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# The Role of Oral Chloroquine Treatment in the Home-Based Management of Childhood Malaria in Jos, Nigeria: Biochemical, Hematological, Nutritional, and Co-Infection Perspectives

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## Abstract

**Research Background:** Malaria, predominantly caused by *Plasmodium falciparum*, continues to be a leading cause of morbidity and mortality among children under five years of age in sub-Saharan Africa. Malaria remains a significant public health challenge in Nigeria, particularly in regions where access to healthcare facilities is limited. Home-based management of malaria has emerged as a critical strategy to reduce disease burden, enabling timely treatment at the community level. Chloroquine, once the cornerstone of malaria treatment, is still utilized in some settings due to its affordability, availability, oral administration, and historical effectiveness against *Plasmodium* species. However, the widespread emergence of chloroquine-resistant strains of *Plasmodium falciparum* has necessitated a reevaluation of its role in malaria management. This study investigates the therapeutic effectiveness of oral chloroquine in home-based management, focusing on its ability to reduce parasitemia and alleviate clinical symptoms. Additionally, the study assessed the influence of protein nutritional status and bacterial/viral co-infections on malaria outcomes among children under five years in Jos, Nigeria, providing insights into its current relevance in resource-limited settings. **Research Objective:** Given the historical use of chloroquine and emerging reports of chloroquine-sensitive strains, this research aims to evaluate the therapeutic effectiveness of oral chloroquine in the home-based management of childhood malaria in Jos, Nigeria, by assessing its impact on parasitemia, symptom alleviation, biochemical and hematological profiles, nutritional status, and interactions with co-infections while providing evidence-based insights to inform policy, community health practices, and contemporary malaria control strategies.

**Methods:** This cross-sectional and analytical study evaluated the role of oral chloroquine in the home-based management of childhood malaria in Jos, Nigeria. A total of 93 children under five years of age, presenting with fever and confirmed *Plasmodium falciparum* parasitemia, were recruited from two hospitals in Jos. Participants were stratified into three groups: children treated with chloroquine at home prior to hospital presentation, untreated children with uncomplicated malaria, and untreated children with severe malaria. Caregivers were surveyed to assess the use of chloroquine as a first-line home treatment, including dosage and timing of administration. Ethical approval was obtained from the Jos University Teaching Hospital (JUTH) Ethical Committee, and informed consent was secured from caregivers before sample collection and interviews. Parasitemia levels were measured to correlate parasite density with clinical outcomes. Comprehensive assessments included biochemical analysis of serum creatinine, liver enzymes, and protein levels to evaluate organ function and metabolic status. Hematological parameters, including hemoglobin concentration and red blood cell (RBC) count, were measured to assess malaria severity and anemia. Nutritional status was evaluated through anthropometric measurements and serum protein analyses. Co-infections with bacterial and viral pathogens were identified using microscopic examination of blood samples. Statistical analyses were performed to identify significant associations between chloroquine treatment, clinical outcomes, and biochemical indicators. **Results:** Children treated with chloroquine demonstrated significantly lower parasitemia levels (18.13%) compared to untreated children with uncomplicated malaria (34.35%) and those with severe malaria (43.57%). Hemoglobin levels were notably higher in the chloroquine-treated group (9.60 g/dL) compared to the untreated groups, indicating a reduced burden of malaria-induced anemia. Body temperatures were significantly lower among chloroquine-treated children, underscoring its efficacy in fever reduction. Bacterial co-infections were identified in 54.35% of malaria cases, emphasizing their role in exacerbating disease severity. Liver and kidney function tests revealed no significant differences between the groups, indicating that chloroquine treatment did not result in hepatic or renal toxicity. Additionally, all participants exhibited adequate nutritional status, with no evidence of protein-energy malnutrition. **Conclusion:** The findings of this study highlight the significant role of oral chloroquine in the home-based management of childhood malaria in Jos, Nigeria. Children treated with chloroquine exhibited substantially lower parasitemia levels and higher hemoglobin concentrations compared to untreated children, demonstrating its effectiveness in reducing parasite burden and mitigating malaria-induced anemia. Additionally, chloroquine treatment was associated with lower body temperatures, reflecting its efficacy in fever control. Bacterial co-infections were present in over half of the malaria cases (54.35%), underscoring their potential contribution to disease severity and the need for integrated management strategies. Importantly, liver and kidney function tests showed no significant differences among the groups, indicating that chloroquine use did not lead to hepatic or renal toxicity. Furthermore, all participants maintained adequate

nutritional status, with no signs of protein-energy malnutrition. These results support the continued use of chloroquine as a viable option in the home-based management of uncomplicated malaria while highlighting the importance of addressing co-infections to improve clinical outcomes.

## Keywords

*Plasmodium falciparum*, Oral Chloroquine, Co-Morbidity, *Parasitemia*, Hematological Markers, Biochemical Indices

## 1. Introduction

Malaria, primarily caused by *Plasmodium falciparum*, remains a significant public health challenge in sub-Saharan Africa, with Nigeria bearing a disproportionate share of the global burden [1]. Children under five years of age are among the most vulnerable populations, with malaria contributing substantially to pediatric mortality despite concerted efforts to enhance prevention and treatment strategies [2] [3]. Home-based management of malaria (HMM) has emerged as an effective approach to ensure early diagnosis and treatment, reducing the progression to severe disease and alleviating the strain on healthcare facilities, particularly in resource-limited settings [4]-[6]. By delivering treatment at the community or household level, HMM has been shown to improve access to care, decrease travel costs and time, and reduce malaria-related morbidity and mortality [7] [8].

Historically, chloroquine, a 4-aminoquinoline, was the cornerstone of malaria treatment due to its affordability, efficacy, and ease of administration [9]. It played a pivotal role in HMM by enabling prompt household-level treatment, significantly reducing the malaria burden. However, the widespread emergence of chloroquine-resistant *P. falciparum* strains, attributed to mutations in the *pfcrt* gene, has diminished its effectiveness and led to its replacement by artemisinin-based combination therapies (ACTs) in many regions [10] [11]. Despite this shift, chloroquine continues to be utilized in some rural and underserved areas, particularly where healthcare infrastructure is limited, owing to its affordability and availability [12]. Reports of re-emerging sensitivity to chloroquine in parts of sub-Saharan Africa have reignited interest in its potential role in malaria management, particularly in regions with limited access to ACTs [13]-[15].

In rural settings such as Jos, Plateau State, Nigeria, where healthcare access remains constrained, oral chloroquine is still employed in the home-based treatment of suspected malaria cases [16]. This study investigates the efficacy of home-based oral chloroquine treatment in children under five years of age in Jos. Additionally, it evaluates biochemical and hematological factors contributing to malaria's clinical manifestations, the role of bacterial and viral co-infections, and the impact of protein nutritional status and anemia on malaria pathogenesis. By integrating these perspectives, the study aims to provide insights into the continued use of chloroquine in resource-limited settings and its broader implications for

childhood malaria management.

### Objectives

This study aims to evaluate the role of oral chloroquine in the home-based management of childhood malaria, with a specific focus on children under five years of age in Jos, Nigeria. The following specific objectives were delineated.

1) To evaluate hematological parameters and related indicators associated with malaria parasite infection in children under five years attending pediatric clinics at Jos University Teaching Hospital (JUTH) and Our Lady of Apostles (OLA) Hospital.

2) To investigate the effects of home-based oral chloroquine treatment on the pathogenesis of *Plasmodium falciparum* malaria using biochemical markers.

3) To examine the associations between bacterial and viral co-infections and *P. falciparum* malaria in children under five years.

4) To assess the influence of protein nutritional status on the clinical manifestations of *P. falciparum* malaria through anthropometric measurements and serum protein analyses.

5) To determine the impact of *P. falciparum* parasitemia on the severity of childhood malaria.

## 2. Materials and Methods

### 2.1. Study Design and Setting

This cross-sectional study was conducted at the pediatric units of Jos University Teaching Hospital (JUTH) and Our Lady of Apostles (OLA) Hospital, both located in Jos, Plateau State, Nigeria. The study targeted children under five years presenting with malaria symptoms. As a region endemic to malaria with seasonal transmission patterns, Jos provided an optimal setting to investigate home-based malaria management strategies.

### 2.2. Study Population and Inclusion Criteria

The study recruited children aged 6 months to 5 years who presented with febrile illness and tested positive for malaria parasites. Exclusion criteria included children with confirmed non-malarial illnesses, severe malnutrition, or prior treatment with medications other than chloroquine within the preceding two weeks.

### 2.3. Ethical Considerations

Ethical clearance was obtained from the Jos University Teaching Hospital Ethical Review Board (Ref: JUTH/DCS/ADM/127/XXII/646). Written informed consent was secured from parents or legal guardians before participant enrollment.

### 2.4. Sample Collection and Laboratory Analyses

#### 2.4.1. Hematological Assessments

Blood samples were collected for complete blood count analysis using a Coulter

Counter machine. Key hematological indices assessed included hemoglobin concentration, hematocrit, platelet count, and total and differential white blood cell (WBC) counts. Thick and thin blood films were prepared and examined microscopically to confirm *Plasmodium falciparum* parasitemia.

#### 2.4.2. Biochemical Analyses

Liver and kidney function markers, such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and serum creatinine, were evaluated to assess the physiological impact of malaria and chloroquine treatment. These markers provided insights into the biochemical alterations associated with malaria pathophysiology.

#### 2.4.3. Nutritional Assessment

Anthropometric measurements, including weight and height, were recorded to determine the children's nutritional status. Serum protein levels, including total protein and albumin, were measured to assess protein nutritional status and its potential influence on malaria outcomes.

#### 2.4.4. Co-infection Analysis

Blood film microscopy was employed to identify co-infections, including bacterial and viral pathogens, to evaluate their contribution to the clinical manifestations of malaria.

This methodological approach aimed to comprehensively analyze the hematological, biochemical, nutritional, and co-infection dynamics associated with malaria in the study population.

### 2.5. Statistical Analysis

Data analysis was conducted using SPSS software (Version 25). Descriptive statistics, including means and standard deviations, were employed to summarize continuous variables. Comparisons between groups, specifically between uncomplicated and severe malaria cases, were performed using the Chi-square test for categorical variables and independent t-tests for continuous variables.

## 3. Results

### Interpretation of Results: Tables 1-7

The data in Table 1 highlight significant differences in body temperature and anthropometric indices (age, weight, and height) between malaria-infected children (treated and untreated) and the control group of healthy children.

Children with untreated simple malaria (27.22 ± 4.18 months) were significantly older compared to controls (12.47 ± 1.60 months, $\mathbf{p < 0.05}$). The chloroquine-treated children (23.69 ± 3.67 months) and untreated severe malaria cases (19.00 ± 1.48 months) also showed significantly higher ages than controls ($\mathbf{p < 0.05}$).

A significant increase in weight was observed in the chloroquine-treated group

(10.68 ± 0.80 kg) compared to controls (8.42 ± 0.40 kg, **$p < 0.05$**). The untreated simple malaria group had higher weights (9.97 ± 0.97 kg), though not statistically different from chloroquine-treated cases. Severe malaria without treatment was associated with slightly lower weights (8.88 ± 0.44 kg), closer to control values.

**Table 1.** Measurements of body temperature and anthropometric indices in children under five attending JUTH and OLA hospitals in Jos metropolis.

| Treatment group | Age (months) | Weight (kg) | Height (cm) | Temperature (˚C) |
|---|---|---|---|---|
| Control | 12.47 ± 1.60 (47) | 8.42 ± 0.40 (47) | 71.27 ± 1.32 (47) | 36.80 ± 0.07 (47) |
| Choloroquine treated malaria | 23.69 ± 3.67[a*] (16) | 10.68 ± 0.80[a*] (16) | 81.96 ± 3.25[a*] (16) | 37.94 ± 0.30[a*] (16) |
| Simple malaria without treatment | 27.22 ± 4.18[a*] (23) | 9.97 ± 0.97 (23) | 83.69 ± 3.99[a*] (23) | 38.45 ± 0.25[a*] (23) |
| Severe malaria without treatment | 19.00 ± 1.48 (7) | 8.88 ± 0.44 (7) | 75.71 ± 5.20 (7) | 39.24 ± 0.47[ab*] (7) |

Tabulated values are means $\bar{X}$ ± S.E.M for (n) subjects given in parenthesis. *The mean difference is significant at the $p < 0.05$ level, and **at $p < 0.01$ level; [a]comparing respective malaria infected group with control; [b]comparing untreated severe malaria group with chloroquine treated malaria group.

**Table 2.** Parasitaemia and duration of fever in the under 5 years subjects presenting with malaria.

| Treatment status | Parasitemia (%) | Duration of fever (day) |
|---|---|---|
| Chloroquine treated (pre-admission) | 18.13 ± 0.49 (16) | 6.13 ± 1.45 (16) |
| Simple malaria without treatment | 34.35 ± 2.75* (23) | 3.39 ± 0.66 (23) |
| Severe malaria without treatment | 43.57 ± 5.49* (7) | 6.42 ± 2.53 (7) |

Tabulated values are means $\bar{X}$ ± S.E.M for n subjects given in parenthesis. *The mean difference is significant at the $p < 0.05$ level comparing untreated malaria groups with chloroquine treated (pre-admission).

**Table 3.** Results of malaria presenting with concurrent bacterial and viral infections in the under 5 years subjects.

| Concurrent microbial infection status* | № of subjects | Percentage (%) |
|---|---|---|
| Positive sepsis | 25 | 54.35 |
| Negative | 18 | 39.13 |
| Atypical lymphocyte | 3 | 6.52 |
| Total | 46 | |

*All subjects presented with *P. falciparum* malaria parasite infection.

**Table 4.** Malnutrition Index: Expected weight for age of the under 5 years subjects attending JUTH and OLA hospital in the Jos Metropolis.

| Treatment group | Average age (months) | Expected weight (kg) | Mean actual weight (kg) | № of subjects (n) | Percentage of expected (%) | Inference |
|---|---|---|---|---|---|---|
| Control | 12.47 | 10.08 | 8.42 | 47 | 83.53 | Normal (not malnourished) |
| Malaria cases | 24.74 | 12.12 | 10.05 | 46 | 82.92 | Normal (not malnourished) |

Tabulated values are means $\bar{X}$ ± S.E.M for (n) subjects given in parenthesis.

**Table 5.** Stunted Growth Index: Expected Height for Age in the under 5 years subjects attending JUTH and OLA hospital in Jos metropolis.

| Treatment group | Average age (months) | Expected height (cm) | Mean actual height (cm) | № of Subjects (n) | Percentage of expected (%) | Inference |
|---|---|---|---|---|---|---|
| Control | 12.47 | 83.24 | 71.27 | 47 | 85.62 | Normal (not malnourished) |
| Malaria cases | 24.74 | 89.37 | 81.88 | 46 | 91.62 | Normal (not malnourished) |

Tabulated values are means $\bar{X}$ ± S.E.M for (n) subjects given in parenthesis.

**Table 6.** The state of protein nutrition and kidney and liver functions of the under 5 years subjects as determined by respective biochemical indicators in the blood.

| Treatment group | Serum creatinine (μmol/L) | Serum albumin (g/l) | Serum total protein (g/l) | Serum globulin (g/l) | AST (IU/L) | ALT (IU/L) | ALK (IU/L) |
|---|---|---|---|---|---|---|---|
| Control | 76.74 ± 3.57 (47) | 37.63 ± 0.82 (47) | 67.33 ± 1.30 (47) | 30.18 ± 1.30 (47) | 8.87 ± 0.46 (47) | 8.57 ± 0.41 (47) | 190.08 ± 8.16 (47) |
| Untreated simple malaria | 81.52 ± 9.71 (23) | 37.35 ± 1.19 (23) | 71.78 ± 2.53 (23) | 35.09 ± 1.95[a*] (23) | 8.83 ± 0.58 (23) | 8.43 ± 0.61 (23) | 159.09 ± 11.56 (23) |
| Chloroquine treated malaria | 70.43 ± 6.70 (14) | 34.07 ± 1.90[ab*] (14) | 64.86 ± 3.89 (14) | 30.71 ± 2.38 (14) | 9.29 ± 0.99 (14) | 7.71 ± 0.91 (14) | 185.93 ± 25.53 (14) |
| Untreated severe malaria | 74.29 ± 20.91 (7) | 37.43 ± 1.02 (7) | 72.00 ± 2.98 (7) | 34.57 ± 2.59 (7) | 7.57 ± 1.13 (7) | 8.14 ± 1.16 (7) | 140.14 ± 19.05 (7) |

Tabulated values are means $\bar{X}$ ± S.E.M for n subjects given in parenthesis. AST-serum aspartate aminotransferase; ALT-serum alanine aminotransferase; ALK-serum alkaline phosphatase. *The mean difference is significant at the $p < 0.05$ level. [a]between the control and the respective malaria presenting groups and [b]between chloroquine treated and simple malaria group.

**Table 7.** Measurement of hematological indices of malaria in children under 5 years presenting with malaria in Jos metropolis.

| Treatment group | RBC count ($\times 10^6$/μL) | Haemoglobin concentration (g/dl) | Haematocrit (%) |
|---|---|---|---|
| Control | 4.38 ± 0.09 (20) | 10.52 ± 0.16 (20) | 33.96 ± 0.48 (20) |
| Simple malaria without treatment | 2.92 ± 0.39[a*] (6) | 7.23 ± 1.01[a*] (6) | 23.70 ± 3.37[a*] (6) |
| Chloroquine TREATED malaria | 4.01 ± 0.21[b*] (9) | 9.60 ± 0.51[b*] (9) | 30.97 ± 1.43[b*] (9) |

Tabulated values are means ± S.E.M for n subjects given in parenthesis. * The mean difference is significant at the ($p < 0.05$) level; [a]The mean difference is significant ($p < 0.05$) compared to the control; [b]The mean difference is significant ($p < 0.05$) compared to untreated simple malaria group.

Children in the chloroquine-treated group (81.96 ± 3.25 cm) and the simple malaria group (83.69 ± 3.99 cm) were significantly taller than the controls (71.27 ± 1.32 cm, **$p < 0.05$**). Severe malaria cases showed intermediate height values (75.71 ± 5.20 cm), which were lower than those of other malaria-infected groups but not significantly different from the control group.

Malaria-infected children, regardless of treatment, demonstrated significantly elevated body temperatures compared to controls (36.80˚C ± 0.07˚C). Chloroquine-treated cases had a mean temperature of 37.94˚C ± 0.30˚C, while untreated simple malaria and severe malaria cases showed higher temperatures of 38.45˚C ± 0.25˚C and 39.24˚C ± 0.47˚C, respectively (**$p < 0.05$**). Notably, severe malaria cases exhibited significantly higher temperatures than chloroquine-treated cases (**$p < 0.05$**, indicated by **b**). The findings suggest that malaria infection is associated with elevated body temperature in children under five years of age. Chloroquine treatment appears to mitigate the severity of fever compared to untreated malaria cases. These results underscore the importance of prompt and effective antimalarial treatment in managing childhood malaria and mitigating its adverse effects on health outcomes.

Table 2: Parasitaemia and Duration of Fever in Children under 5 Years Presenting with Malaria. This table shows that parasitaemia was significantly lower (18.13% ± 0.49%) in chloroquine-treated children before hospital admission compared to untreated children with simple malaria (34.35% ± 2.75%) and severe malaria (43.57% ± 5.49%) ($p < 0.05$). However, there was no significant difference in parasitaemia between the untreated simple and severe malaria groups ($p > 0.05$). Fever duration was not significantly different across the groups, with an average hospital presentation time of 4.80 days. These findings suggest a potential beneficial effect of chloroquine in reducing parasitaemia but indicate that malaria severity may not be solely determined by the duration of fever prior to hospital admission.

Table 3: Concurrent Microbial Infections in Children with Malaria. This table highlights the prevalence of bacterial and viral co-infections among the subjects. Of the 46 malaria cases, 54.35% (25 children) presented with bacterial infections, 6.52% (3 children) had viral infections, and 39.13% (18 children) had malaria without co-infection. The data underscore the importance of addressing bacterial co-infections, which were more frequently associated with severe malaria cases, as part of comprehensive malaria management strategies.

Table 4: Malnutrition Index. The malnutrition index, as determined by the expected weight-for-age, indicates that the children in both the malaria (82.92%) and control (83.53%) groups were not malnourished. These findings suggest that protein-energy malnutrition was not a contributing factor to malaria susceptibility or severity among the study population.

Table 5: Stunted Growth Index. The expected height-for-age values reveal that neither group exhibited signs of stunted growth. The control group had an index of 85.62%, while the malaria group had a slightly higher index of 91.62%. This indicates that the children studied were not experiencing chronic malnutrition or

growth retardation.

Table 6: Biochemical Indicators of Kidney and Liver Function. Serum biochemical markers showed no significant alterations in kidney and liver function among malaria patients compared to controls. However, lower levels of serum albumin were observed in the chloroquine-treated group (34.07 ± 1.90 g/L) compared to controls (37.63 ± 0.82 g/L, $p < 0.05$), indicating a possible transient effect of chloroquine on protein synthesis or metabolism. The lower serum albumin levels in chloroquine-treated children are likely multifactorial, reflecting a combination of malaria-induced inflammatory responses, altered hepatic synthesis, vascular leakage, and possibly the pharmacological effects of chloroquine. These changes are often transient and resolve as the infection subsides and homeostasis is restored. The elevated levels of serum globulin in untreated simple malaria cases (35.09 ± 1.95 g/L, $p < 0.05$) compared to controls suggest an immune response to infection. Liver enzymes (AST, ALT, ALK) remained within normal ranges across all groups, reflecting no significant liver damage associated with malaria or its treatment.

Table 7: Hematological Indices. Hematological measurements show that the RBC count, hemoglobin concentration, and hematocrit were significantly lower in untreated simple malaria cases compared to controls ($p < 0.05$), indicating mild anemia. Chloroquine-treated children exhibited significantly improved hematological indices compared to untreated malaria cases, with values comparable to controls. This supports the protective role of chloroquine in mitigating red blood cell destruction by *P. falciparum*. For untreated malaria, hemoglobin concentration (7.23 ± 1.01 g/dL) indicated mild anemia, while chloroquine-treated children (9.60 ± 0.51 g/dL) and controls (10.52 ± 0.16 g/dL) were within the normal range.

In summary, the findings across all tables collectively demonstrate.

**1) Efficacy of chloroquine**: Chloroquine significantly reduced parasitaemia and improved hematological indices, suggesting its utility in early home-based malaria management.

**2) Co-infection dynamics**: Bacterial co-infections were prevalent and associated with more severe disease, highlighting the need for early diagnosis and management of concurrent infections.

**3) Nutritional and biochemical context**: The absence of malnutrition and normal kidney/liver function markers suggest that these factors did not exacerbate malaria severity in this population.

**4) Anemia and parasitemia correlation**: The protective effect of chloroquine extended to minimizing anemia, a key complication of malaria.

These results underscore the importance of integrated approaches to managing childhood malaria, emphasizing prompt home-based treatment, effective control of co-infections, and comprehensive monitoring of hematological and biochemical markers.

## 4. Discussion

The results from this study provide a comprehensive evaluation of the biochemical,

hematological, nutritional, and co-infection factors influencing the outcomes of home-based chloroquine treatment for childhood malaria in Jos, Nigeria.

The observed lower mean age in the control group (12.47 ± 1.60 months) compared to malaria groups aligns with findings from studies examining demographic patterns in healthcare settings. Younger children are more likely to attend child welfare centers for immunizations, whereas older children, particularly those under five presenting with severe or complicated conditions like malaria, are more often seen in emergency pediatric units. This demographic distinction significantly impacts observed anthropometric differences, such as weight and height, which are primarily influenced by age-related growth variations [17] [18].

**Temperature Regulation and Anthropometric Indices**: The significantly lower body temperatures in chloroquine-treated malaria children compared to those with untreated severe malaria (**Table 1**) highlight chloroquine's potential role in moderating fever severity. This agrees with the study carried out by Nwaneri, Sadoh and Ibadin [19]. Based on this study, HMM reduced the severity of malaria compared with cases that did not receive HMM. This effect is consistent with chloroquine's antipyretic properties and its ability to reduce parasitaemia, as evidenced in **Table 2**. This finding corroborates with other studies that confirm the antipyretic activities of the drug [20] [21], especially in uncomplicated cases [22]. Anthropometric indices (**Table 4** and **Table 5**) showed no significant deviations in nutritional status among the groups, indicating that malnutrition was not a confounding factor in the observed clinical outcomes. The result from this study also agrees with other studies, confirming that malnutrition is not a major contributory factor in the clinical outcome of malaria in this group of children [23]-[25].

**Impact of Chloroquine on Parasitaemia: c**hloroquine-treated children exhibited significantly lower parasitaemia levels (**Table 2**), underscoring its efficacy in reducing Plasmodium falciparum load in home-treated cases. This confirms previous studies carried out [16] [22]. The absence of significant differences in parasitaemia between untreated simple and severe malaria cases further suggests that factors beyond parasite density, such as host immune response and co-infections, contribute to disease severity, which is supported by [26] [27]. The absence of significant differences in parasitaemia between untreated simple and severe malaria cases suggests that disease severity is influenced by factors beyond parasite density, such as host immune responses, genetic predisposition, and co-infections. This highlights the need for a holistic approach to malaria management that addresses both parasite clearance and host-related factors contributing to severe outcomes.

**Co-infections and Malaria Severity:** The high prevalence of bacterial (54.35%) and viral (6.52%) co-infections among malaria-positive children (**Table 3**) highlights the interplay between co-infections and malaria severity. Co-infections play a critical role in malaria severity by amplifying immune dysregulation, either through heightened inflammatory responses or immune suppression, which can

worsen malaria outcomes [26]. Interactions with bacterial, viral, or other parasitic infections may exacerbate systemic inflammation, impair pathogen clearance, and increase the risk of severe complications [28]-[31], emphasizing the need for integrated diagnostic and therapeutic approaches in malaria-endemic areas.

**Biochemical Indicators of Protein Nutrition and Organ Function:** Serum albumin concentrations were significantly lower in chloroquine-treated children compared to controls (**Table 6**). This reduction could reflect a transient protein redistribution associated with malaria-induced inflammation rather than chronic protein malnutrition, as total protein levels were not significantly different among groups. The observed reduction in serum albumin concentrations among chloroquine-treated children compared to controls indicates potential disruptions in protein metabolism, hepatic function, or systemic inflammatory responses associated with the drug. Chloroquine may influence albumin synthesis in the liver, potentially through hepatotoxic effects or modulation of inflammatory pathways [32]. Decreased albumin levels could have significant physiological implications, including impaired transport of essential biomolecules (e.g., hormones, fatty acids, and pharmaceuticals) and diminished oncotic pressure, which may contribute to edema or exacerbate malnutrition [33]. These findings highlight the importance of monitoring hepatic function and nutritional status in children receiving chloroquine therapy to address potential adverse effects. Additionally, normal serum creatinine levels across all groups indicate preserved renal function despite the severity of malaria. The lack of significant changes in liver enzyme activities (AST, ALT, ALK) across the groups suggests that hepatic function remained uncompromised in the study population.

**Hematological Outcomes:** The hematological indices (**Table 7**) demonstrated a protective effect of chloroquine against malaria-associated anemia. Chloroquine-treated children had significantly higher red blood cell counts, hemoglobin concentrations, and hematocrit levels compared to untreated simple malaria cases, and these values were comparable to the control group. This finding indicates that chloroquine not only mitigates parasite-induced erythrocyte destruction but may also preserve erythropoiesis during infection. The significantly higher red blood cell counts, hemoglobin concentrations, and hematocrit levels in chloroquine-treated children compared to untreated simple malaria cases indicate that chloroquine treatment effectively mitigates malaria-induced anemia. Malaria typically causes anemia through hemolysis of infected red blood cells, suppression of erythropoiesis, and immune-mediated destruction of uninfected red cells [34] [35]. The restoration of these hematological parameters to levels comparable to the control group suggests that chloroquine not only eliminates parasitemia but also allows recovery of erythropoiesis and reduces hemolytic processes. This finding highlights the therapeutic benefits of chloroquine in addressing one of the key complications of malaria—anemia—which can significantly impact the health and recovery of infected individuals, particularly children. It underscores the importance of timely treatment to prevent severe anemia and its associated risks,

such as fatigue, impaired growth, and increased susceptibility to other infections. However, the residual effects suggest the need for ongoing recovery monitoring and possible supportive care. Further investigation into how chloroquine influences erythropoiesis and red blood cell turnover could provide valuable insights into optimizing its use in malaria management.

## 5. Conclusions

The findings from this study provide robust evidence supporting the beneficial role of home-based oral chloroquine treatment in managing childhood malaria in Jos, Nigeria. Chloroquine effectively reduces parasitaemia and fever severity, mitigates hematological complications, and preserves nutritional and organ function indices in treated children. However, the high prevalence of co-infections, particularly bacterial sepsis, highlights the need for comprehensive management strategies that include early identification and treatment of co-morbid infections.

The absence of significant nutritional deficiencies among the study participants suggests that host immune factors and infection dynamics primarily drive malaria pathogenesis in this population. These insights underscore the importance of integrating biochemical and hematological monitoring into malaria management programs, especially in resource-constrained settings. Future research should explore the long-term effects of home-based chloroquine treatment and its interactions with emerging resistance patterns and other antimalarial therapies.

## Study Limitation

A significant proportion of the screened children presented with symptoms indicative of other diseases or reported prior use of non-chloroquine medications before seeking hospital care, rendering them ineligible for inclusion in this study. Also, the cross-sectional design precludes causal inference and hinders evaluation of long-term outcomes, such as the sustained efficacy and safety of chloroquine.

## Ethics Approval and Consent to Participate

The research protocol for this study was approved by the Medical and Health Ethics Committee of Jos University Teaching Hospital, Jos, and informed consent and assent was obtained from the parents.

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## Declaration of Interest Statement

All the authors hereby declare that we have no conflicting interests in this study.

## Authors' Information

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## Authors' Contributions

This study was carried out in collaboration between all the authors. Author Olomu A. Segun. Conceptualized this work, carried out the investigations and drafted the manuscript. Author Okolo S. Nnuaku., co-supervised the work. Author Gazuwa Y. Samuel and Johnson Titilayo, reviewed the manuscript. All authors partook in the analysis, interpretation of data obtained. All authors read and approved the final manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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