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PREVALENCE OF MALARIA, THE EFFECT OF PARASITAEMIA ON BLOOD PARAMETERS AND IRON LEVEL OF INFECTED CHILDREN UNDER FIVE YEARS OF AGE IN ITU, SOUTH-SOUTH, NIGERIA

***[1]Bassey Eyibio Bassey, [2]Ekaette Victor Etefia, [3]Ekamma Godwin Adams, [2]Mfonbong Edo Akpan**

[1]Department of Microbiology, Federal University of Technology, Ikot Abasi, Akwa State, Nigeria.
[2]Department of Medical Microbiology and Parasitology, Faculty of Clinical Science, University of Uyo, Uyo, Akwa Ibom State, Nigeria.
[3]Department of Biological Science, Akwa Ibom State Polytechnic, Ikot Asurua, Ikot Ekpene

*Corresponding authors' email: basseybassey@futia.edu.ng

ABSTRACT

Infection due to malaria constitutes a devastating health concern in Itu with varied haematological implications. To determine the status of the infection, the effect of parasites on some haematological parameters, and serum iron level of infected children under 5 in Itu Local Government Area, Nigeria, a cross-sectional study involving 430 children was conducted. Samples were collected from subjects following obtaining consent from caregivers. Malaria prevalence and parasitaemia level was diagnosed microscopically. Haematology auto-analyzer was used to determine haematological parameters. Hitachi 912 analyzer was used to determine serum iron levels from the samples. Malaria prevalence of 41.08% was recorded in the study. The highest prevalence (42.86%) was reported among the female subjects. The mean level of haemoglobin, packed cell volume, red blood cell level, lymphocyte, monocytes, and eosinophil count, decreases significantly ($p < 0.05$) in infected children and the mean level of neutrophil, as well as white blood cell count, increases compared to the non-infected subjects. A weak correlation between the level of parasite load and Hb (r= 0.108), PCV(r=0.247), and RBC (r= o.074) was also reported. The study recorded a higher mean serum ferritin level (648 ng/ml) compared to non-infected, lower mean serum transferrin (6.41 ng/ml) compared to normal, and mean serum iron (54.40 ng/ml) was higher than normal. Therefore, it is essential to pay keen attention to these blood indices in the management of malaria among under 5 children in the study area.

Keywords: Malaria, Parasitaemia, Hematological Parameters, Iron, Ferritin, Transferrin

INTRODUCTION

Thirty percent (30%) of deaths in children under 5 are attributed to malaria in Akwa Ibom State (National Malaria Indicator Survey, 2022). The state recorded the highest prevalence of 30.1% among children under 5 in the South-South region of the country (National Malaria Indicator Survey, 2022). *Plasmodium* infection causes most child mortality in many low-income nations with children and pregnant women majorly at risk. Malaria is reported all year round in the state with about 95% of the inhabitants likely to be infected. Malaria is a devastating parasitic disease to human population with a serious public health concern. Blood parasite, genus *Plasmodium* is implicated with malaria. *Plasmodium falciparum, P. malariae, P. vivax, P. ovale,* causes disease in man and *P. knowlesi is zoonotic* (Aribodor *et al.*, 2003). The parasite is transmitted through the bite of an infected female *Anopheles* mosquito (WHO 2019), which acts as a vector while taking a blood meal. Although much attention has been given to malaria globally, it remains an overwhelming cause of morbidity and mortality among the vulnerable population, especially in tropical countries. In Nigeria, there was an estimated 68 million cases of malaria reported in 2021 with 194,000 mortality (WHO, 2023). Children age 5 and below accounted for 80% of these burden. Nigeria constitutes 31% of world malaria burden and 40% of the total Africa reported cases (WHO, 2023). Nigeria has the highest burden of malaria globally, accounting for nearly 27% of the global malaria burden (WHO 2023). The country has the potential of malaria transmission throughout the year.

Malaria contributes to a wide range of an enormous burden in an extensively distributed population with premature deaths, infirmities from sickness, and inhabits on economic and social development (Hajison et al. 2017). Major clinical signs observed in malaria infection are caused during parasites circulation in the blood (Antwi-Bafour et al., 2023). *Plasmodium* introduction into the circulating blood results in the release of metabolic waste substances including hemozoin pigment and other toxic materials in the infected red blood cells (Olivier et al., 2014). These released toxic substances in the blood break the affected red blood cells and release merozoites that attack other cells (Olivier et al., 2014). The haemozoin as well as metabolic waste, including glucose phosphate isomerase (GPI) triggers speceilize white blood cells that phagocytosize foreign antigens thereby producing signaling molecules that results in fever and rigors (Mawson , 2013, Price et al., 2001).

Blood is constitutes of red blood cells and white blood cells that are responsible for proper functioning of internal structures of the body (Okoroiwu et al., 2014). The effect of malaria parasite in bloodstream causes alteration in the roles and function of the blood cells. These cells are neutrophils, eosinophils, lymphocytes, basophils, and monocytes. Malaria parasite has been reported to cause changes in the haematological status of man alongside other conditions such as anaemia, thrombocytopenia and leukocytosis, leukopenia, lymphocytosis, monocytosis, eosinophilia, and neutrophilia (Eledo et al., 2018). Hence, the impact of malaria parasites often manifests in the haematological parameters. The level of parasitaemia in the blood system inclines triggers anaemia leading to progressive deterioration effect and restrained bone marrow (Obeagu et al., 2017)

Malaria has impacted greatly on blood parameters systems. These changes in the haematological parameters due to malaria may result in complications and impact the parthenogenesis of *Plasmodium* parasite (Izah et al., 2017). The effect of malaria parasite density can bring about an alteration in the serum ferritin and transferrin levels of the infected humans. Alterations in serum ferritin and transferrin

levels are essential to defects associated with the accumulation of iron, iron build-up, and its circulation also in infection demonstrated by swellings, wounds, and repair for instance in *Plasmodium* parasite or helminths infection (Torti and Torti, 2019). Studies have shown that anaemia is frequently associateted with children. Pathological conditions including the destruction of red blood cells weakened production of red blood cells, segregation of iron, and inadequacy may lead to anaemic condition increase in blood iron level due to the intensity of malaria (Anumudu et al., 2008, Brabin, 2012,). Akwa Ibom State is holoendemic with malaria and pregnant women and children, 5 years and below are mostly affected. The state provides a favourable environment for the breeding and transmission of malaria. This study seeks to examine the prevalence of malaria, effect of malaria parasite on haematological indices, and serum ferritin and transferrin levels in children under 5 in Itu Local Government Area of Akwa Ibom State, Nigeria

MATERIALS AND METHODS

Study Area

This study was carried out in Itu Local Government Area of Akwa Ibom State, located in the tropical rain forest zone of South-South region of Nigeria. Itu Local Government Area has 5 Clans and 84 villages. With its state capital in Mbak Atai, Akwa Ibom State has a land area of 606.10 square kilometers and a projected population of 163,200 (Statistical Year Book of Akwa Ibom State, 2013). Itu Local Government Area lies between Ibiono Ibom and Ikono Local Government Area on the West, Uyo, and Uruan Local Government Area on the South, and Odukpani in Cross River State and Arochukwu in Abia State on the North and North-East. The climatic condition of Itu is describe by hot muggy weather with two marked season the dry season running through November to March and the wet season spanning from April to October. Itu Local Government has annual temperature range from 23^0 C and 31.7^0 C and a mean annual rainfall of about 3,500mm. the climatic conditions, soil structure, and texture create a favourable environment for the proliferation and breeding of mosquitoes. Malaria is transmitted all year round and increases during the rainy season (AKMOH, 2000). The major concern of this work was on the human population distribution in the area. Samples for this study were collected from Primary Health Center Control Base, West Itam purposefully selected in the study area. The choice for this health facility was influence by the fact that, it serve as referral point in the Local Government Area.

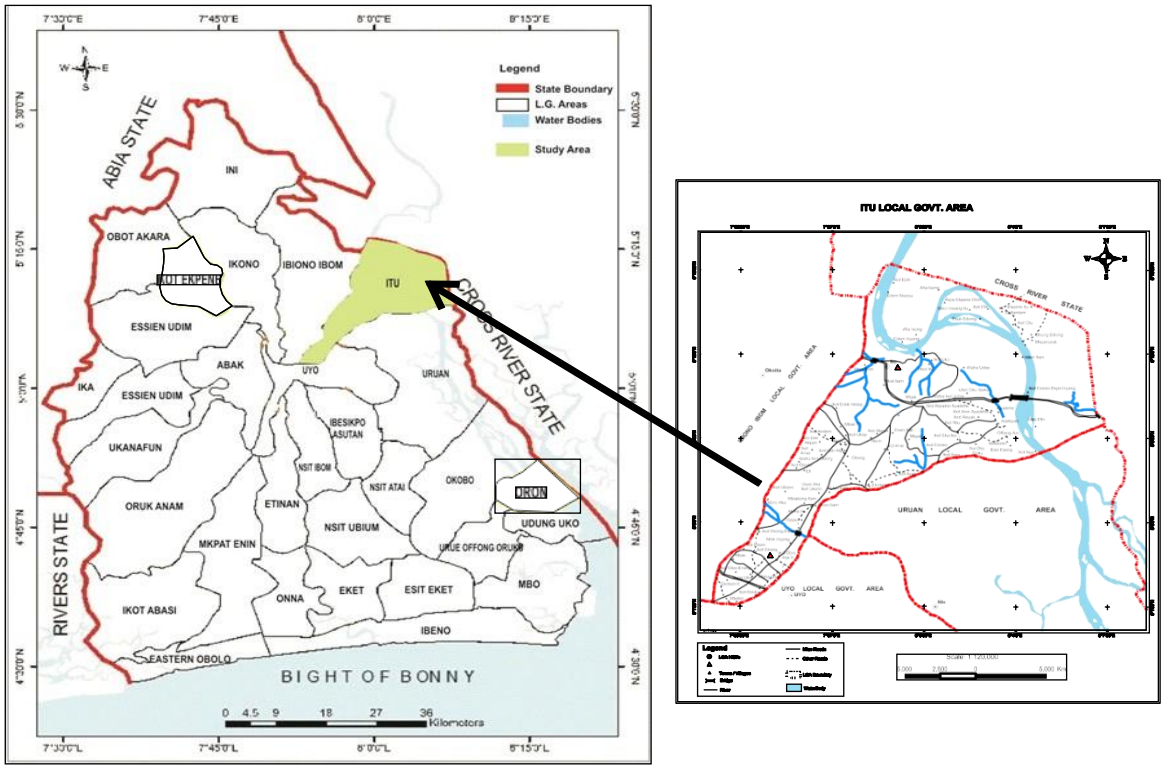

Figure 1: Map of Akwa Ibom State and Itu Local Government Area showing the study area

Study Design

A cross-sectional study was adopted in this study. This technique includes haematological parameters, iron serum analysis, and examination of blood samples of malaria parasite and its parasitaemia in Itu Local Government Area.

Study Subjects and Sample Size

These include patients visiting the selected health facilities considered in the study. Only Children age 0 – 5 years participated in the study. The study was carried out between November 2020 and October 2021. Taro Yamane's approach for finite population was adopted for the determination of sample size. Therefore the formula;

$n = N/1+N(e)^2$

Where;

n = expected sample size

e = level of significance (precision level)

N = finite population out of which the samples were drawn.

For this work, the estimated population size was 248,786 (the annual population estimate of in/out patients visiting health facilities in (Akwa Ibom State Statistical year book 2013). The level of significance (e) was at 0.05 or 5%.

For this study estimated sample size was 399.99.

Blood Sample Collection
Following recruiting study subjects. All subjects who were enrolled for the study were subjected to intravenous blood collection for malaria parasite examination following methods described by Cheesbrough, (2005). A tourniquet was tied to the upper arm of each of the participants so that the vein become visible. Methylated spirit was used to clean the part from which the blood was to be collected. The vein was punctured with a needle fixed to a syringe and the plunge of the syringe was pulled gently until 2ml of blood was drawn into the syringe. Collected blood samples were preserved in a well labelled Ethylenediaminetetraacetic acid (EDTA) (csequestrene) anticoagulated venous blood bottles for thick and thin smears preparation and others haematological studies. Blood films were prepared within 30 minutes of blood collection.

Blood Films Preparation
Both thin and thick films were prepared on the same slide. The slide was completely clean and grease-free with a frosted end to enhance labeling.

Preparation Thin Blood Film
Blood sample was use to make a dot at the center of a grease free glass slide. Using a smooth edge spreader slide, position at angle 45^0 , the sample was immediately spread to make a thin film. The blood was dispersed evenly to produce a uniform thin smear toward the end of the slide. Each slide was labelled and air dried at room temperature. This process was repeated twice for each blood sample. The blood films were dehaemoglobinized by didding it into a buffered solution. Fixation was done by adding drops of absolute alcohol (methanol) to the thin smear on the prepared slide. This was allowed for 60 seconds and air dry afterward. Staining was perform 24 hour after fixing of the sample. The alcohol was not allowed to touch the thick film

Preparation thick blood film
A large portion of each sample was use to make, a circular thick film of about 15mmX15mm in diameter using the edge of another slide at the other end of the glass slide. The film was so made that it was possible to see (but not read) newsprint through the film. This was labeled accordingly and air dried at room temperature. The procedures was repeated of all the samples collected.

Staining Techniques and Microscopy
Staining of thick and thin smear preparation was done by immersing the film slide in a jar containing a freshly prepared Giemsa stain for 10 minutes. The Giemsa stain was diluted at 1:10 volume with distilled water. After 10 minutes the stained slide was removed from the stain jar and was washed in buffered solution. The slides were allowed to rest on a rack till it become dry.

Identification of Malaria Parasite
The stained slide was examined microscopically using oil immersing lense (x100 objectives). The film (both thin and thick) were covered with oil immersion. Each film was examined one after the other under the microscope (Cheesbrough, 2005; WHO, 2010).

Determination of Parasitaemia
Parasitaemia was assessed based o parasites density per µl of blood using oil immersion objective (x100) following the method described by Cheesbrough, (2005). The number of parasites per High Power Field (HPF) was counted in 10 fields. Averaged number of parasites was then calculated. The average number of parasites per HPF was multiplied by 500 to obtained the number of parasites per µl of blood. Blood was considered to be negative when malaria parasite was not found in 10 field of view examined.

Determination of Haematological Parameters from Blood Samples
Haemoglobin (Hb), White blood cell (WBC), Red blood cell (RBC) and Blood haematocrit (packed cell volume - PCV) were determined using Mindray BC-2800 Auto- haematology analyser with reagents from the Mindray Company, China, following protocol describe by CDC (2004). The analyser was turned on by placing the power switch on the rear panel ON. After 4 – 7 minutes of initialization of the system, the count screen was automatically entered. This was ascertained by ensuring that date and time displaced on the screen were correct. At the ‘’count’’ screen the (MODE) key was pressed and the ‘’WB-ALL’’ Mode was selected. The anti-coagulated blood collected was gently mixed up again and placed under the sample probe. The aspirate key was then pressed to aspirate the sample. Start up key was the pressed to start the analysis of the sample. After 5 minutes the results appeared on the screen. The results were copied out and the system reset for another analysis.

Measurement of Serum Iron, Transferrin and Ferritin
One millilitre of blood was placed in into a clean, sequestrene bottle, centrifuge at 3000 rpm then allow the serum to separate at room temperature. The serum collected is preserved The kept at -20°C until use. For the alalysis of serum iron, serum ferritin and transferrin. The frozen sera is allowed to thawed at room temperature them mixed thoroughly.
Iron component, Serum Iron, ferritin and transferrin were determined following method described by Ahlan *et al.* (2001). Hitachi 912 machine wells were loaded with the blood sera. Before processing the assay, the calibration was made on the Hitachi 912 machine by STD2 (serum-based calibrator). To ensure result accuracy, Precinorm U and Precipath U control buttons were initiated at the same time, also with the precinorm UPX control, which enabled accuracy. Following calibration, 150µl of the samples was pipetted into each sample cup and placed in the machine. An adequate amount of reagent, diluent, and wash solution was added. The start button was pressed to run the analysis. When the analysis was completed, the system automatically stopped and the results were displayed on the screen.

Data analysis
Data obtain from the study were analysis using SPSS ver. 11.5 (SPSS Inc., Chicago, IL, USA). Result of haematological level and iron status was presented in simple mean and standard deviation. Chi-square was to determined significant different between the rate of malaria infection in male and female at 5% probability level. Student t-test determined the significant different between variation in the haematological level and iron status of parasitze and non parasitze subject. Also, the regression coefficient was deployed to determine the relationship between the level parasitaemia and changes in haematologic

RESULTS AND DISCUSSION
A total of 430 blood sample were collected between the period of the study to examined the prevalence and the level of malaria parasitaemia from the infected subject using microscopy. Overall prevalence of 181(41.09%) was recorded. The highest prevalence among females 105

(42.86%) and males recorded 76(41.08%) prevalence as shown in Table 1. The difference in the prevalence of malaria according to sex was statistically significant (p<0.05). Age group 0-2 years had the highest incidence of infection 117(43.82%) while age group 2-3 years 64(39.26%) recorded the lowest incidence. The difference according to age was statistically significant (*p<0.05) (X_{cal}=8.10; df(1); X_{crt}=6.869*). Table 1, also indicates the level of parasitaemia from the infected subject. The highest mean malaria parasitaemia was recorded among age group 0-2 years (1983.11 μl^{-1}), while the lowest intensity of infection was recorded for age 3-5 years (1973.07 μl^{-1}).

Table 1: Prevalence of malaria in Itu Local Government Area relation to age and sex

Age	Male		Female		Total No examined	No infected (%)	Mean Parasitaemia (µl)/ CI
	No examined	No infected (%)	No examined	No infected (%)			
0 – 2	115	48(41.74)	152	69(45.34)	267	117(43.82)	1983.11 (1683.18±2283.04)
3 – 5	70	28(40.0)	93	36(39.7)	163	64(39.26)	1974.07 (1674.23±2274.16)
Total	185	76(41.08)	245	105(42.86)	430	181(42.09)	
P-value	0.004				0.0001		

X^2_{cal} = 8.109, df (1) (P<0.05)

The result in Table 2 shows the haematological parameters of malaria infected and non-infected subjects in the study area. The mean value of haemoglobin (Hb) of the infected subject ranges from 8.75 g/dl to 9.55g/dl for age group 0-2 through age 3-5 years respectively. These value decreases from the Hb value of non-infected subjects which ranges from 11.53g/dl to 11.86 g/dl for age group 0-2 through age 3-5 years respectively. The difference in the level of Hb of the infected subjects and the non-infected subjects was statistically significant (p< 0.05). The mean PCV ranges from 27.11% to 27.41% for infected subjects for age group 0-2 through age 3-5 years respectively, while the non-infected subject recorded mean PCV ranges from 39.41% to 40.42% for age group 0-2 through age 3-5 years respectively. The difference in the level of PCV of the infected subjects and the non-infected subjects was statistically significant (p< 0.05). variation was also observed in the mean value of red blood cell (RBC) of the infected subject compared with that of non-infected subjects. The RBC values range from 2.77 X 10^3µl to 3.18 x 10^3µl for the infected subjects and 4.03 X 10^3µl to 4.51 X 10^3µl for non-infected subjects with age group 0-2 through 3-5 years respectively. The mean value of WBC of the infected subject were higher than that of the non-infected persons across the age group. The difference in the level of RBC and WBC of the infected subjects and the non-infected subject was statistically significant (p< 0.05).

The haematological parameters of the infected and non-infected subjects in relation to sex indicated in table 2 shows that, the changes recorded for Hb level of the infected male and female was significant (p<0.05). Hb values in infected ranges from 8.66g/dl to 8.97g/dl and non-infected ranges 11.38 to 11.44 g/dl for male and female respectively. Variation was recorded in PCV and RBC level of the infected and non-infected subject between the males and females. These changes was statistically significant (p<0.05). Similarly, WBC level of the infected subject between the male female did not show wide differences. The WBC value of the male infected subject increase slightly from the non-infected subjects ranging from 5.38 x 10^3µl for females to 5.99 x 10^3µl for male infected subjects and 6.32 x 10^3 µl for male to 6.81 x 10^3 µl for females non-infected subjects.

The study also observed statistically significant (p<0.05) variation in the mean value of eosinophil, neutrophil and monocyte between male and females infected and non-infected subjects. There was increase in the mean value of neutrophil ranging from 2.779 x 10^3µl in female to 2.880 x 10^3µl in male for non-infected subjects and 3.04 x 10^3µl in female to 3.106 x 10^3µl in male for infected subjects. The changes in mean value of basophil and lymphocyte on infected and non-infected subjects between the males and females was not statistically significant (p>0.05).

The result of the study also revealed the relationship between parasitaemia and Red Blood cell level of the infected subjects as shown in figure 2, recorded a weak relation between the two parameters with the correlation coefficient r= 0.0074. However, this relationship was not statistically significant (p<0.05). Similarly, the relationship between parasitaemia and Hb, PCV, and WBC level of infected subjects indicated a weak relationship between the two parameters with a correlation coefficient r=0.108, 0.247, and -0.063 respectively. Also, these relationships were not statistically significant (p>0.05).

Table 3. revealed the measurement of serum ferritin, transferrin and serum iron level from the infected subject. Serum ferritin level of the male infected subject decreases as age increases. From the results the mean serum ferritin level in male infected subjects ranges from 581.12 ng/ml for age group 3-5 years to 648.30ng/ml for age group 0-2years. In the female infected subjects, the mean serum ferritin level ranges from 611.31ng/ml for age group 3-5 years to 632.63ng/ml for age group 0-2years. The difference between the mean serum ferritin level in male and female infected subjects was statistically significant (p<0.05). Transferrin measurement of the infected subjects indicates that the mean serum transferrin levels of the infected subjects were below the normal body transferrin level. In male the mean serum transferrin level ranges from 5.6 0ng/ml for age group 3-5years to 6.41ng/ml for age group 0-2years while in female the mean serum transferrin levels ranges from 6.56ng/ml for age group 0-2years to 6.68ng/ml for age group 3-5years. The transferrin level in the infected female subject were slightly higher than that of the male. There was no significance different observed in the mean serum transferrin level between the male and the female infected subjects (p>0.05). The result also indicates the level of serum iron of the infected subject in the study. The mean serum iron level of the male infected subjects ranges from 54.40 ng/ml for age group 0-2 years to 55.62ng/ml for age group 3-5years while in female the mean serum iron level ranges from 47.18ng/ml for age group 3-5 years to 48.81ng/ml for age group 0-2years. The serum iron level of the infected subjects recorded were higher the normal body serum iron level. The difference in the serum iron level observed between the male infected subject and female infected subjects was statistically significant (p<0.05).

Table 2: Haematological parameters of the infected subject and non-infected subjects

Parameters	0 -2 (years)		3-5 (years)		Male		Female		P-value
	Non-Infected	infected	Non-Infected	infected	Non-Infected	infected	Non-Infected	infected	
Hb (d/gl)	11.±1.22	8.75±2.32	11.86±1.98	9.55±2.01	11.44±0.40	8.97±0.272	11.38±0.51	8.61±0.12*	0.027
PCV (%)	39.41±2.13	27.41±2.08	40.07±2.11	27.11±1.97*	40.32±1.10	28.01±3.41	39.66±0.004	27.30±0.11*	0.001
RBC ($\times 10^3$ µl)	4.03±1.44	2.77±1.21	4.51±3.51	3.18±0.75*	4.11±0.72	2.71±0.11	4.37±0.23	2.91±1.31*	0.013
WBC ($\times 10^3$ µl)	5.32±1.52	6.62±2.30	6.12±2.72	6.75±1.86*	5.99±1.10	6.32±0.72	5.38±0.54	6.81±1.77	0.357
Basophils ($\times 10^3$ µl)	0.083±0.01	0.078±0.0	0.082±0.003	0.074±0.004	0.085±0.00	0.076±0.001	0.084±0.000	0.071±0.013	0.114
Eosinophils ($\times 10^3$ µl)	0.464±0.017	0.403±0.014	0.505±0.010	0.462±0.035	0.486±0.321	0.413±0.003	0.500±0.154	0.436±0.101*	0.041
Neutrophil ($\times 10^3$ µl)	2.811±0.058	3.104±0.127	2,836±0.026	3.232±0.074*	2.880±0.007	3.106±1.331	2.779±0.041	3.045±0.211*	0.049
Monocytes ($\times 10^3$ µl)	1.095±0.046	1.343±0.085	1.161±0.044	1.408±0.028*	1.107±o.112	1.299±0.003	1.115±0.016	1.337±1.013*	0.046
Lymphocytes ($\times 10^3$ µl)	4.909±0.300	3.931±0.358*	5.077±0.092	4.753±0.177	5.001±0.274	4.768±0.003	4.891±0.041	4.432±0.240	0.200

Hb=haemoglobin, PCV= Packed Cell Volume; RBC= Red Blood Cell; WBC= White Blood Cell (significance (*) P<0.05)

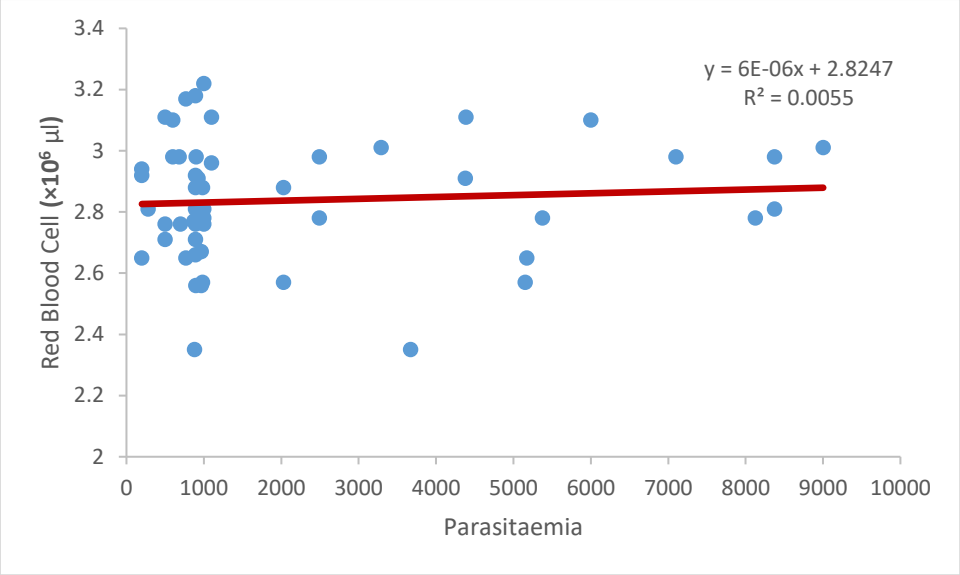

Figure 2: Showing the relationship between malaria parasitaemia and level of Bed Blood Cell (RBC) (P=0.596)

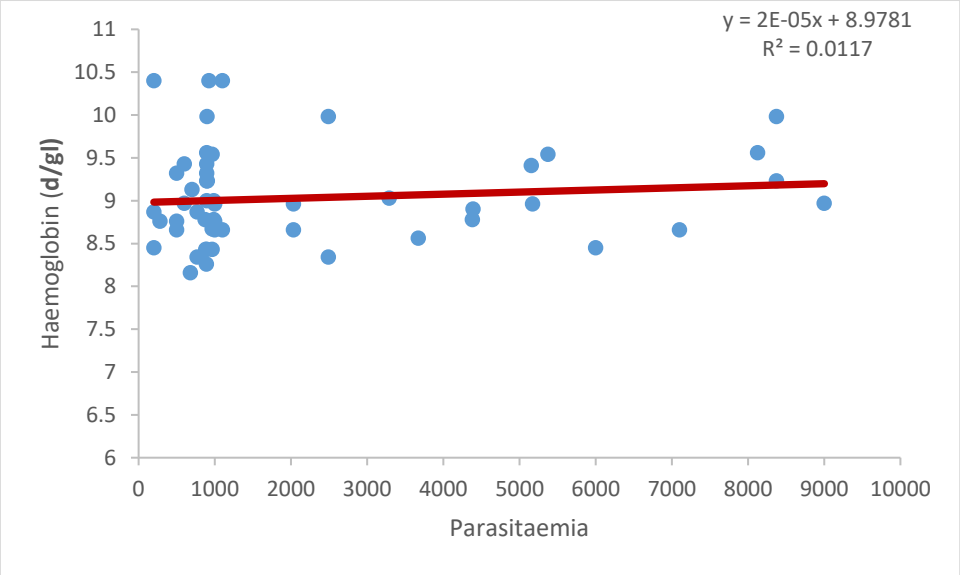

Figure 3: Showing the relationship between malaria parasitaemia and level of Haemoglobin (Hb) (r=0.108, p=0.702)

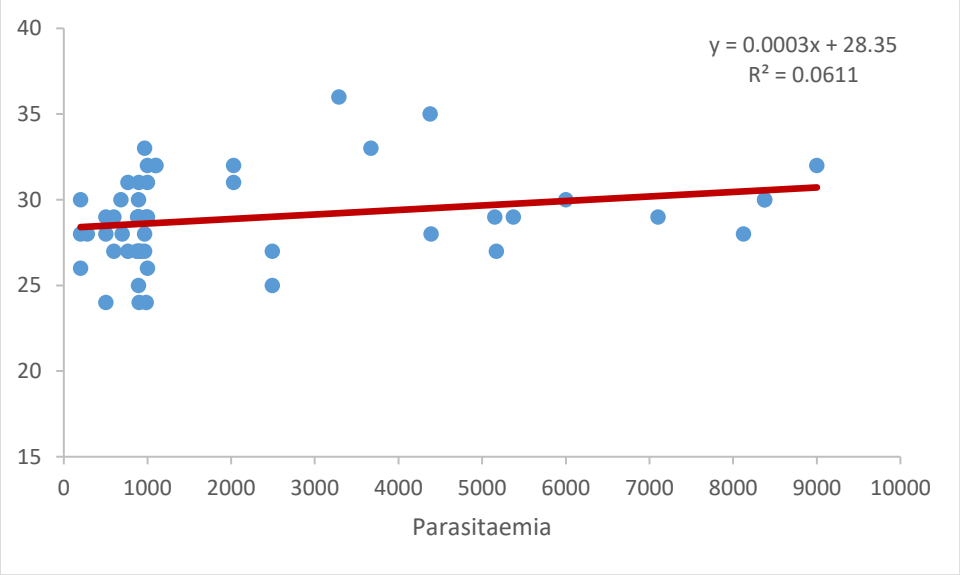

Figure 4: Showing the relationship between malaria parasitaemia and level of Packed Cell Volume (PCV) (r=0.247, p=0.226)

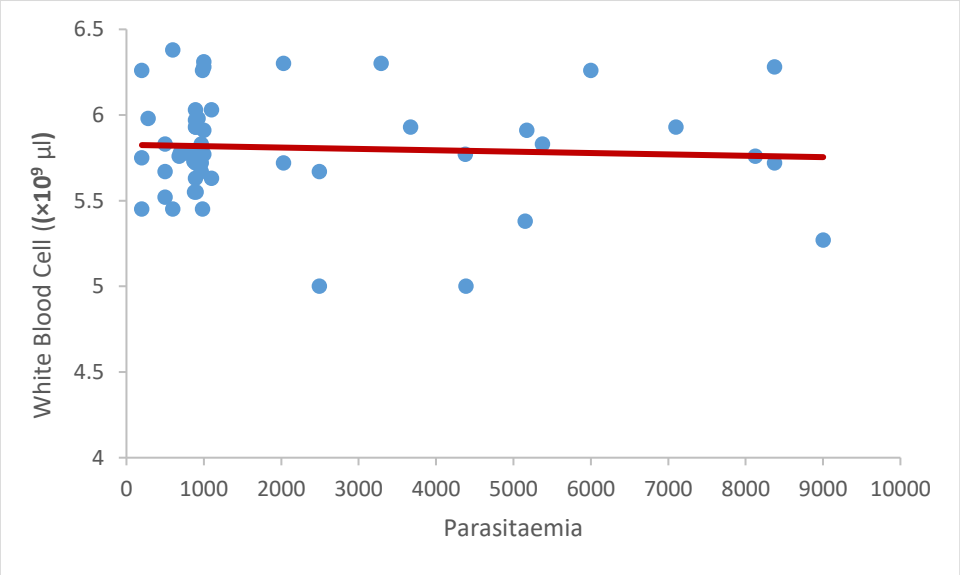

Figure 3: Showing the relationship between malaria parasitaemia and level of White Blood Cell (WBC) (p=0.432)

Table 3: Measurement of Serum ferritin, Transferrin and Serum iron level from the infected subject

Age	Male			Female		
	Serum ferritin (ng/ml)	Serum Transferrin (ng/ml)	Serum Iron (ng/ml)	Serum ferritin (ng/ml)	Serum Transferrin (ng/ml)	Serum Iron (ng/ml)
0-2	648.30±4.34*	6.41±0.72	54.40±2.16	632.63±3.28*	6.56±0.78	48.81±0.98*
3-5	581.12±2.73*	5.60±1.11	55.62±5.16	611.31±0.32*	6.68±1.34	47.18±4.75

SF= Normal (15-250 ng/ml); Risk (increase above normal);ST= Normal (25-34 ng/ml) Risk=decrease below 30% SI normal (9-30.4 ng/ml); Risk = (increase above normal). Significance (*) ($p<0.05$)

Discussion

Plasmodium infection stands as a major parasitic disease in the tropical countries of Africa, causing most deaths among children (WHO,2016). Approximately 97% of the Nigerian population has been reported to have the likelihood of being infected by this malaria parasites (PMI, 2015). The present study recorded a prevalence of 41.08%. This prevalence was slightly lower than the report of Atting *et al*, (2016) elsewhere within the Akwa Ibom State who reported a prevalence of 42.6%, also Bassey, (2017) recorded a higher prevalence of 56.41% within Akwa Ibom State. This prevalence was higher than the overall prevalence (30.01%) of malaria cases in children reported by the state (AKMOH, 2022). The rate of infection recorded in this study is quite daunting. This indicated a sustained transmission of malaria within the endemic area. Elsewhere in Nigeria higher prevalence of malaria than the present study has been reported. Sam-Wobo *et al*, (2014), reported malaria prevalence of 71.1% in

Anambra, and in Ogun State 53.5% prevalence was reported (Sam–Wobo *et al*., 2010). Similarly, in Anambra, Onyido *et al*. (2011) recorded 70.6% of malaria prevalence. The overall malaria prevalence in the present study appears substantially lower when compared with other similar studies conducted in other neighboring countries. In Garbon 70% of malaria prevalence was reported (Marielle *et al*. 2003). Also in Malawi, malaria prevalence of 45% was recorded among Children 0-5years of age (Precious *et al*. 2017). In other studies a significantly lower prevalence was obtained, In the Iwo community, Oyo State, 21.1% prevalence was reported by Igbenegbu *et al*. (2011), and 17% prevalence by Anumudu *et al.* (2006). These variations in results could be associated with climatic conditions and human activities that may influence the proliferation and breeding of mosquitoes as well as promoting mosquito bites. The study area is noted with an adequate amount of rainfall that can sustain breeding sites of malaria vectors.

The high rate of infection due to malaria documented in the present study indicated the burden of malaria in the study area which impacts the immunity of the population (Klinkenberg *et al*. 2005). This accentuates the reason malaria still poses a serious challenge despite tremendous efforts toward elimination. This high prevalence could also be ascribed to treatment failure which is common in the population and other environmental conditions such as puddles, ditches, and gutters which encouraged the breeding of mosquitoes to enhance transmission of malaria. The study recorded a significant ($p<0.05$) high prevalence across the age group. Similarly, Sam Wobo *et al*, (2014) and Syafruddin *et al*. (2009) reported high malaria prevalence across age groups in their studies. This could be associated with the shared immunity of mother and child. Malaria in children may cause cerebral malaria in children, anaemia, and also implicated poor growth in children (Olasehinde, 2010). This could most likely be that children's behaviour could expose them to mosquito bites and subsequent malaria transmission. This finding corroborates the study by Aribodor *et al.* (2003) who uncomplicated malaria in children under 5 years.

Haematological abnormalities were confirmed in this study among participants infected with malaria parasites compared to normal subjects. There was a significant reduction of Hb level, PCV, and RBC counts in the subjects infected with malaria compared to the uninfected group. This was in agreement with an earlier study by Abdalla, (2008). This could be a result of the children being more susceptible to the infection and their immune system often being compromised with other associated factors such as feeding conditions and other physiological factors including concomitant infection (Brooker *et al*, 2007). The increase of parasite density in the blood could result in the rupturing of RBCs, loss of both infected and uninfected cells However, It is thought to result from fact that, the parasite's primary target is the red blood cell resulting in RBCs destruction, accelerated removal of both parasitized and non-parasitized cells (Price *et al*. 2001), bone marrow dysfunction (Abdalla, 2008) and the level of parasitemia (Kitua *et al.* 1997). This study further corroborates the study by Maina *et al*. (2010) who documented that infants with malaria parasites showed significant variations in some blood indices with low RBC count and Hb concentration as the main indicators for *Plasmodium* infection This result also agrees with previous work by Francis *et al*. (2014) and Kotepui *et al.* (2014). However, this was contrary to the report in Dubai where the variation in haematological parameters was not associated with malaria parasite density. (Abro *et al.* 2008). This reduction in the haematological parameters in the malaria-infected subjects may reflect anaemia as a result of rupturing of RBCs and malfunctioning of the spleen. The result also showed a slight elevation of WBC level in malaria-infected subjects. This could probably be that at the release of the merozoites into the bloodstream, there was increased production of leukocytes to attack the parasite. The WBC count Increases in the present study due to malaria parasite infection was in line with previous studies by Obeagu *et al*. (2017) and Eledo and Izah, (2018). This was also in line with a previous report in which WBC level increased significantly in malaria-infected subjects Abro *et al*. (2008). However, this contradicts the findings by Senthilkumaar and Sarojini, (2013) who reported alteration in WBC level is associated with haematological defect instigated by malaria parasite infection.

This study also reported a slight decrease in the level of basophil, eosinophil, monocytes, and lymphocytes of the infected subjects compared to the non-infected subjects. This result corroborates the findings by Kotepui *et al*., (2014), and Gansane *et al.,* (2013). The reduction in lymphocyte, monocytes, and eosinophil levels due to *Plasmodium* parasite infection here could be as a result of the spleen receiving more action of the lymphocytes (Erhart *et al.,* 2014). The result of the study contradicts the study in Kenya where there was a marked increase in the level of monocyte in children infected with *Plasmodium* parasite compared to the uninfected children (Maina *et al*., 2010). The slight variation observed in the level of basophil recorded in the study could be as a result mosquito bite which causes allergic reaction in the host. Similarly, neutrophil level increases in children with malaria parasites compared to the uninfected children. However, this contradicts the findings of Senthilkumaar and Sarojini, (2013) who reported slight reduction in the level of neutrophil in children infected with malaria parasites. This result agrees with the study of Maina et al. (2010) where neutrophil level increases with the prevalence of malaria parasites.

It was observed in this study that decrease in PCV and Hb which are responsible for anaemia in infected subjects did not alter the serum ferritin level. However, there was a significant different increase ($p>0.05$) in the mean level of ferritin in the study with age group 3-5years recording the highest (648.30µg/l in males and 632.63µmol/l in females). This was in agreement with Stoltzfus *et al*., (2000) who reported damage of red blood cells due to *Plasmodium* parasite infection as well as obstruction of production of red blood cells in the bone marrow which could lead to deficiency of iron in the blood. This could bring about alteration in sink iron (ferritin). Similarly, Adelekan and Thurnham, (1990), reported high serum ferritin concentrations in children with malaria parasite infection.

This high mean serum ferritin in malaria-infected subjects in the study compared to normal could explain the fact that blood iron accumulation decreases in children mostly when red blood cells are attacked (Yip, 2004). These results corroborate the findings of Stoltzfus *et al.* (2000) and Anumunu *et al*. (2006) where serum ferritin increases in subjects infected with malaria parasites. In the study, there was no marked variation in serum ferritin levels between the male and female. This study also affirmed the study Anumunu *et al*. (2006) who reported no varying difference in serum ferritin levels about gender.

This study also showed an increase in serum ferritin levels as serum transferrin decreases. This was in line with previous studies with symptomatic and mildly symptomatic *falciparum* malaria. (Mockenhaupt *et al.* 1999; Stoltzfus *et al.* 2000; Beesley *et al*. 2000; Williams *et al*. 2011). High serum ferritin levels as well as decreased serum transferrin reported in this

study were not surprising. Christine, (2013), reported that the presence of malaria parasites in the blood could result in serious pathological complications with may trigger increase in the level serum ferritin concentration. The decreased level of serum transferrin in the study could be related to a decrease in the level of Hb and PCV as a result of increased parasitaemia in the infected subject. Transferrin is known to be the main iron transport protein found in the blood (Christine, 2013). Variation in transferrin level could be as a result of alteration in erythropoietic activity. This study also aligned with the report of Stoltzfus *et al.* (2000) and Odunukwe *et al*. (2001)

In conclusion, this study indicated that malaria parasite infection is associated with obstruction of red blood cell production among children in malarious areas. Decreased haemoglobin and lymphocyte levels could influence superficial blood destruction. Hence, giving keen observance during haematological parameters, such as RBC, Hb, platelet, lymphocyte, and monocyte levels when interpreting and evaluating malaria parasite impact on children's immunity in endemic areas. Malaria infection influences haematological and biochemical parameters to varying degrees. These parameters can serve as indicators for monitoring the impact of infection and as well provide guidance for the effective management of malaria patients.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This was obtained from Akwa Ibom State Ministry of Health

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