, Under-Two Children, Malaria, Sierra Leone

1. Introduction

Malaria remains a significant global health challenge, particularly in sub-Saharan Africa, where it disproportionately affects young children [1]. In 2019, it was estimated that malaria caused approximately 409,000 deaths, with children under five years old representing a substantial proportion of these fatalities [2]. Furthermore, in 2022, the WHO African Region accounted for 94% and 95% of malaria cases and fatalities, respectively, reflecting the disease's greatest burden (WHO, Malaria prevalence, 2023). In Sub-Saharan Africa (SSA) children continue to be the most susceptible to malaria and its fatalities. However, as a result in 2022 report, children under 5 years of age accounted for nearly 80% of all malaria deaths in the WHO African Region [3]. Children aged 2 - 12 months show a prevalence for malarial parasitemia, while those aged 12 - 60 months have a higher prevalence of malaria [4]. The vulnerability of infants and toddlers to malaria is primarily due to their immature immune systems, which are less capable of combating infections compared to older children and adults. In sub-Saharan African precisely countries like Sierra Leone and Democratic Republic of Congo, malaria is the leading cause of high infant mortality and morbidity [5]. After the bite, malaria is accompanied by fever, chills, sweating, headache, body and muscular aches, nausea, vomiting, and appetite loss are the first symptoms to appear [5].

As research indicates that clinical manifestations of malaria typically include fever, palmar pallor, and gastrointestinal symptoms which are specific to children under 2 [6]. Furthermore, malaria in infants under two years old can present with a variety of signs and symptoms, which may differ from those observed in older children and adults [7]. The treatment of *P. falciparum* malaria in children aged 0 - 2 years requires careful consideration of their unique physiological characteristics and the potential risks associated with antimalarial medications [8].

However, the treatment requires treatment guidelines such as first-line treatment for infants weighing ≥ 5 kg Artemisinin-based therapies (ACTs) are recommended, including artemether-lumefantrine (A-L) and artesunate-amodiaquine (A-AQ) [9].

For infants weighing < 5 kg the World Health Organization (WHO) advises using oral quinine as the primary treatment [10]. Although Artemisinin based Combination Treatments are generally preferred for uncomplicated malaria, their use in this weight category is limited, with artesunate-amodiaquine being the only

ACT registered for infants weighing ≥ 4.5 kg [11]. Thus, the main reasons for introducing Intermittent Preventive Treatment in Infant-Sulfadoxine and Pyrimethmine in infants aged 0 - 2 years, the S-P has been shown to reduce the risk of clinical malaria, anaemia, and hospital admissions in infants [11].

In areas where malaria transmission occurs year-round, infants often suffer repeated episodes of malarial illness [11]. IPTi-SP is administered three times during the first year of life at intervals corresponding to routine vaccination schedules [12].

However, the use of Sulfadoxine-Pyrimethamine ensures that infants receive preventive treatment at key points in their development [13]. Before April 1998, 73% of children under 2 years received less than the recommended target dose of 25 mg/kg sulfadoxine plus 1.25 mg/kg pyrimethamine [14]. However, between 1993-1999, the efficacy of S-P was monitored in 1,175 children under 24 months in western Kenya with intense malaria transmission. There was an inverse relationship between S-P dose (mg/kg) and probability of parasitological treatment failure by day 7 [10]. Sulfadoxine-pyrimethamine (S-P) has been studied for its effectiveness in treating and preventing malaria in children, particularly those under two years of age. Furthermore, S-P has been shown to be effective in treating uncomplicated *falciparum* malaria in children under two years old [15]. Studies indicate that appropriate dosing is crucial, as underdosing can lead to treatment failure. Additionally, due to the medication effectiveness, additional countries have implemented the usage of IPTi-SP [16], most notably Sierra Leone [17]. However, Sierra Leone as a nation did introduce IPTi-SP among pregnant women and children 0 - 2 years old. However, the intermittent preventive treatment of malaria in infants (IPTi) has shown to be a key malaria control strategy implemented in Sierra Leone, specifically targeting children aged 0 - 2 years [18]. This approach involves administering an anti-malarial drug, sulfadoxine-pyrimethamine (SP), alongside routine immunizations to reduce malaria prevalence in Under 2 children [12]. In addition to standard immunization and different immunization programs, the administration of IPTi consists of a treatment course of sulfadoxine-pyrimethamine between the ages of 10 - 14 weeks and 9 months. However, this study aims at determining the trend of This study aims to determine the prevalence and trends of different *Plasmodium* species in children 0 - 2 years of age in Metropolitan District in Sierra Leone post administration of S-P.

2. Methods

2.1. Study Design

This research employs a comparative cross-sectional study in children under 0 - 2 years of age at Ola During Children Hospital (ODCH), King Harman Maternal and Child Health Hospital (KHMCH), and Rokupa Government Hospital (RGH) to examine the trends of *Plasmodium* species these selected hospitals within the Metropolitan district of Sierra Leone. The study was conducted from July to November 2024 "While the study was done at one point in time, the term 'trends' is used to describe patterns and differences in the types of *Plasmodium* species

found at the different hospitals during the study period."

2.2. Study Population

The targeted population for this research were Children under the age of two years who visited the ODCH, KHMCH and RGH in the Metropolitan District of Sierra Leone post S-P. A total of 155 children were enrolled in this study after doctors' visits.

The children attending ODCH, KHMCH, and RGH for postnatal care and disease manifestation of febrile illness, confirmed evidence of receiving S-P, residence living in withing study site, no evidence of malnutrition, updated immunization record to date, and no allergy of S-P were included in this study. Children 0 - 2 years with complicated illnesses, have had multiple malaria episodes and had been treated with multiple antimalarial drugs as well as parents who failed to give consent for their minors to partake in the study were excluded from the study. Participants' demographics were obtained using questionnaire which was answered by either their parents or guardian during the course of this research.

2.3. Sampling Strategy

In this study a purposive sampling approach to select children under two years old who met our study criteria. These were kids who came to Ola During Children's Hospital (ODCH), King Harman Maternal and Child Health Hospital (KHMCH), or Rokupa Government Hospital (RGH) for postnatal care or because they had a fever, and who had already received Sulfadoxine-Pyrimethamine (S-P). Children were enrolled consecutively after seeing the doctor, so we included those who naturally came through each facility during our study period, from July to November 2024. The aim was to include a balanced number of participants from each hospital, based on the number of under-two patients they typically see, so that we could make fair comparisons between the three locations. The total sample of 155 children was drawn proportionally based on each hospital's usual patient volume and reflected the kinds of children normally seen there both in terms of age and the reasons for their visit.

We also looked at hospital records and clinic attendance logs to make sure our sample lined up with the broader under-two population served by each facility. This helped us feel confident that the children in our study were a good representation of the general population of young children attending these hospitals.

2.4. S-P Timing and Infection Risk

In Sierra Leone, Sulfadoxine-Pyrimethamine (S-P) is given to infants at 10 weeks, 14 weeks, and 9 months of age as part of the IPTi schedule. For this study, the date of each child's most recent S-P dose was recorded based on parent or guardian recall, and where possible, verified using child health cards.

The time interval between the most recent S-P dose and blood sample collection was calculated. Based on this, children were grouped into the following categories:

- 0 - 2 weeks (recent dose),
- 3 - 4 weeks, and
- More than 4 weeks (likely outside the expected protective window).

This interval was included as a variable in the statistical analysis to explore any relationship between time since S-P administration and the presence of *Plasmodium* infection.

2.5. Sample Collection and Analysis

All samples were collected with the aid of a standard operating procedure (SOP) by trained and qualified phlebotomists using two methods which are the Venipuncture technique and Finger pricking techniques (capillary). Rapid diagnostic testing was carried out on children with clinical symptoms of febrile illness as confirmed by the clinician. A venous blood sample was subsequently taken from participants who had positive RDT for blood smear analysis. Microscopic examination was performed only on children who tested positive by rapid diagnostic test (RDT) to confirm and speciate *Plasmodium* infections. This approach was chosen to optimize resources and reduce the workload associated with microscopy, as RDTs provide a rapid initial screen for malaria infection. Furthermore, both thick and thin smears were made, thick film for parasite density and thin film for speciation. The thin smears were put to air dry while the thick smears were directly stained using a 15% Giemsa working solution. The thin smears were fixed with absolute ethanol for 2 minutes, air dried and then stained with 3% Giemsa stain for 15 minutes.

The thick smears were fixed with absolute ethanol and then stained with Giemsa stain for 15 minutes after they were washed using deionized water.

2.6. Microscopic Examination of Blood Smears

Microscopic examination of blood smears using the times 100 oil immersion lens was used during this study. The thin film reading was done by counting white cells and identifying the different species of Plasmodium, whereas the thick film was observed by counting white cells against the parasite and then calculated according to Parasite density = number of parasites counted × 8000 white cells/μL/number of white cells counted.

The results were analyzed using statistical package such as SPSS.

Ethical clearance: Ethical clearance was obtained for the commencement of this research through the Sierra Leone Ethic Board.

3. Results

Generally, the observed distributions of *Plasmodium* species in these 3 facilities varied and the distribution were aligned to an overall distribution in varying sets. This section presents the analysis of malaria infection and plasmodium species distribution in children under the age of two in three selected hospitals in the Metropolitan district of Sierra Leone. The results are discussed through statistical analysis and testing with the study objectives and the existing literature on the

topic. The results are been presented in the following order.

Socio-demographic characteristics of study participants

Age distribution of Plasmodium species

Table 1 shows the distribution of plasmodium species by age categories. The ages are categorized into groups to aid in understanding age demographics and plasmodium species distribution. It helps identify the age category in which malaria infections are more prevalent or which ages are more susceptible to malaria. There were 13 cases of malaria in age category 0 - 6 all of which were *P. falciparum* no cases of *P. ovale* or *P. malariae*. Age category 7 - 12 months has the highest cases of 73 which includes *P. falciparum* (71), *P ovale* (1) and *P. malariae* (1). Age category 13 - 18 recorded 11 cases of which *P. falciparum* is only recorded. Age category 19 - 24 months has 58 cases all recorded for *P. falciparum*.

Table 1. Distribution of *Plasmodium* species by age.

	SPECIES			
AGE (months)	*P. falciparum*	*P. malariae*	*P. ovale*	Total (%)
0 - 6	13	0	0	13 (9)
7 - 12	71	1	1	73 (47)
13 - 18	11	0	0	11 (7)
19 - 24	58	0	0	58 (38)
Total	153	1	1	155

Below is a pie chart that gives a visual representation of the age distribution.

The pie chart age analysis shows a major distribution within the age category of 7 - 12 months which accounts for 47% (71 cases) of the total cases (Figure 1). The age category of 19 - 24 months also has also has a significant majority which represents 38% (58 cases) of the total. Age categories 13 - 18 and 0 - 6 months bear a minimum distribution of 9% (13 cases) and 7% (11 cases) respectively.

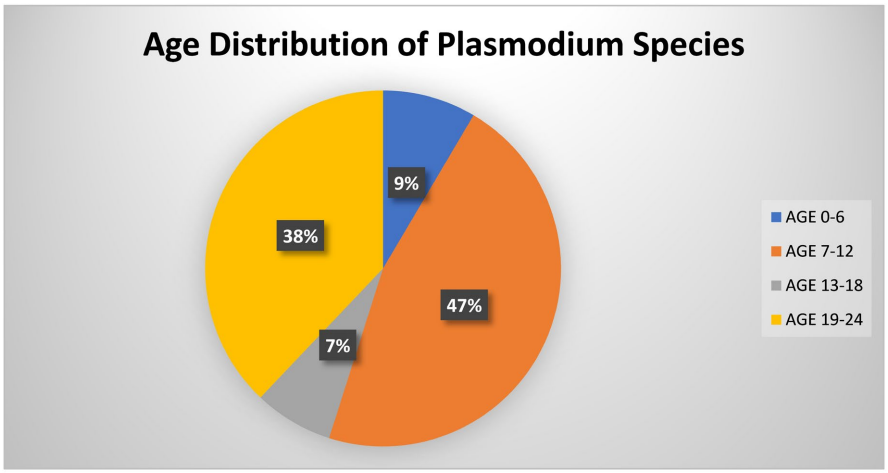

Figure 1. A pie chart showing the percentages of the age distribution of plasmodium species.

Sex distribution of plasmodium species

Table 2 shows the distribution of plasmodium species by sex of the total sample size. This is categorised into male and female. From the total sample population (n = 155), there were 99 cases (64% of the total population) for females which were all *P. falciparum* and 56 cases (36% of the total sample population) for males recorded which comprised *P falciparum* (54 cases), *P. malariae* (1 case), *P. ovale* (1 case).

Table 2. Distribution of *Plasmodium* species by sex from the total sample size.

	SPECIES			
SEX	*P. falciparum*	*P. malariae*	*P. ovale*	Total (%)
FEMALE	99	0	0	99 (64)
MALE	54	1	1	56 (36)
Total	153	1	1	155 (100)

Table 3 shows the distribution of *Plasmodium* species by sex from each study facility. ODCH recorded 38 cases for females and 26 cases for males leading to a total of 64 cases. There was a total of 47 cases from RGH, 31 were females and 16 were males. A total of 44 cases were recorded from KHMCH, 30 females and 14 males.

Table 3. Distribution of *Plasmodium* species by sex from each study facility.

FACILITY	SPECIES		
	Female	Male	Total
ODCH	38	26	64
RGH	31	16	47
KHMCH	30	14	44
Total	99	56	155

In Figure 2, ODCH shows a high representation of the sample size with its male and female cases being higher than the other two facilities. The female cases are slightly higher than those of the males. RGH and KHMCH are quite close in comparison.

Figure 3 shows a high distribution of *P. falciparum* in all three facilities. Both *P. malariae* and *P. ovale* show relatively low distribution.

Prevalence of *Plasmodium* species in children under the age of two

Table 4 represents the frequency distribution table which lists the occurrence of different *Plasmodium* species detected in the sample. The total number of valid cases analyzed was 64, which represents 63.4% of the total data. The remaining 37 cases which makes us about 36.6% of the data were marked missing. Valid species 1 (*P. falciparum*) constitutes 62 cases of 61.4% of the overall dataset and 96.9% of the valid cases (cumulative percentage). Valid species 2 (*P. malariae*) & 3 (*P. ovale*) had only one case each, representing 1.0% each of the overall data and 1.6% each

of the valid cases. Species 2 increased the cumulative percentage to 98.4% and species 3 concluded the cumulative percentage to 100% of the valid cases.

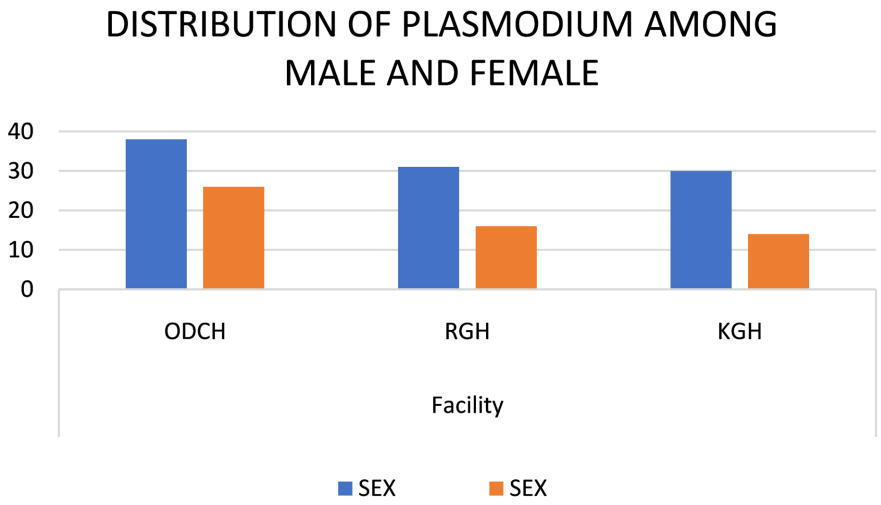

Figure 2. Bar chart showing the visual representation of the distribution of *plasmodium* species by sex in the three study facilities.

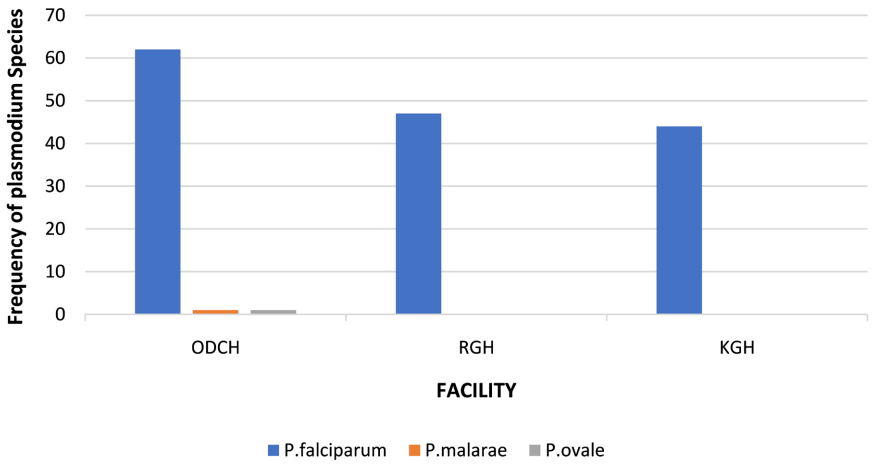

Figure 3. Distribution of *plasmodium* species in children under the ages of two in the ODCH, RGH, and KHMCH.

Table 4. Frequency distribution of *Plasmodium* species.

Cumulative distribution (Valid species)	SPECIES			Cumulative Percent
	Frequency	Per cent	Valid Percent	
ODCH	62	61.4	96.9	96.9
RGH	1	1.0	1.6	98.4
KHMCH	1	1.0	1.6	100.0
Total	64	63.4	100.0	
Missing system	37	36.6		
Total	101	100.0		

4. Discussion

Malaria remains to be a global burden and pose a health issue in children 0 - 2, and it is over diagnosed which result in treatment failure [19].

Mixed malaria infections are often difficult to detect, largely due to limitations in diagnostic approaches and the widespread use of rapid diagnostic tests (RDTs) that are specific to *Plasmodium falciparum* [20].

This study focused on examining the prevalence and trends of different *Plasmodium* species across three hospitals located in metropolitan districts of Sierra Leone using microscopy.

4.1. Age Characteristics

From the findings in this study, children aged 7 - 12 months accounted for 73 cases, representing 47% of the total sample's population, indicating that this age group is particularly vulnerable to malaria infections. This finding is comparable with other studies conducted in Malawi as it was shown that children 7 - 12 months are vulnerable [21]. A study conducted by also reported a significant prevalence of malaria in children over six months of age, with the peak mean age falling between 7 and 9 months [22]. Similarly, children aged 19 - 24 months constituted a high-risk group, with 58 cases, making up 38% of the total recorded case [23]. Additionally, [24] in a recent malaria indicator survey, reported malaria prevalence rates based on microscopic diagnostics of 17% among children aged 6 - 59 months in Guinea and 22% in Sierra Leone.

4.2. Sex Distribution Characteristics

Out of the total 155 cases recorded, 99 were female, while 56 were male, with the highest number of female cases reported at ODCH compared to KHMCH and RGH.

This highlights that female children were more frequently infected and hospitalized than males. This trend aligns with findings from [25] which similarly reported higher malaria infections and hospital admissions among females compared to males. Interestingly, the results also revealed a notable distribution of other *Plasmodium* species among male children.

4.3. Distribution of *Plasmodium* Species across Selected Facilities

4.3.1. Facility-Specific Distribution

ODCH reported the highest number of *Plasmodium* infections, accounting for over 40% of total cases and recording three distinct species: *P. falciparum* (90%), *P. malariae*, and *P. ovale* (1% each).

RGH reported slightly more cases than KHMCH, but both facilities had similar results, each representing over 20% of the total cases, with *P. falciparum* being responsible for 100% of the infections. These findings corroborate previous studies, such as that of *Bah* (2020), which identified a high prevalence of *P. falciparum* in Sierra Leone, while other *Plasmodium* species remain rare.

4.3.2. Environmental Distribution of *Plasmodium* Species

ODCH and RGH, located in semi-rural areas and adjacent slum communities, recorded higher cases of *Plasmodium* infections compared to KHMCH. Furthermore, KHMCH, is situated in a primarily urban highland area with no slum settlements, reported fewer cases. This observation aligns with [26], who demonstrated a higher prevalence of malaria among children living near lakeshores and slum areas compared to those in highland regions.

4.3.3. Prevalent *Plasmodium* Species in Children Aged 0 - 2 Years in Sierra Leone

P. falciparum emerged as the dominant species across the three selected hospitals, accounting for 90% of the total cases. This establishes *P. falciparum* as the primary Plasmodium species affecting children aged 0 - 2 years in Sierra Leone. Other *Plasmodium* species, such as *P. malariae* and *P. ovale*, contributed marginally to the overall malaria burden in this age group. These findings are consistent with [27] who identified *P. falciparum* as the most prevalent malaria species in Sierra Leone.

5. Conclusions

To understand the trends of different *Plasmodium* species in children 0 - 2 years who have been administered S-P. Analysis of *Plasmodium* species trends in children aged 0 - 2 revealed that *Plasmodium falciparum* was the most prevalent species, with a marked increase in cases in female compared to male.

This suggests that environmental factors, such as increased mosquito activity during the wet season, significantly contribute to the incidence of malaria in this vulnerable age group. Notably, the study revealed that *P. falciparum* is prevalent in slum settings and wharves as the hospital with the highest frequency happens to be in the said location.

Recommendations for Practical Action-Based on the study's conclusions, the following recommendations are proposed to address malaria prevalence effectively:

1) Strengthening Malaria Control Programs

Given that *P. falciparum* is the predominant species causing severe malaria in children under two years, malaria control efforts should prioritize this species. Preventive strategies such as the distribution of insecticide-treated bed nets, indoor residual spraying, and promoting early diagnosis and treatment must be strengthened.

2) Awareness Campaigns for Caregivers

Educational programs should focus on empowering caregivers to recognize early symptoms of malaria in young children. Prompt hospital visits when symptoms are identified can significantly improve treatment outcomes.

3) Implementation of Good Sanitation Practices

The Ministry of Health should enforce sanitation regulations, including regular community clean-ups and the establishment of effective drainage systems, partic-

ularly in malaria-prone areas.

4) Enhanced Malaria Surveillance and Research

Continuous monitoring and research on malaria trends in children under two years should be conducted across various districts. This will aid in detecting rising trends, tracking drug resistance, and identifying outbreaks involving other *Plasmodium* species.

6. Limitations

This study has several limitations. First, species identification was based solely on microscopy without molecular confirmation, which may limit accuracy in differentiating closely related *Plasmodium* species. Second, the study did not assess molecular markers of drug resistance, which could provide important information on treatment efficacy. Finally, the cross-sectional design did not allow for longitudinal follow-up to monitor changes in infection status or the effectiveness of S-P prophylaxis over time.

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Conflicts of Interest

The authors had no conflict of interest.

References

[1] Oladipo, H.J., Tajudeen, Y.A., Oladunjoye, I.O., Yusuff, S.I., Yusuf, R.O., Oluwaseyi, E.M., *et al.* (2022) Increasing Challenges of Malaria Control in Sub-Saharan Africa: Priorities for Public Health Research and Policymakers. *Annals of Medicine & Surgery*, **81**, Article 104366. https://doi.org/10.1016/j.amsu.2022.104366

[2] Al-Awadhi, M., Ahmad, S. and Iqbal, J. (2021) Current Status and the Epidemiology

of Malaria in the Middle East Region and beyond. *Microorganisms*, **9**, Article 338. https://doi.org/10.3390/microorganisms9020338

[3] Anjorin, S., Okolie, E. and Yaya, S. (2023) Malaria Profile and Socioeconomic Predictors among Under-Five Children: An Analysis of 11 Sub-Saharan African Countries. *Malaria Journal*, **22**, Article No. 55. https://doi.org/10.1186/s12936-023-04484-8

[4] Zehner, N., Adrama, H., Kakuru, A., Andra, T., Kajubi, R., Conrad, M., *et al.* (2021) Age-Related Changes in Malaria Clinical Phenotypes during Infancy Are Modified by Sickle Cell Trait. *Clinical Infectious Diseases*, **73**, 1887-1895. https://doi.org/10.1093/cid/ciab245

[5] Majambere, S., Pinder, M., Fillinger, U., Ameh, D., Conway, D.J., Green, C., *et al.* (2010) Is Mosquito Larval Source Management Appropriate for Reducing Malaria in Areas of Extensive Flooding in the Gambia? A Cross-Over Intervention Trial. *The American Society of Tropical Medicine and Hygiene*, **82**, 176-184. https://doi.org/10.4269/ajtmh.2010.09-0373

[6] Stauffer, W. and Fischer, P.R. (2003) Diagnosis and Treatment of Malaria in Children. https://academic.oup.com/cid/article/37/10/1340/451166

[7] Schumacher, R.F. and Spinelli, E. (2012) Malaria in Children. *Mediterranean Journal of Hematology and Infectious Diseases*, **4**, e2012073. https://doi.org/10.4084/mjhid.2012.073

[8] Aleshnick, M., Ganusov, V.V., Nasir, G., Yenokyan, G. and Sinnis, P. (2020) Experimental Determination of the Force of Malaria Infection Reveals a Non-Linear Relationship to Mosquito Sporozoite Loads. *PLOS Pathogens*, **16**, e1008181. https://doi.org/10.1371/journal.ppat.1008181

[9] Issa, M.S., Warsame, M., Mahamat, M.H.T., Saleh, I.D.M., Boulotigam, K., Djimrassengar, H., *et al.* (2023) Therapeutic Efficacy of Artesunate–Amodiaquine and Artemether–Lumefantrine for the Treatment of Uncomplicated Falciparum Malaria in Chad: Clinical and Genetic Surveillance. *Malaria Journal*, **22**, Article No. 240. https://doi.org/10.1186/s12936-023-04644-w

[10] Kalkman, L.C., Hanscheid, T., Krishna, S., Kremsner, P.G. and Grobusch, M.P. (2022) Antimalarial Treatment in Infants. *Expert Opinion on Pharmacotherapy*, **23**, 1711-1726. https://doi.org/10.1080/14656566.2022.2130687

[11] Esu, E.B., Oringanje, C. and Meremikwu, M.M. (2019) Intermittent Preventive Treatment for Malaria in Infants. *Cochrane Database of Systematic Reviews*, **2019**, CD011525. https://doi.org/10.1002/14651858.cd011525.pub2

[12] Fombah, A.E., Chen, H., Owusu-Kyei, K., Quinto, L., Gonzalez, R., Williams, J., *et al.* (2023) Coverage of Intermittent Preventive Treatment of Malaria in Infants after Four Years of Implementation in Sierra Leone. *Malaria Journal*, **22**, Article No. 145. https://doi.org/10.1186/s12936-023-04575-6

[13] Beshir, K.B., Muwanguzi, J., Nader, J., Mansukhani, R., Traore, A., Gamougam, K., *et al.* (2023) Prevalence of Plasmodium Falciparum Haplotypes Associated with Resistance to Sulfadoxine–Pyrimethamine and Amodiaquine before and after Upscaling of Seasonal Malaria Chemoprevention in Seven African Countries: A Genomic Surveillance Study. *The Lancet Infectious Diseases*, **23**, 361-370. https://doi.org/10.1016/s1473-3099(22)00593-x

[14] Terlouw, D.J., Nahlen, B.L., Courval, J.M., Kariuki, S.K., Rosenberg, O.S., Oloo, A.J., *et al.* (2003) Sulfadoxine-Pyrimethamine in Treatment of Malaria in Western Kenya: Increasing Resistance and Underdosing. *Antimicrobial Agents and Chemotherapy*, **47**, 2929-2932. https://doi.org/10.1128/aac.47.9.2929-2932.2003

[15] Amimo, F., Lambert, B., Magit, A., Sacarlal, J., Hashizume, M. and Shibuya, K. (2020) *Plasmodium falciparum* Resistance to Sulfadoxine-Pyrimethamine in Africa: A Systematic Analysis of National Trends. *BMJ Global Health*, **5**, e003217. https://doi.org/10.1136/bmjgh-2020-003217

[16] Sangho, O., Tounkara, M., Whiting-Collins, L.J., Beebe, M., Winch, P.J. and Doumbia, S. (2021) Determinants of Intermittent Preventive Treatment with Sulfadoxine-Pyrimethamine in Pregnant Women (IPTp-SP) in Mali, a Household Survey. *Malaria Journal*, **20**, Article No. 231. https://doi.org/10.1186/s12936-021-03764-5

[17] Buh, A., Kota, K., Bishwajit, G. and Yaya, S. (2019) Prevalence and Associated Factors of Taking Intermittent Preventive Treatment in Pregnancy in Sierra Leone. *Tropical Medicine and Infectious Disease*, **4**, Article 32. https://doi.org/10.3390/tropicalmed4010032

[18] Lahuerta, M., Sutton, R., Mansaray, A., Eleeza, O., Gleason, B., Akinjeji, A., *et al.* (2021) Evaluation of Health System Readiness and Coverage of Intermittent Preventive Treatment of Malaria in Infants (IPTi) in Kambia District to Inform National Scale-Up in Sierra Leone. *Malaria Journal*, **20**, Article No. 74. https://doi.org/10.1186/s12936-021-03615-3

[19] Orish, V.N., Ansong, J.Y., Onyeabor, O.S., Sanyaolu, A.O., Oyibo, W.A. and Iriemenam, N.C. (2016) Overdiagnosis and Overtreatment of Malaria in Children in a Secondary Healthcare Centre in Sekondi-Takoradi, Ghana. *Tropical Doctor*, **46**, 191-198. https://doi.org/10.1177/0049475515622861

[20] Kotepui, M., Kotepui, K.U., De Jesus Milanez, G. and Masangkay, F.R. (2020) Summary of Discordant Results between Rapid Diagnosis Tests, Microscopy, and Polymerase Chain Reaction for Detecting Plasmodium Mixed Infection: A Systematic Review and Meta-Analysis. *Scientific Reports*, **10**, Article No. 12765. https://doi.org/10.1038/s41598-020-69647-y

[21] Andronescu, L.R., Buchwald, A.G., Sharma, A., Bauleni, A., Mawindo, P., Liang, Y., *et al.* (2023) *Plasmodium falciparum* Infection and Disease in Infancy Associated with Increased Risk of Malaria and Anaemia in Childhood. *Malaria Journal*, **22**, Article No. 217. https://doi.org/10.1186/s12936-023-04646-8

[22] Dosoo, D.K., Adu, G.A., Kingsley, K., Odei-Lartey, E., Adomako, K., Atuguba, F., *et al.* (2024) Prevalence and Factors Associated with Malaria among Children Aged 6 Months to 10 Years in the Greater Accra Region of Ghana: A Community-Based Cross-Sectional Survey. *Malaria Journal*, **23**, Article No. 289. https://doi.org/10.1186/s12936-024-05109-4

[23] Ujuju, C.N., Mokuolu, O.A., Nwafor-Okoli, C. and Nnamani, K.O. (2023) Unravelling Factors Associated with Malaria Parasitaemia among Children 6–24 Months to Inform Malaria Interventions in Nigeria: Evidence from 2021 Malaria Indicator Survey. *Malaria Journal*, **22**, Article No. 247. https://doi.org/10.1186/s12936-023-04683-3

[24] Röbl, K., Fischer, H., Delamou, A., Mbawah, A.K., Geurts, B., Feddern, L., *et al.* (2023) Caregiver Acceptance of Malaria Vaccination for Children under 5 Years of Age and Associated Factors: Cross-Sectional Household Survey, Guinea and Sierra Leone, 2022. *Malaria Journal*, **22**, Article No. 355. https://doi.org/10.1186/s12936-023-04783-0

[25] Okiring, J., Epstein, A., Namuganga, J.F., Kamya, E.V., Nabende, I., Nassali, M., *et al.* (2022) Gender Difference in the Incidence of Malaria Diagnosed at Public Health Facilities in Uganda. *Malaria Journal*, **21**, Article No. 22. https://doi.org/10.1186/s12936-022-04046-4

[26] Hajison, P.L., Feresu, S.A. and Mwakikunga, B.W. (2018) Malaria in Children Under-Five: A Comparison of Risk Factors in Lakeshore and Highland Areas, Zomba District, Malawi. *PLOS ONE*, **13**, e0207207. https://doi.org/10.1371/journal.pone.0207207

[27] Koroma, J.M., Wang, Y.J., Guo, X., Zhang, X.Q., *et al.* (2022) A Cross-Sectional Survey on the Malaria Control and Prevention Knowledge, Attitudes, and Practices of Caregivers of Children Under-5 in the Western Area of Sierra Leone. *Tropical Medicine and Infectious Disease*, **7**, 1-17.