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Evaluating the Accuracy of Venous and Capillary Blood Collection in Malaria Diagnosis in Children 0-2year Post Administration Sulfadoxine and Pyrimethamine in Selected Hospitals in the Metropolitan District of Sierra Leone

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Abstract

Introduction: *Malaria remains a major public health challenge in Sierra Leone, particularly among children under five, with those aged 0–2 years most vulnerable due to immature immune systems. Preventive interventions, such as Sulfadoxine–Pyrimethamine (SP), have reduced malaria incidence and severity, yet accurate diagnosis remains critical. Malaria can be detected using microscopy, rapid diagnostic tests, or molecular methods, but result accuracy depends on blood sample quality. Venous collection provides larger volumes but is more invasive, while capillary sampling is quicker and less distressing for children. This study evaluates the accuracy of venous and capillary blood for malaria diagnosis post-SP administration, aiming to inform optimal pediatric practices.*

Method: *This comparative cross-sectional study was conducted from July to November 2024 in children aged 0–2 years at three selected hospitals (Ola During Children Hospital, King Harman Maternal and Child Health Hospital, and Rokupa Government Hospital) in Sierra Leone. A total of 150 children post-Sulfadoxine-Pyrimethamine administration were enrolled using purposive sampling. Blood samples were collected via venous and capillary methods for malaria diagnosis using RDTs and microscopy. Clinical assessments, parasite density counts, and demographic data were recorded. Ethical approval was obtained from the Sierra Leone Ethics Board.*

Results: *The maximum capillary parasite density was 450,000, while the venous parasite density was 100,000. Capillary samples therefore had significantly higher maximum recorded density than venous samples. The mean density of venous parasites was 9,988.83, whereas the capillary parasite density was 24,353.22; compared to venous samples, the average parasite density in capillary samples was more than double. The standard deviation of venous parasite density was 19,031.034, while that of capillary parasites was 65,530.911.*

Conclusion: *This study evaluated the accuracy of venous and capillary blood collection methods for malaria diagnosis and found that capillary samples consistently showed higher parasite densities compared to venous samples.*

Keywords: Venous, Capillary, Malaria, Plasmodium, Children.

Introduction

Malaria remains one of the most persistent public health challenges in Sierra Leone, especially among children under five years of age. Despite continuous national and international efforts, the disease still accounts for a significant proportion of hospital admissions and child mortality [1]. Children between 0–2 years are particularly vulnerable due to their developing immune systems and limited previous exposure to the malaria parasite [2]. The introduction of preventive interventions such as the use of Sulfadoxine and Pyrimethamine (SP) for intermittent preventive treatment has played a major role in reducing the incidence and severity of malaria among infants and young children. However, even with such preventive measures in place, accurate diagnosis remains central to effective malaria control and treatment [3].

Malaria diagnosis can be performed using different techniques, including microscopy, rapid diagnostic tests (RDTs), and molecular methods [4]. Regardless of the diagnostic approach, the accuracy of results is heavily dependent on the quality of the blood sample collected. In clinical and field settings, blood can be obtained either through venous collection (drawing blood from a vein) or through capillary collection (obtaining a small drop of blood from a fingertip or heel prick). Both methods have their advantages and limitations, but there are ongoing concerns regarding their relative accuracy, especially in pediatric populations where blood volume, sample handling, and comfort are important considerations [5].

Venous blood collection is generally considered the gold standard because it provides a larger volume, allowing for multiple tests and better quality control. However, it can be more invasive, technically demanding, and distressing for young children (Furqan Hasan et al. n.d.). Capillary blood collection, on the other hand, is less invasive, requires minimal equipment, and can be performed quickly, making it suitable for routine and field-based malaria diagnosis [4]. Furthermore, variations in sample quality, improper collection techniques, and microclot formation can influence test accuracy. Understanding how these two methods compare in real-world clinical settings is therefore vital to ensure that malaria diagnosis in children is both reliable and child-friendly [6].

This study, titled "Evaluating the Accuracy of Venous and Capillary Blood Collection in Malaria Diagnosis in Children 0–2 Years Post Administration of Sulfadoxine and Pyrimethamine in Selected Hospitals in the Metropolitan District of Sierra Leone," seeks to address this critical gap. By comparing the diagnostic outcomes from venous and capillary blood samples, the research aims to determine which method provides higher sensitivity, specificity, and reliability in detecting malaria infections among young children who have recently received S-P as a preventive measure. The study is particularly significant within the Sierra Leonean context, where malaria control remains a top health priority and healthcare facilities face challenges with laboratory resources and trained personnel. Ensuring that the most accurate yet practical sampling method is adopted could improve diagnostic efficiency, guide better treatment decisions, and ultimately strengthen malaria surveillance programs. In summary, this research does not only evaluate two blood collection methods but also contributes to improving diagnostic practices for malaria in vulnerable populations. The findings will provide evidence-based recommendations to health practitioners and policymakers, supporting the country's broader efforts to reduce malaria-related morbidity and mortality among children.

Methodology

Study Design

This research employs a comparative cross-sectional study in children 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 disease severity in positive cases of malaria infestation. The study was conducted from July to November 2024.

Study Site

Three well-known tertiary institutions in Sierra Leone Ola During Children Hospital (ODCH), King Harman Road Hospital (KGH) and Rokupa Hospital (RGH) were the sites for this research because of their reputation for providing high-quality paediatric care. Paediatric patients from all three sites provided samples, which were forwarded to the laboratory at Connaught Hospital for analysis in the Haematology and Microbiology Departments.

Study Population

The targeted population for this research were Children under the age of two years who visited the three hospitals in metropolitan district of Sierra Leone post S-P. A total of one-hundred and fifty (150) children were enrolled in this study after doctors' visits.

Inclusion Criteria

Participants were children between 0 and 2 years of age who had a confirmed diagnosis of malaria infection through either a rapid diagnostic test (RDT) or blood smear. Only those presenting within the targeted hospitals and residing in Freetown were included in the study. Additionally, legal guardian were required to sign parental consent to ensure ethical approval and compliance.

Exclusion Criteria

Children presenting with any severe illness unrelated to malaria, such as acute respiratory infections, severe malnutrition, or congenital disorders, were excluded to avoid confounding clinical factors that could influence blood parameters or interfere with accurate malaria diagnosis. Participants who had received blood transfusions, other antimalarial medications, or antibiotics within two weeks prior to recruitment were also excluded, as these could alter parasitemia levels or affect diagnostic outcomes. Additionally, children whose parents or guardians declined consent, as well as those who were uncooperative during blood sample collection, were excluded. Participants who were not within the designated age range (0–2 years), had not visited or been admitted to the selected hospitals, or had incomplete clinical or demographic data were also excluded from the study.

Sampling Strategy and Representativeness

Participants were recruited consecutively from children aged 0 to 2 years attending the three hospitals for postnatal care or febrile illness during the study period from July to November 2024. The study employed purposive sampling to include children who had received Sulfadoxine-Pyrimethamine (S-P) prophylaxis and met the inclusion criteria, ensuring a focus on those at risk for malaria infection in this age group. To ensure that the sample of 150 children was representative of the under-two population served by each hospital, the selection reflected the proportionate patient load at each facility based on hospital attendance records for children in this age range during the study period. Additionally, demographic characteristics such as age distribution, sex, and clinical presentation were compared with hospital records to confirm similarity with the broader population of children under two years attending these hospitals. This approach minimized selection bias and allowed findings to be generalized to the local under-two population receiving care at the participating hospitals.

Sample Size

The study required a minimum of 150 samples, which was determined using the unmatched cross-sectional study. The calculation was done using EPI INFO software version 7, with a 95% confidence level, a desired margin of error of 5%, a statistical power of 80%, and a Risk factor of 2.

Using the formula: $n = \frac{Z^2.P\,(1-P)}{E^2}$

Where n = sample size required

P= Estimated prevalence

E= margin of error

Confidence level = 95%, which corresponds to a Z-value of 1.96.

A total of 150 samples were collected for the study, distributed across the three hospitals as follows: Ola During Children's Hospital (ODCH) – 50 samples, Rokupa Government Hospital (RGH) – 40 samples, and King Harman Maternal and Child Health Hospital (KHMCH) – 60 samples, making a total of 150 participants.

Justification of Sample Size

This study included one hundred and fifty (150) in total. A precision-based method was used to select the sample size, with the goal of estimating the percentage of children with moderate to severe malaria with a 95% confidence level and a ±8% margin of error. A minimal sample size of about 150 individuals was shown to be adequate to generate accurate estimates, assuming an estimated prevalence of moderate-to-severe malaria of roughly 50% (to allow for maximum variability). This figure also took into consideration the possibility of data loss as a result of incomplete records or withdrawals. Therefore, it was decided that the final sample of 150 was sufficient to achieve the goals of the study.

Sample Collection Timing in Connection with S-P Dosing

Blood samples for malaria and hemoglobin testing were taken from children between 0 and 2 years old who came to the hospital with symptoms of fever. All children included in the study had already received at least one dose of Sulfadoxine-Pyrimethamine (S-P) through the national immunization program, which gives S-P at 10 weeks, 14 weeks, and 9 months of age. Because S-P is given based on age, the number of doses each child received depended on how old they were at the time they visited the hospital. Samples were not taken at a specific number of days after S-P was given instead, the children were tested when they showed signs of illness. The goal was to check how severe the malaria was in children who had previously received S-P. Information about S-P doses was confirmed using the child's health card or by asking their caregiver.

Sample Collection and Analysis

Sample was 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 prior by clinician. For every positive RDT sample, venous blood sample was implored for thick smear.

Capillary Malaria Confirmatory Analysis

Capillary malaria confirmatory analysis using Rapid Diagnostic Tests (RDTs) was carried out by obtaining small blood samples from a fingertip or heel prick of the participating children. The test was used to detect Plasmodium antigens, providing quick confirmation of malaria infection and supporting the comparison of capillary and venous blood diagnostic accuracy.

Microscopic Examination of Blood Smears

Microscopic examination of blood film was carried out using the x100 (oil immersion) magnification for parasite density count. Parasite density count was done by utilizing WHO standard for parasite density count using the following: Parasite density = number of parasites counted x 8000 white cells/µL/number of white cells counted. We assessed the distribution of parasite density using the Shapiro-Wilk test. Since the data were skewed, we applied a logarithmic transformation to normalize the distribution and meet the assumptions required for parametric statistical tests.

Malaria Diagnosis

Confirmation of malaria infection via blood RDT and microscopy for using further malaria test thick and thin smear.

Ethical Clearance

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

Results

In this chapter, we discuss into the analysis of data collected through cross sectional methods to explore the research questions outlined in earlier chapter. This analysis provides insights into correlations and significant outcome related to malaria diagnosis using capillary and venous blood collection. The result presented indicates a Pearson correlation analysis between hemoglobin levels and parasite density across a sample of 150 individuals from a general population.

Table 1: The table above helps to compare the distribution of individuals by gender across different age groups, providing insights into the demographic structure of the sample population.

Count	Age group (In Months)					
Sex		0-6	7-12	13-18	19-24	Total
	Female	8	44	9	31	92
	Male	2	21	6	29	58
Total		10	65	15	60	150

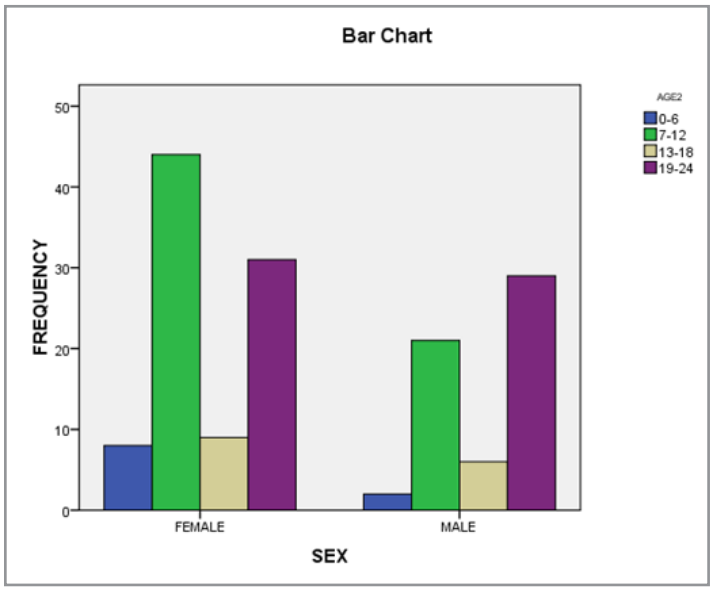

Figure 1: presents a bar chart illustrating the distribution of different age groups

The 0–6 months age group has the lowest frequency across both sexes. In the 7–12 months group, females show a significantly higher frequency, indicating a larger count in this category. The 13–18 months group exhibits notable differences, with more males than females. Finally, the 19–24 months age group shows equal representation, with similar frequencies observed for both sexes.

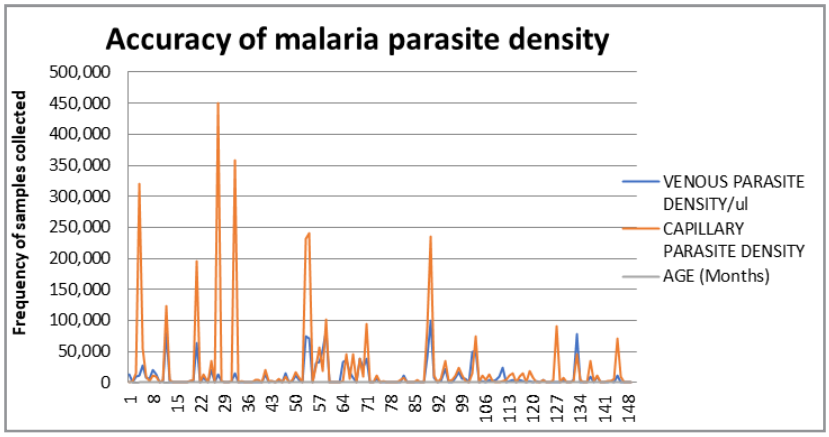

Figure 2: The chart above displays the accuracy of malaria parasite density Figure 2 compares three variables..

The venous parasite density, represented by the blue line, shows fewer peaks and is generally lower in frequency than the capillary measurements. This indicates that venous parasite density values are lower in some age groups compared to capillary measurements. The capillary parasite density, represented by the red line, exhibits repeated peaks at various ages, particularly between 2 to 6 months. These peaks reflect a considerable number of samples collected within that age range, indicating higher frequencies of parasite density assessments in those groups. The age in months, represented by the green line, serves as a reference point along the x-axis rather than a variable with fluctuating values, as the green line appears constant.

The y-axis indicates the frequency of samples collected and the x-axis indicates age in months

Table 2: Above is the table that summarizes the statistics for venous and capillary malaria parasite densities across 149 samples

Comparison between Capillary and Venous Sample Collection					
	N	Minimum	Maximum	Mean	Std. Deviation
VENOUS PARASITE DENSITY/ul	149	0	100000	9988.83	19031.034
CAPILLARY PARASITE DENSITY	149	0	450000	24353.22	65530.911
Valid N (listwise)	149				

These are the interpretations for each column:
The sample size (N) for both capillary and venous parasite densities was 149. The minimum values for both venous and capillary parasite densities were zero, indicating that some samples showed no detectable parasite presence. The maximum parasite density recorded in capillary samples was 450,000, while in venous samples it was 100,000, showing that capillary samples had significantly higher maximum densities. The mean parasite density for venous samples was 9,988.83, whereas for capillary samples it was 24,353.22; compared to venous samples, the average parasite density in capillary samples was more than double. The standard deviation for venous parasite density was 19,031.034, while that for capillary parasites was 65,530.911, indicating greater variation in parasite density measurements among capillary samples than in venous samples.

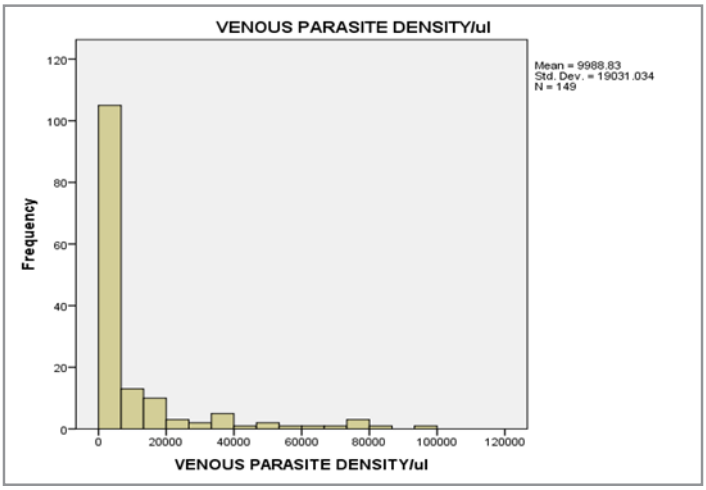

Figure 3: This graph is a histogram of venous parasite density it visualizes te distribution of venous parasite density across the 149 samples.

The frequency, represented on the y-axis, indicates the number of samples within specific ranges of venous parasite density, which are displayed along the x-axis. The distribution shows that the majority of samples fall within the lower density range of 0–20,000 parasites/µL, with a significant peak at the very low end. Only a few samples recorded parasite densities above 20,000, as the frequency drops substantially with increasing density.

Table 3: Shows the statistical analysis of capillary and venous method of parasite density analysis

Statistics analysis of the two methods				
		VENOUS PARASITE DENSITY/ul	CAPILLARY PARASITE DENSITY	Ages in month
N	Valid	149	149	149
	Missing	1	1	1
Mean		9988.83	24353.22	15.74
Median		1520.00	3200.00	13.00
Std. Deviation		19031.034	65530.911	6.637
Variance		362180268.321	4294300348.606	44.046
Minimum		0	0	4
Maximum		100000	450000	24

Valid (N): 149 samples (with 1 missing).

The mean venous parasite density is 9,988.83, representing the average parasite count across all samples. The median value of 1,520 indicates that half of the venous parasite densities fall below this point. The standard deviation of 19,031.034 suggests a high degree of variability in venous parasite densities among the samples. The variance, calculated as 362,180,528.321, represents the square of the standard deviation and further reflects the extent of variation within the dataset. The minimum recorded value is 0, indicating that some samples showed no detectable venous parasite density, while the maximum value of 100,000 represents the highest density observed.

Capillary parasite density

The valid sample size (N) is 149, with one sample missing from the dataset. The mean capillary parasite density is 24,353.22, indicating that the average parasite density in capillary samples is much higher than that observed in venous samples. The median value of 3,200 shows that half of the capillary parasite densities fall below this point, suggesting that while most samples have relatively low parasite counts, a few samples exhibit very high densities. The standard deviation, recorded at 65,530.911, reflects very high variability in capillary parasite density measurements—much greater than that observed in the venous samples.

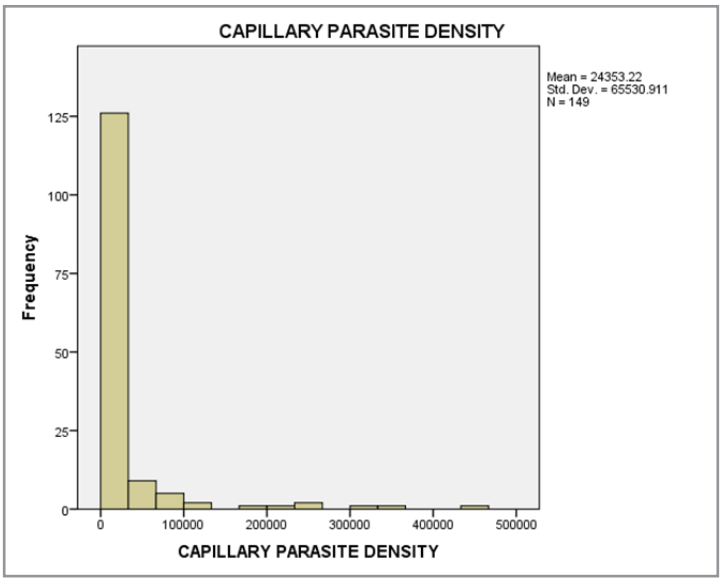

Figure 4: The chart above is a histogram showing the distribution of capillary parasite density among a sample group. This is an explanation of what it means.

The capillary parasite density, represented on the x-axis, ranges from 0 to 500,000, with values grouped into bins to display the frequency distribution. The y-axis shows the frequency, or the count of individuals within each parasite density range. The distribution indicates that most of the sample population has low capillary parasite density values, usually below 100,000, and is heavily skewed to the right, with only a small percentage of individuals exhibiting densities above this range. On average, individuals have a parasite density of 24,323.35, while the standard deviation of 60,350.91 reflects considerable variability within the group. The overall sample size (N) is 149.

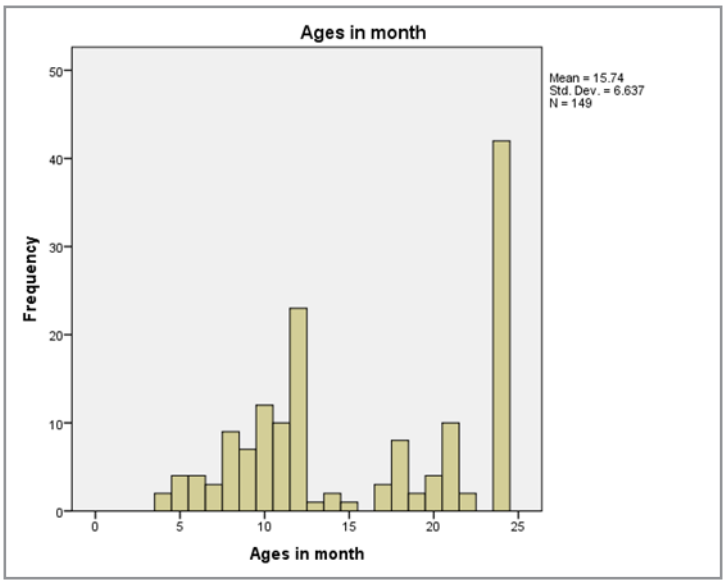

Figure 5: The table above shows the distribution of ages (in months) among 149 people in the sample group is shown in this histogram chart. Here's a detailed interpretation.

The x-axis, representing ages in months, displays individual ages ranging from 0 to 25 months, with values grouped into "bins" or intervals to illustrate the distribution. The y-axis indicates the frequency, or the number of individuals within each age range. The distribution shows peaks at 10 and 25 months, suggesting a somewhat bimodal pattern, with the highest frequency at 25 months, where a substantial portion of the population is concentrated. Smaller peaks are also observed around 8–10 months and 17–20 months. The mean age of the group is 15.7 months, with a standard deviation of 8.2 months, and the total sample size (N) is 149.

Discussion

This study compared the accuracy of two blood collection methods – venous and capillary – for determining malaria parasite density in children aged 0–2 years after administration of sulfadoxine–pyrimethamine (SP). Our findings show that capillary samples registered substantially higher parasite densities (mean = 24,353.22 parasites/µL) compared with venous samples (mean = 9,988.83 parasites/µL). In addition, the standard deviation for capillary samples (65,530.91) far exceeded that of venous samples (19,031.03), indicating greater variability in parasite counts with capillary sampling.

When set against existing literature, our results both converge with and diverge from previous studies. For instance, a study in Gabon found that capillary sampling led to higher parasitaemia estimates compared with venous blood (median 495 vs 429 parasites/µL; capillary ~16.6% higher) and also demonstrated improved diagnostic sensitivity in low density infections [7]. Similarly, a study in Ethiopia comparing capillary, venous and buffy coat methods found significantly higher mean parasite counts in capillary blood buffy-coat preparations (4,692.88 parasites/µL) compared to venous (631.43 parasites/µL) – highlighting how sample type may influence quantification [8].

On the other hand, some studies report no statistically significant difference in parasite density between capillary and venous compartments. For example, in Uganda, simultaneous capillary and venous samples in children and adults with uncomplicated malaria showed no meaningful difference in density throughout follow-up [9]. Likewise, in Sierra Leone, paired capillary and venous blood samples tested by two different PCR assays showed no significant difference in parasite detection Click or tap here to enter text.Our study revealed that children under two years, who had received S-P, presented notably higher parasite densities in capillary blood compared to venous samples [10]. This finding aligns with research suggesting that parasites may preferentially reside in the peripheral microvasculature (capillaries) due to sequestration in small blood vessels [11].

In the context of young children, whose vascular and immune systems are still developing, this peripheral localization might influence the observed higher capillary densities and greater variability in measurements [10]. This aligns with the idea that capillary beds may “trap” more parasites, thereby yielding higher parasite densities when sampled from capillary blood. The larger variability in capillary counts could reflect that phenomenon as well as heterogeneity of sample collection in young infants [12]. Our findings bear practical implications. Since capillary sampling is less invasive, more feasible in field settings, and appears to capture higher parasite loads (which may enhance sensitivity), it may be the preferred method for diagnosing and monitoring malaria in very young children especially in resource constrained settings. However, the wide variability suggests that standardising collection and processing remains critical if using capillary samples for quantitative assessments.

We must acknowledge limitations. Our study was cross sectional rather than longitudinal, so we cannot assess changes over time or the effect of repeated SP doses. Also, while we observe higher parasite counts in capillary blood, we cannot definitively attribute this to heavier parasite burden rather than methodological factors such as microclots, and sample volume differences. Further longitudinal and mechanistic studies especially in young children are needed to clarify whether capillary sampling is reliably more sensitive or simply yields higher counts due to microvascular factors. In summary, this study adds to the evidence base by demonstrating that in a cohort of children aged 0–2 years in Sierra Leone post SP administration, capillary blood sampling yielded higher parasite densities with greater variability than venous sampling [13]. While previous research has been mixed, the age specific focus and high parasite counts in our study suggest that capillary sampling may offer diagnostic advantages in young children. Ultimately, the choice of collection method should consider both practicality and the need for quantitative accuracy and our findings support prioritising capillary sampling in young children subject to standardized protocols.

Conclusion

As malaria is a burden of disease in Sub-saharan Africa, so it is in Sierra Leone affecting children 0-2 years with high morbidity and mortality. The aim of the study was to look into two different methods of detecting P.falciparum in children 0-2 years post S-P administration. The study revealed a notable difference between the capillary and venous blood collection methods for assessing parasite density. The capillary method showed higher parasite counts, likely due to differences in blood flow and sample collection areas. This suggests that the capillary method may be more effective for evaluating malaria parasite density, particularly in field-based settings.

Recommendations

Use Capillary blood as the gold standard for malaria diagnosis in healthcare settings, especially in high-risk groups (infants and immunocompromised individuals). Develop integrated diagnostic protocols combining capillary-based screening and venous based confirmation. Train healthcare workers in both methods to enhance diagnostic accuracy and reduce false negatives. Ensure accessibility to venous blood collection tools and microscopy or advanced diagnostic technologies in remote areas. Conduct large-scale studies to validate the findings across different malaria-endemic regions. Investigate the physiological factors contributing to age- and gender-based differences in parasite density. Explore innovative diagnostic tools that combine the practicality of capillary collection with the sensitivity of venous sampling.

Limitations of the Study

The study’s relatively small sample size may limit the generalizability of the findings. Larger studies are needed to confirm trends. Variability in diagnostic tools (e.g., microscopy versus PCR) may introduce inconsistencies in parasite density measurements. The study is limited to a specific region, which may not reflect conditions in other malaria-endemic areas. Broader age groupings may overlook subtle differences in diagnostic accuracy within narrower age ranges.

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