

Effects of Malaria Infection on Haematological Parameters among Patients in Kano State, Nigeria

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Abstract

Destruction and alteration of blood cells especially erythrocytes are the common devastating effects of malaria infection. This leads to haematological changes often characterised by anaemia, thrombocytopenia and leucocytosis or leucopenia. The aim of this study is to assess the effects of malaria infection on erythrocytes and leucocytes with associated risk factors. 200 malaria positive patients were enrolled in this study. The patients' haematological parameters and parasitemia level were assessed. Plasmodium falciparum was detected in 197 (98.5%) patients as the most predominant specie while 3 patients had mixed infection. A mean parasite density of 11,496 parasites/ μ L was observed with majority of the patients showing parasitaemia of <10,000 parasites/ μ L. Age groups 1-5yrs, 6-15yrs and 26-35yrs had patients that recorded parasitaemia of >50,000 parasites/ μ L. The mean white blood cells count, neutrophils and eosinophils count in malaria infected patients were seen to be increased compared to the malaria negative control group. Haemoglobin concentration, haematocrit level and mean cell haemoglobin were however seen to be lower in the malaria positive patients than the control group. Majority of the patients had hypochromia indicated by lower mean cell haemoglobin which increases with severity of malaria infection. Haematological changes can be used to depict severity of malaria infection among all age groups.

Keywords: Malaria, Haematological, Parameters, Kano State, Leucocytes.

INTRODUCTION

An estimated 216 million malaria cases occurred globally in 2016 with 445,000 deaths attributed to the disease mainly in sub Saharan Africa and Asia (WHO, 2017).

One of the devastating effects of malaria infection is the alteration and destruction of blood cells especially erythrocytes. Haematological changes such as anaemia, thrombocytopenia and leucocytosis or leucopenia are common complications in malaria and they play a major role in malaria pathology (Kotepui *et al.*, 2015; Garba *et al.*, 2015). The extent of these alterations varies with level of malaria endemicity, background haemoglobinopathy, nutritional status, demographic factors and malaria immunity (Erhart *et al.*, 2004; Price *et al.*, 2001).

Kotepui *et al.* (2015) stated in a study that patients infected with different malarial parasites exhibit important changes and differences in many hematological parameters with neutrophil and eosinophil counts being the two most important changes during malarial infection. Similarly, Garba *et al.* (2015) found that malaria has significant impact on some haematological parameters in which low packed cell volume (PCV), low platelets count and high total white blood cell count (WBC) occur. On

the contrary, incidence of malaria parasitemia was observed to correlate significantly ($p < 0.05$) with decrease in PCV and WBC (Obimba and Eziuzor, 2015).

Due to the disparity in reports on changes seen in blood cells parameters of patients with malaria infection based on their background and other risk factors, we analyse and evaluate the haematological changes in haematocrit level, erythrocytes count, haemoglobin concentration, total leucocytes count, mean cell volume, mean cell haemoglobin and mean cell haemoglobin concentration observed in patients with cases of malaria.

The aim of this study is to assess the effects of malaria infection on haematological parameters and find the associated risk factors.

MATERIALS AND METHODS

Study Area

The study was conducted in Kano State, in 7 hospitals across the three senatorial districts namely; Dambatta General Hospital (GH), Gwarzo GH (from North), Gaya GH, Rano GH (from South), Sir Muhammad Sanusi Specialist Hospital, Infectious Diseases Hospital and Hasiya Bayero Paediatric Hospital from Kano central.

Study design

The study was a cross-sectional one where systematic random sampling was used to select patients who present with malaria signs and symptoms for the study.

Sample collection and processing

About five milliliters of whole blood was collected by venepuncture into a Tri potassium EDTA container as described by Lewis *et al.* (2008). Thick and thin blood films were made and stained using giemsa stain. The detection of malaria parasites, identification and parasites density estimation was done using guidelines by NMCP (2005) and IMMC (2011). The thin blood film was also used for leucocytes differential count as described by Lewis *et al.* (2008).

Haematology assay

Haematology test was also conducted using Sysmex XP-300 where haematocrit level (PCV), haemoglobin concentration (Hb), total leucocytes count (TLC), erythrocytes count and other erythrocytes indices (MCV, MCH, MCHC) were determined according to Sysmex Corporation (2012) instructions.

Data analysis

Data obtained was analysed using SPSS version 20 to establish statistical significance and relationships.

Ethical approval

Ethical approval was obtained from Kano State Ministry of Health ethical committee. Informed consent of patients was obtained before enrolment.

RESULTS

Out of the 200 malaria positive patients enrolled, 108 were females while 92 were males indicating 54% and 46% respectively. The age of the patients ranged from 1-70 years old with a mean of 20.04 years (SD = 15.07). The age group 6-15yrs old formed majority of the patients (31.5%) followed closely by age groups 1-5yrs and 16-25yrs with 35 patients (17.5%) each. The educational status of the patients ranged from being informal to tertiary level of education. Majority of the study population (32.0%) attend primary schools.

The predominant Plasmodium parasite seen was *P. falciparum* where a total of 197 samples gave *P. falciparum* infection while only three samples gave mixed infection with *P. ovale* yielding 98.5% and 1.5% respectively. The common stage observed for all the malaria infection was the trophozoite stage (Plate 1), gametocytes of *P. falciparum* were also observed in 6 samples (3%) mixed with the trophozoites. No schizont stage of *P. falciparum* was seen in any of the samples.

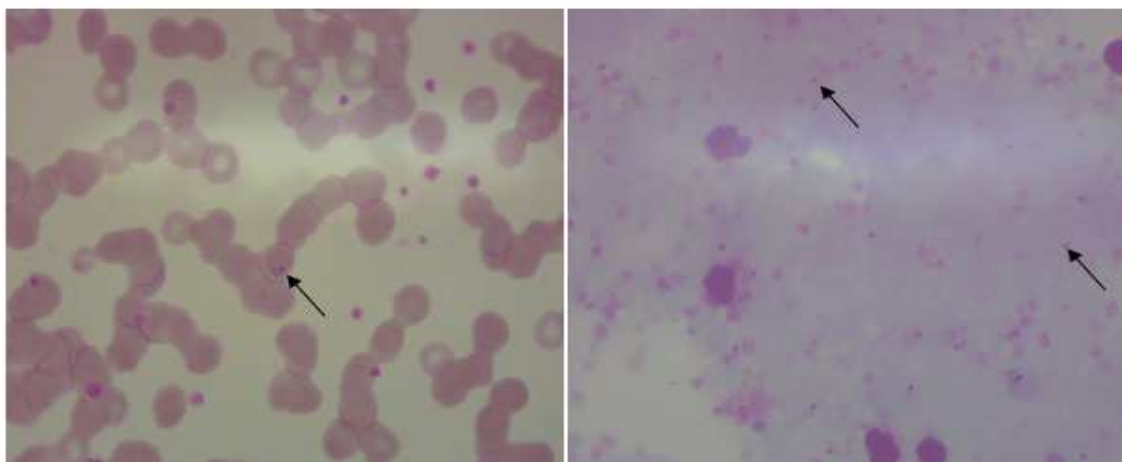


Plate 1: Images of malaria parasites in thin (right) and thick (left) films pointed by arrows

The parasite density was observed to range from 93 - 132,761 parasites/ μ L with a mean parasite density of 11,496 parasites/ μ L (SD = 22,237). Within all age groups, most of the patients had a parasite density of less than 10,000. Age groups 1-5yrs, 6-15yrs and 26-35yrs

had patients that recorded parasitaemia of >50,000 parasites/ μ L. The parasitaemia in age groups 16-25yrs and >46yrs were found to be less than 35,000 parasites/ μ L. Figure 1 depicts the distribution of parasitaemia across the age groups.

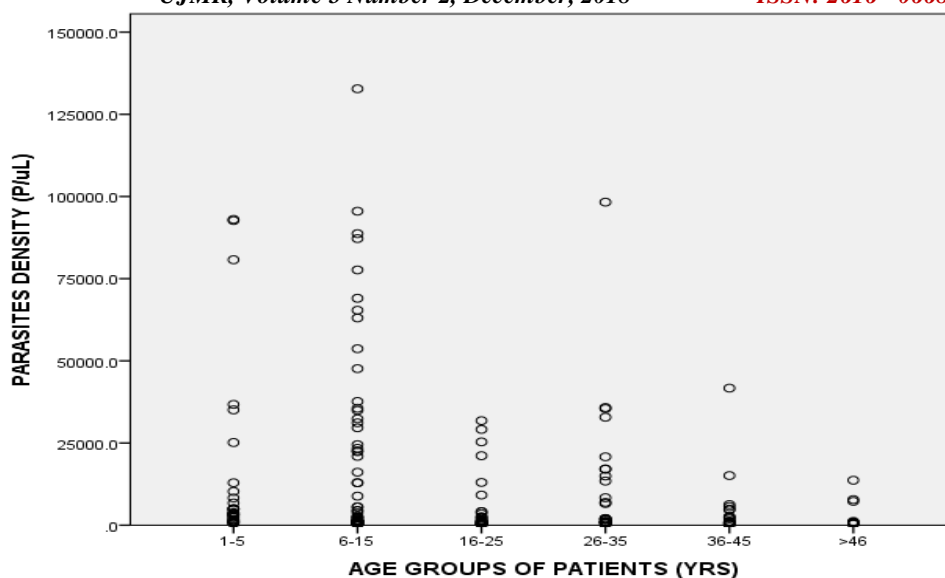


Figure 1: A scatterplot showing the distribution of parasitaemia in relation to age groups. Key: P/μL - Parasites per microliter, YRS - Years

Independent t-test showed statistical difference when comparison was made of haematological parameters between malaria positive cases and negative controls. No significant difference was observed in erythrocytes count, haemoglobin concentration, haematocrit level and mean cell volume for the same groups. The WBC was seen to range from 1.4 - 25.4 x 10⁶/L with a mean of 8.5 x 10⁶/L. Similarly, the erythrocytes count, haemoglobin concentration, haematocrit level,

MCV and MCH were observed to range from 1.41 - 7.78 x 10¹²/L, 3.1 - 19.3 g/dL, 7.5 - 60.0%, 57.7 - 120.1 fL and 16.4 - 40.9 pg respectively as seen in Table 1. There was a significant rise in leucocytes count in the malaria positive (p <0.05) compared to the malaria negative controls. Similar high values were recorded in neutrophils and eosinophils count with a statistical significance. However, low counts were recorded in MCH, MCHC, lymphocytes and monocytes counts.

Table 1: A comparison of the haematology parameters means between malaria infected group and controls (malaria negative).

Haematology parameters	Malaria Positive Means (± SD)	Malaria Negative Means (± SD)	t-test p-value
WBC (x10 ⁶ /L)	8.5 ±4.9	6.1 ±2.3	0.001*
RBC (x10 ¹² /L)	4.4 ±1.2	4.5 ±0.8	0.682
HBG (g/dL)	11.4 ±3.2	12.6 ±2.0	0.217
HCT (%)	35.8 ±10.0	37.3 ±5.9	0.328
MCV (fL)	83.5 ±8.9	83.6 ±6.2	0.157
MCH (pg)	26.2 ±3.1	26.9 ±2.2	0.032*
MCHC (g/dL)	31.4 ±2.4	32.1 ±1.6	0.956
Neutrophils (%)	56.9 ±14.4	51.5 ±14.8	0.020*
Lymphocytes (%)	32.3 ±13.3	38.4 ±14.7	0.005*
Monocytes (%)	6.0 ±3.9	8.8 ±2.9	0.000*
Eosinophils (%)	4.1 ±3.5	1.3 ±1.6	0.000*

Key: SD - Standard Deviation, WBC - White Blood Cells, RBC - Red Blood Cells, HBG - Haemoglobin Concentration, HCT - Haematocrit Level, MCV - Mean Cell Volume, MCH - Mean Cell Haemoglobin, MCHC - Mean Cell Haemoglobin Concentration. *- Statistical significance observed (p < 0.05)

The total leucocytes count was grouped into three; Leucopaenia (WBC = 1.4-3.9 x10⁶/L), Normal leucocytes count (WBC = 4.0-11.9 x 10⁶/L) and Leucocytosis (WBC ≥12 x 10⁶/L). The patients leucocytes counts groups were compared in relation to their parasitaemia groups using Pearson chi-square, there was a significant difference between the WBC groups ($\chi^2 = 24.120$, $p < 0.05$). Most of the patients (129) had normal leucocytes count compared to

those with leucopaenia (28) or leucocytosis (43).

The eosinophils count was also grouped into eosinopenia (0-2%), normal eosinophils count (3-5%) and Eosinophilia (≥6%). Comparison with parasitaemia revealed that there was no significant difference between the groups ($\chi^2 = 1.896$, $p > 0.05$). However, most of the patients with severe parasitaemia had eosinophilia compared to other groups (Table 2).

Table 2: Comparison of malaria infection severity with WBC, Eosinophils and MCH classification in patients.

Characteristics	Parasitaemia Groups			χ^2	p-value
	Low* (%)	Moderate** (%)	Severe*** (%)		
WBC					
Leucopaenia	15(23.1)	13(10.7)	0(0.0)	24.120	0.000
Normal	48(73.8)	71(58.2)	10(76.9)		
Leucocytosis	2(3.1)	38(31.1)	3(23.1)		
Eosinophils					
Eosinopaenia	24(36.9)	36(29.5)	4(30.8)	1.896	0.755
Normal	26(40.0)	58(47.5)	3(23.1)		
Eosinophilia	15(23.1)	28(23.0)	6(46.1)		
MCH					
Hypochromia	33(50.8)	74(60.7)	8(61.5)	2.598	0.627
Normochromia	32(49.2)	47(38.5)	5(38.5)		
Hyperchromia	0(0.0)	1(0.8)	0(0.0)		

Key: *Low - ≤ 999parasites/μL, **Moderate - 1000-10000 parasites/μL, ***Severe - >10000 parasites/μL.

The MCH values were also grouped into those with Hypochromia (≤ 26.9pg), Normochromia (27.0 - 34.0pg) and Hyperchromia (≥34.1pg). Though there was no significant difference between the groups, however, most of the patients had hypochromia compared to other MCH groups.

DISCUSSION

More female patients were seen to be malaria positive in this study mainly due to their high number in the study population. The National Bureau of Statistics records showed that among reported notifiable diseases, malaria accounted for 70.3% of diseases in females in 2015 while it was only 56.8% in males (NBS, 2016). This was contrary to what was obtained by Wogu *et al.* (2017) where though the male subjects were lower in number than the females, they recorded a prevalence of 47.0% against the female's 39.4%. This was attributed to staying outdoors at night not fully clothed for longer periods by the males. Dawaki *et al.* (2016) also had such high prevalence in the males counterpart (61.2%) compared to the females

(59.7%). Idris *et al.* (2016) also showed high malaria infection prevalence in females.

More than 98.0% of the malaria infection was due to *P. falciparum*, which is the common *Plasmodium* specie seen in this part of the world. This finding is in line with a survey conducted by NMEP where *P. falciparum* accounted for 98.2% of all malaria cases with other species (*P. malariae*, *P. ovale* and mixed infection) making up the < 2.0% (NMEP *et al.*, 2016). Though no mixed infection was found in Kano State during the survey, our research obtained a 1.5% of mixed infection precisely with *P. ovale*. This could be as a result of globalisation of the populace because certain cases of *P. ovale* were detected in the neighbouring Kaduna State during the survey (NMEP *et al.*, 2016). Similar mixed malaria infections were previously reported by Ceesay *et al.* (2015); Nanvyat *et al.* (2017) and Oluboyo *et al.* (2017).

The wide ranged parasite density obtained could be due to the study not restricted to a particular age group, since both children (from 1 year) and adults were included in the study.

Camargo *et al.* (2018) recorded a similar finding with a parasitaemia range of 32 - 85,320 parasites/ μ L. Nneji *et al.* (2015) conducted a study involving children aged 1-15years only which showed a higher range (1,000-354,667 parasites/ μ L). Considering the low immunity in children and the high risk of exposure to the infection, made them more liable to high parasitaemia compared to other age groups. There was a high parasite density in age groups 6-16 years probably due to the high risk of exposure to mosquito bites and low immunity. Surprisingly, the age group 1-5 years had lower parasitaemia compared to age group 6-15 years most likely due to a sort of protection for the younger ones from their parents by providing nets and other malaria prevention measures. Our result tallied with that of Caseey *et al.* (2015) where they studied children in different malaria transmission settings in Africa and found out that parasitaemia is higher in age group 10-15years followed by 1-9years. The low parasite density in the age group >46years could probably be due to established and experienced immunity as a result of exposure to the infection over years. The significance rise in WBC may be due to their function as phagocytes that destroy infected cells, in this case malaria infected

cells. This could be an explanation for the increase in mean neutrophils and eosinophils count compared to the control group. Kotepui *et al.* (2015) also reported a similar finding. There was also a decrease in haemoglobin concentration, haematocrit level and MCH probably due to utilisation of the inherent heme moiety of the haemoglobin by the malaria parasites for its metabolism. Obimba and Eziuzor (2015), Garba *et al.* (2015) and White (2018) also documented similar findings.

CONCLUSION

There are changes in haematological parameters of patients infected with malaria where an increase in leucocytes and relative decrease in mean cell haemoglobin was observed compared to malaria negative patients. Haematological parameters changes in WBC, HCT and MCH can be used to predict the severity of malaria infection especially in children.

RECOMMENDATIONS

Malaria infection should be managed simultaneously with haematinics to improve the quality and quantity of blood cells destroyed during the infection.

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