



Malaria Prevalence and Anemia Status of Children Attending a Health Facility in Yola

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Authors' contributions

This work was carried out in collaboration among all authors. Author BAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors HI and MB managed the analyses of the study. Author BAA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Background: Malaria and anemia among children especially those that are <5 years of age are still diseases of public health concern. This study was designed to determine the effect of malaria on the anaemia status of under five children attending a health facility in Yola, Adamawa state, Nigeria.

Methods: Blood samples were collected from out-patient under five children reporting at the paediatric unit of the hospital. The blood samples were screened for the presence of malaria parasites by microscopy while their anaemia status was determined by checking their packed cell volume (PCV). The prevalence rate of malaria, anemia, and malaria-anemia was calculated. The level of significance was determined using chi-square (χ^2) statistics.

Results: Of the 200 samples, 124 (62%) were positive for malaria, with the prevalence being higher in males. 103 of the patients had PCV values below 33% giving an overall anaemia prevalence of 51.5% of anemia cases. The results obtained show that the three forms of anaemia – mild, moderate and severe were seen in the sampled population with moderate anaemia being the most prevalent (29.0%); the results also show that malaria parasite density has an effect on the PCV levels of the children at $p = .0001$, and patients with severe anaemia had the highest parasite loads.

Conclusion: Malaria remains a common infection among under five children in this environment and predisposes them to having anaemia. Moderate malaria is also the most common form of anaemia seen in malaria positive children.

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1. INTRODUCTION

Anaemia, defined as a reduction in the number of red blood cells (RBCs) or the haemoglobin content of blood, is amongst the most prevalent health challenges in the world [1]. About a quarter of the entire population of the world are afflicted with this condition [1]. Women and children under five years old are the most affected. Anaemia poses a global health challenge not only due to its prevalence but also due to the adverse effect it has on affected children [2]. Anaemia predisposes under five children to altered cognitive function, impaired motor development and growth [3, 4] poor academic performance, a decline in immune capability leading to increased susceptibility to infections, fatigue and decreased responsiveness [4].

Several factors contribute to the risk and development of anaemia especially in children. The factors contributing to the development of anemia can be classified under socio-demographic, nutritional and infectious factors [1,5]. Amongst the infectious factors, one of the most significant causes of anaemia in children is malaria [6]. Malaria affects a large segment of the world's population; about a third of the world at risk of malaria infection yearly with children under five years of age being the most susceptible to malaria disease [7], they are also the most susceptible to developing malaria anaemia.

Malaria anaemia is a direct consequence of the pathognomonic changes induced in the body by the malaria parasite (*Plasmodium* species) infection. Immunologic and inflammatory processes induced by parasite antigens and/or cytokines as well as coinfections with other parasites play a role in the development of malaria anaemia [8]. Dysregulation of the immune system may also increase the risk of developing anaemia as they aggravate malaria-associated inflammation [9]. The specific pathognomonic changes following a plasmodium parasite attack include clearance and/or destruction of infected red blood cells (iRBCs), the heightened clearance of uninfected red blood cells (uRBCs), splenic sequestration of red blood cells (RBCs), erythropoietic suppression and dyserythropoiesis [10].

During human malaria infection, many uninfected red cells are destroyed in the spleen and their

destruction has been identified as a major contributor to malarial anemia [11]. Both mathematical modeling and clinical observations suggest that 10-32 times as many uninfected RBCs are removed from the circulation for each infected erythrocyte [12]. uRBCs are believed to be destroyed either owing to the presence of adhesive proteins on their surface and or due to reduced deformability. The former are usually destroyed by IgG/complement binding while the latter are destroyed by macrophages in the spleen. Erythropoietic suppression and dyserythropoiesis induced by a prolonged or aggravated inflammatory response by the immune system also play a role in the destruction of uninfected rbc's. The resultant effect of these changes is the low haemoglobin values observed especially in young children suffering from malaria.

Owing to the risk of developing anaemia after malaria infection, this pilot study was undertaken to determine the effect of malaria on the anaemia status of children attending a health facility in Yola.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted at Specialist Hospital Yola, located in Yola North Local Government Area (LGA), Adamawa State; North Eastern Nigeria. Yola lies between coordinate: 9° 15'N 12o 25'E. Yola has a tropical climate, marked by dry and rainy seasons. The rainy season commences in April and ends in the middle of or late October. The dry season starts in November and ends in March [13]. Temperature in Yola reaches 40°C around April; while minimum temperature could be as low as 18.3°C between December and early January which marks the harmattan period, occasioned by the north-easterly trade winds.

2.2 Study Design and Population

The study was a hospital-based, descriptive study. Only out-patients under five children reporting at the pediatric unit of Specialist hospital Yola, who were referred for confirmatory malaria diagnosis from the month of May to July, 2021 were included in this study. A total of 200 randomly selected under five children were screened. Prior to blood sample collection, the

consent of parents/ guardians of the children was obtained.

2.3 Blood Sample Collection

About five ml of blood was collected from each patient. This was dispensed into ethylene diamine tetra-acetic acid (EDTA) bottles and mixed thoroughly. Each blood sample was labelled appropriately.

2.4 Detection of the Malaria Parasite in the Blood Samples

The presence of the malaria parasite was diagnosed by examination of stained thick and thin films prepared for each blood sample. The thin blood smears were fixed with methanol and the thick smears were left unfixed. Each slide was subsequently stained with 10% Giemsa solution and left for ten minutes. The slides were viewed for the presence or absence of the malaria parasites by a trained microscopist. While the thick smears were used for detection of the presence of the malaria parasite and for parasite-density counting, the thin smears were used for the confirmation of the infecting parasite species. Smears were considered negative if no parasites were seen in 100 fields.

2.5 Parasite Load

Malaria parasite load was determined from the thick films by counting parasite in relation to a predetermined number of white blood cells and an average of 8,000µl was taken as standard. 200 leucocytes were counted. All parasite species and forms including both sexual and asexual forms were counted. For positive smears, the number of parasites was counted against 200 white blood cells (WBC). Parasite density was calculated assuming 8,000 WBC per microlitre using the formula:

Parasite density = (Number of parasites counted / Number of leukocytes counted) × 8000

2.6 Determination of Haematocrit Levels

Anti-coagulated (EDTA) blood sample from each subject was aspirated into micro-hematocrit capillary tubes. One end of the capillary tube was sealed with a sealant and placed in a micro hematocrit centrifuge and centrifuged for 3 to 5 minutes at 10,000 rpm to achieve a constant packing of the red blood cells. The packed cell volume (PCV) was measured as a ratio of the whole blood volume [14]. Based on WHO criterion as adopted in 1968, anaemia was defined as PCV ≤ 33% (Hb < 11.0 g/dL) and further classified as mild, moderate, and severe using PCV cutoffs of 30-33% (10–10.9 g/dL), 21-29% (7.0–9.9 g/dL), and less than 20% (7.0 g/dL), respectively.

3. RESULTS AND DISCUSSION

3.1 Malaria Prevalence

A total of 200 children were included in this study. Of the 200, 103 were males and while 97 were females. The results show that of the 200 samples, 124 (62%) were positive for malaria. The results further show that malaria was more prevalent in males with 68 positives (34%) than in females 56 (28%) as presented in Table 1.

The results obtained showed that 62.0% of the persons in the sampled population were positive for malaria showing that there is high prevalence of malaria in the population. The prevalence figure recorded in this study is higher than that recorded by Nassai et al., [4] and Elechi et al., [15] who reported malaria prevalence figures of 50.6% and 27.7% in Yola and Maiduguri respectively. The seemingly high figure observed in this study is not unexpected. Ugwu and Zewotir [16] have noted that under 5 year-old malaria prevalence hotspots are localized in the north western and north eastern parts of the country. They also reported that Adamawa State is one of the states with a highly significant malaria prevalence.

Table1. Malaria Prevalence in the sampled population

	Malaria		Total
	Positive	Negative	
Gender	Male	68 (34.0%)	103 (51.5%)
	Female	56 (28.0%)	97 (48.5%)
	Total	124 (62.0%)	200 (100.0%)

$\chi^2 = 1.456$, Odds Ratio (OR) = 1.422, P value = 0.288

Malaria was observed to be more prevalent among male patients with 34.0% of the males sampled being positive for the parasite while the prevalence in their female counterparts was 28.0%. The results obtained are similar to that of Kuniya et al., [17]. Their results revealed that the male children had more malaria positive cases than the female children with prevalence rates of 32.2% and 25.6% respectively. On statistical analysis however the difference in the rate of infection was shown to be non-significant in the two studies indicating that gender is not a critical factor in infection with the plasmodium parasite in under 5 children in the sampled population.

3.2 Anaemia Prevalence and Effect of Malaria on the Anaemia Status of the Sampled Population

Of the 200 children sampled in this study, 103 had PCV values below 33% giving an overall anaemia prevalence of 51.5% as depicted in Table 2. The result observed is similar to that of The Nigeria Demographic Health Survey (NDHS) 2018 average anaemia prevalence data figures of 68% among Nigerian children aged 6–59 months. It is also similar to that obtained by Ughasoro et al., [18] working in the south eastern part of Nigeria and Sumbele et al., [5] in Cameroon which shares a common boundary with Adamawa state; they observed anaemia prevalence figures of 49.2% and 62% respectively. The results show that anaemia is still prevalent in this part of Nigeria and that the level is of public health concern. The World Health Organisation (WHO) recommends that anaemia prevalence that is higher than 40% among children aged 6–59 months should be considered as a severe public health problem.

The results in Table 2, also showed that malaria had a significant effect on the anaemia status of the children sampled. Of the 103 children who had PCV values below the normal threshold, 101 were malaria positive. The figures obtained was correlated as significant on statistical analysis indicating that children who were malaria positive were more likely to have PCV values less than the acceptable threshold. Sumbele et al., [5] have also reported that children who were positive for malaria parasite had significantly higher anaemia prevalence than those who were malaria parasite (MP) negative. Similarly, Oladeinde et al., [19] have reported that infection

with the plasmodium parasite is an important risk factor for the development of anaemia in children. Children infected with the plasmodium parasite are at risk of developing anaemia due to the increased destruction of RBCs (both parasitized and non-parasitized); erythropoietic suppression and dyserythropoiesis induced by a prolonged or aggravated inflammatory response by the immune system may also play a role in the increased destruction of rbc's.

3.3 Distribution Pattern of the Patients into different Anaemia Categories Based on PCV values

Table 3 shows the distribution pattern of anaemia based on the PCV values. The results obtained show that the three forms of anaemia – mild, moderate and severe were seen in the sampled population. The distribution pattern of the patients based on their PCV values show that the most prevalent form of anaemia seen in this study was moderate anaemia 58 (29.0%); children with mild anaemia were 30 (15.0%) while children with severe anaemia were 15 (7.5.0%).

On statistical analysis (pairwise comparison) the difference in the figures for the moderate and mild anaemia groups when compared with the non-anaemia group was correlated as significant (The odds ratio of the severe anaemia group could not be calculated due to the zero count of severe anaemia in the malaria negative patients). Kuniya et al., [17] and Aregbeshola et al., [6] obtained similar results. Kuniya et al., [17] also observed that the three forms of anaemia were present in the children sampled at a prevalence of 12.5%, 34% and 20% while Aregbeshola et al., [6] reported prevalence figures of 26%, 38% and 3% for mild, moderate and severe anaemia respectively. The results further show that while only two (2) of the malaria negative children had anaemia (one each with mild and moderate anaemia), majority of the malaria positive children had one form of anaemia or the other indicating that malaria predisposes to the worst form of anaemia, severe anaemia. There are varying degrees of anaemia seen especially in children. Different factors such as the nutritional status and genetics determine the level of anaemia seen. The interplay of the aforementioned factors and infection with the plasmodium parasite thus determines the level and severity of anaemia seen in each child.

Table 2. Prevalence of Anaemia between the malaria positive and malaria negative children in the Sample Population

	Anaemia Status		Total
	PCV ($\geq 34\%$)	PCV ($\leq 33\%$)	
Malaria positive	23 (18.6%)	101 (81.4%)	124 (100%)
Malaria negative	74 (97.4%)	2 (2.6%)	76 (100%)
Total	97 (48.5%)	103 (51.5%)	200 (100%)

$\chi^2 = 117.201^a$, OR = 162.48, P value = .0001;

NB: % is within group

Table 3. Distribution Pattern of the Patients into different categories Based on PCV values

	PCV values				Total
	Normal (≥ 34)	Mild (30-33%)	Moderate (21-29%)	Severe (≤ 20)	
Malaria positive	23	29	57	15	124
Malaria negative	74	1	1	0	76
Total	97	30	58	15	200

Pairwise comparison: normal vs mild: $\chi^2 = 50.437$, P value = .0001, OR = 93.3; **normal vs moderate:** $\chi^2 = 80.81$, P value = .0001, OR = 183.4; **normal vs severe:** $\chi^2 = 33.728^a$, P value = .0001, OR could not be calculated due to zero count of severe anaemia in the malaria negative patients

Table 4. Effect of parasite load on PCV values

Anaemia Group (PCV Values)	N	Parasite Load (Geometric Mean)	Standard Error	P value
Normal (≥ 34)	97	2.65	11.14	.0001
Mild (30-33%)	30	253.65	18.19	
Moderate (21-29%)	58	370.08	23.01	
Severe (≤ 20)	15	996.08	54.49	
Total	200	39.13	21.35	

3.4 Effect of Parasite Load on PCV Values

The results of the effects of parasites load on the PCV values is described in Table 4. The results of the determination of the effect of parasite load on PCV values shows that parasite load has a significant effect on PCV values (P = 0.0001).

Statistical analysis of the geometric mean of the different groups shows that the non-anaemic group had the lowest mean geometric mean while the severe anaemia group had the highest geometric mean parasite load. The results obtained are similar to that by Kotepui et al., [20]. They also observed that malaria parasite density has an effect on the haemoglobin levels. The parasite load has an effect on anaemia as the higher the parasite load the higher the number of RBCs that will be infected and the greater will be the number of RBCs eventually destroyed when the parasites are released from the RBCs to initiate another cycle of infection. The parasite load may thus be a pointer to the anaemia status of malaria positive patients.

4. CONCLUSION

The study revealed that malaria prevalence is high in this population. The study also reveals that malaria is an important risk factor for the development of anemia among under five children in this population and that the parasite load has a bearing on the severity of anemia seen. Malaria prevention and/or treatment may thus be an important step in the management of anemia among children under five years of age.

5. RECOMMENDATION

The authors will recommend that every child under the age of five that is brought to any health facility for malaria diagnosis, he or she should also be screen for anemia.

CONSENT AND ETHICAL APPROVAL

Prior to sample collection, an introductory letter was obtained from Microbiology department, Modibbo Adama University of Technology Yola,

to the management of Specialist Hospital Yola in order to obtain ethical clearance for the research. The importance of the study was explained to the parents/guardians of the children before seeking their consent. Confidentiality was maintained.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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