



## Research Article

## Effects of *Plasmodium Falciparum* Parasitaemia on Hepatomegaly among Patients Attending State Specialist Hospital and University of Maiduguri Medical Center, Borno State, Nigeria

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## ABSTRACT

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Malaria caused by *Plasmodium falciparum* is associated with pathological alterations in several organs, particularly the liver. This study assessed the effect of *P. falciparum* parasitemia on liver size (hepatomegaly) among patients attending the State Specialist Hospital and the University of Maiduguri Medical Centre, Borno State, Nigeria. A total of 100 malaria-positive blood samples were collected between August and September and analysed for malaria parasite density, liver function enzymes, and related biochemical parameters. High parasite densities were observed among individuals aged 21–30 and 71–80 years, as well as within the weight categories of 40–50 kg and 61–70 kg. Parasitemia showed a positive association with aspartate aminotransferase and alkaline phosphatase levels, while alanine aminotransferase showed no significant association among patients from the University of Maiduguri Medical Centre ( $p > 0.05$ ). No significant relationship was found between age and alanine aminotransferase levels ( $p = 0.379$ ). Increased parasite density was associated with enlarged liver size, particularly in patients aged 21–30 and 71–80 years, with hepatomegaly measurements ranging from 18.9 to 27.9 cm in diameter. Male patients exhibited greater liver enlargement than females in both hospitals. These findings suggest that *P. falciparum* parasitemia is associated with measurable liver changes, underscoring the importance of routine liver function monitoring during malaria management and the need for further molecular studies.

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## INTRODUCTION

*Plasmodium falciparum* is a unicellular and apicomplexan protozoan parasite of both humans and animals, it is the deadliest species of *Plasmodium* that causes malaria in humans (Touze *et al.*, 2017). The parasite is transmitted

through the bite of an infected female *Anopheles* mosquito which causes the disease's most dangerous form, but infection can effectively occur through the exposure to infected blood (transfusion malaria) and congenital transmission (Malar *et al.*, 2019). *P.*

*falciparum* malaria is responsible for 50% of all malaria cases as reported by World Malaria Report (WMR, 2021). While, *P. falciparum* is regarded as the deadliest parasite in humans, World Health Organization on Malaria Report in 2021, shows there were 241 million cases of malaria in the year 2020, resulting in an estimated 627,000 deaths and in contrast nearly all malarial deaths are caused by *P. falciparum*, and 95% of such cases occur in Africa (WHO, 2021). Children under five years of age are most affected, accounting for 80% of the total deaths. In Nigeria malaria is considered a serious public health challenge, in which children, pregnant women and the elderly are at higher risk of being infected with malaria due to low immunity that can fight malaria parasites. Malaria parasite can affect organs in the body such as liver (Burgio and Erhabor, 2019; Asker and Volkan, 2020). Liver involvement in malaria infection has become a common case in patients with severe malaria as sometimes manifests as jaundice which is an increase in serum bilirubin level, Hepatomegaly, rise in liver enzymes concentration like aspartate aminotransaminase/alanine transaminase show reduction in albumin and an increase in prothrombin. There are usually specific histopathological alterations and changes in liver function test parameters, (fulminant hepatic failure and hepatic encephalopathy) (Rajesh *et al.*, 2003). Some studies also reported that malaria hepatitis is characterized by increased transaminase levels to more than three times the upper limits of normal and alkaline phosphatase (Bhalla *et al.*, 2017). The liver has a wide range of functions including detoxification, protein synthesis, production of biochemical's necessary for digestion, storing of glycogen and hormone production (Enemchukwu *et al.*, 2020). There are usually specific histopathological alterations and changes in liver function test. The changes

$$N = \frac{Z^2 Pq}{d^2}$$

Where n = sample size for blood.

z = statistics for a level of 95% confidence interval = 1.90

P = Prévalence rate = 23 % (Onakewhor & Chiwuzie, 2011) = 0.23

d = precision (allowable error) = 5% = 0.05

$$q = (1-p) = 1 - 0.23 = 0.77$$

$$\text{Thus } n = \frac{(1.90)^2 \times 0.09 \times 0.77}{(0.05)^2}$$

caused in the hepatic cell by sporozoite can lead to the leakage of parenchymal and membranous enzymes of the liver into the circulatory system, which can be responsible for the increase in liver enzymes (Burtis and Ashwood, 2010). The severity of malaria infection has been linked with the increase in the level of liver enzymes in the body (Onyesom and Onyemakonor, 2011). The progress in the control and prevention of *P. falciparum* malaria parasites, the disease remains a major health challenge, which contributes immensely to the morbidity and mortality especially in tropical and subtropical regions. The *P. falciparum* parasitemia progress to severe form causing disruption of biochemical parameter of liver such as (AST, ALP & ALT). This leads to Hepatomegaly. However, with access to early diagnosis with antimalarial treatments can prevent complications and death (Mavundla and Gidebo, 2022).

## MATERIALS AND METHODS

### Study Area

The study was conducted in State Specialist Hospital (SSH) and University of Maiduguri Medical Center (UMC). Maiduguri Borno State in North-eastern Nigeria. Borno state was formed in 1976 from the split of the North-eastern state. Borno has an estimated land mass of about 61,435 square kilometers, with latitude between 11° 50 North and longitude 13° 09 East, it is attended by many patients from different locations. It was purposely chosen because of the number of patients attending the hospital making it easy to achieve the desired sample size and its proximity and convenience to many dwellers of Maiduguri city including peoples from far local governments (LGA) and even from neighboring States.

### Samples Size Determination

The samples size were determined using the formula provided by Antonisamy and Arya (2012)

= 100 blood samples was recruited for the study

### Sample collection

A total of 100 blood samples was collected by venepuncture from patients presented with signs and symptoms suggestive of *P. falciparum* malaria parasites in ethylene diamine tetra acetic acid (EDTA) container, and plain bottle aseptically from patients attending State Specialist Hospital (SSHM) and Unimaid Medical Center Maiduguri (UMC), and labeled appropriately. All samples collected were handled and transported aseptically to the parasitology and hematology laboratory

### Laboratory procedure

Four milliliter (4 ml) of blood was collected by vein puncture from each patient by a laboratory technician, using 5ml needle and disposable syringe. 2ml of the whole blood was immediately transferred into ethylene diaminetetra acetic acid (EDTA), while the remaining 2ml was transferred into plain bottle and were allowed to clot and serum were later separated. The level of liver enzymes was determined from the serum. The parasitemia were determined using the whole blood respectively.

### Preparation of film for parasite density counts

#### Thick Blood film preparation

The drop of whole Blood was placed on clean grease-free slide using a glass spreader, to make a thick film, and allowed to air dry, free from dust and flies, and labeled with patient identity.

#### Staining procedures

The slide was placed on a staining rack above the sink and stained with Giemsa freshly diluted with buffered water, pH 7.2, for 30 minutes, and washed with running tap water, and allowed to stand upright to air dry which was examined under the microscope using ( $\times 100$ ) objective lens for malaria parasites (Brain *et al.*, 2020).

#### Determination of parasites densities

The World Health Organization procedure was adopted for malaria cases, Giemsa stain thick blood film was used for assessment and parasites densities was determined using an average white blood cell (WBC) of 8000 per  $\mu$ l. The parasitemia per  $\mu$  of blood was calculated using WHO (1996:2003) and Alphonse and Laveran (2019). A slide was considered negative when no parasite was found after screening of 200

fields. For those slides that were positive the number of parasites counted per 200 white blood cells were used to calculate parasite density on the basis of 8000 leukocyte per  $\mu$ l of blood.

Where:  $P = NP \times 8000 / NL$

Where: P represents malaria parasitaemia (per  $\mu$ l),

NP is the number of parasites

NL is number of (WBC) Leucocytes.

Serum was separated from the whole blood in plain bottles and stored immediately at  $-20^{\circ}\text{C}$  for aspartate aminotransferase, alanine aminotransferase, and alkaline phosphatase analysis which were performed within 2 days of sample collection (Bain *et al.*, 2020)

### Determination and Estimation of serum AST and ALT

AST and ALT were estimated using Dinitrophenyl hydrazine coupling colorimetric technique (Reitman and Frankel, 1957).

#### Determination of Aspartate Amino transferase (AST)

Into a clean test tubes placed in a rack and arranged in a water bath regulated at  $37^{\circ}\text{C}$ , 0.5ml of AST reagent 1 was dispensed, 100 $\mu$ l of distilled water was dispensed in to the test tube marked blank, while 100 $\mu$ l of patients serum was dispensed into other with control in the appropriate position, the contents of the test tube were properly mixed and incubated for 30minutes in the water bath, 0.5ml of AST reagent (2-4 dinitrophenyl hydrazine) was dispensed into all the test tubes and incubated for 20minutes at  $20^{\circ}\text{C}$ , 5.0ml of sodium hydroxide (colour developer) was introduced in to test tube to stop the reaction, it was then mixed and read at 546nm wavelength against the reagents blank after 5minutes. The concentration was determined using a Table provided by the manufacturers (Reitman and Frankel, 1957).

#### Determination of Alanine Amino transferase (ALT)

Into a clean test tubes placed in a rack and arranged in a water bath regulated at  $37^{\circ}\text{C}$ , 0.5ml of ALT reagent 1 was dispensed, 100 $\mu$ l of distilled water was dispensed in to the test tube marked blank, while 100 $\mu$ l of patients serum was dispensed in to other with control in the appropriate position, the contents of the test tube were properly mixed and incubated for

30minutes in the water bath, 0.5ml of ALT reagent (2-4 dinitrophenyl hydrazine) was dispensed in to all the test tube and incubated for 20minutes at 20°C, 5.0ml of sodium hydroxide (colour developer) was introduced in to test tube to stop the reaction, it was then mixed and read at 546nm wavelength against the reagents blank after 5minutes. The concentration was determined using a Table provided by the manufacturers (Reitman and Frankel, 1957).

#### **Determination of Alkaline Phosphatase (ALP)**

Exactly 0.5ml of alkaline phosphatase substrate was dispensed into the test tube labeled test, standard and blank, 0.05ml of each samples serum was added to the test tube labeled test alongside the standard and the distilled water respectively, this was mixed and incubated for 10 minutes at 37°C, then 2.5ml of alkaline phosphatase color developer was introduced, the absorbance of the sample was mixed and read at 55nm wavelength against the blank after 5 minutes. The concentration was determined using a Table provided by the manufacturers (Klein and Babson, 1960).

#### **PROCEDURE FOR ABDOMINAL ULTRASOUND SCAN TO DETECTS HEPATOMEGALY.**

A curvilinear transducer equipment (3-5 MHZ) was used and adjusted to the abdominal preset (Hagen-Ansert, 2018).

**Positioning:** The patient was lay supine, for better liver visualization, the left and right lateral decubitus position were used (Rumack *et al.*, 2018)

**Liver (Hepatomegaly detection):** The examination started in the right upper quadrant with the transducer placed below the ribcage. Scanning was done in the longitudinal plane to assess liver length. Normal liver size was < 15cm. A liver measuring > 15.5 cm indicated Hepatomegaly (Sander and Winter, 2016).

**Dynamic techniques:** The patient was asked to take a deep breath and hold it to move the liver into better view.

**Post –procedure**

The gel was cleaned off the patient’s skin and they were informed that the physician would review the results

#### **RESULTS**

**Parasite Density in Relation to Age of Patients**

Table 1 shows the descriptive Statistics of *P. falciparum* malaria parasites density in relation to age of patients. Parasitemia were higher among individuals 21-30 and 71-80 years age group, means SD (1118.6±7.3625) and (1678.0±1.1547), and lowest among 41-50years age group; with mean SD (549.6±4.4279) and (150.00±1.1547).

**Table 1:** *Plasmodium falciparum* malaria parasite densities among ages of patients

Ages (Years)	Mean	SD	Minimum	Maximum
<b>State Specialist Hospital, Maiduguri</b>				
10 – 20	918.3	5.8429	917.30	919.30
21 – 30	1118.6	7.3625	1117.6	1119.6
31 – 40	722.4	4.3597	721.40	723.40
41 – 50	549.6	4.4279	548.60	550.60
51 – 60	809.4	0.8206	808.40	810.40
61 – 70	1023.5	2.5047	1022.5	1024.5
71 – 80	1110.3	5.5142	1109.3	1111.3
<b>Unimaid Medical Centre</b>				
Ages (Years)	Mean	SD	Minimum	Maximum
10 – 20	460.00	1.1547	459.00	461.00
21 – 30	901.20	0.8206	900.20	902.20
31 – 40	1037.8	0.8206	1036.8	1038.8
41 – 50	139.00	1.1547	149.00	151.00

51 – 60	300.00	1.8257	298.00	302.00
61 – 70	150.80	0.8206	138.80	140.80
71 – 80	1678.0	1.1547	1677.0	1679.0

**Parasites Density in Relation to Gender of Patients**  
 patients. Males tended to have higher parasite densities on average compared to females in both hospitals; male had the higher PD mean SD (1005.6±215.21) and SD (782.65±904.04), while female had mean (628.01±328.31) and female (766.61±613.46). In SSH and UMC respectively (Table 2)

**Table 2:** *Plasmodium falciparum* malaria parasite densities in relation to gender of patients

GENDER	Mean	SD	Minimum	Maximum
<b>State Specialist Hospital, Maiduguri</b>				
Female	628.01	215.21	0.00	1016.6
Male	1005.6	328.31	667.50	1220.7
<b>Unimaid Medical Centre</b>				
GENDER	Mean	SD	Minimum	Maximum
Female	766.61	613.46	0.00	1678.0
Male	782.65	904.04	0.00	2299.9

**Parasites Density in Relation to Body Weight of Patients**

Table 3 shows descriptive Statistics for *P. falciparum* malaria parasite densities among body weights of patients. The highest parasite densities were observed among patients weighing 40-50 and 61-70 kg range and had the highest mean SD of parasite density (1150.2

± 214.75) and (1028.0 ± 4.8083), while those in the 40-50 and 81-90 kg range (473.17 ± 669.16) and (380.00 ± 311.13) had the lowest parasite densities. Those in the 81-100 kg category in unimaid medical center had no recorded parasite densities, indicating that no cases were observed in that group (Table 3).

**Table 3:** *Plasmodium falciparum* malaria parasite densities in relation to the body weights of patients

Body Weights (kg)	Mean	SD	Minimum	Maximum
<b>State Specialist Hospital, Maiduguri</b>				
40 – 50	1150.2	214.75	998.30	1302.0
51 – 60	868.30	47.093	835.00	901.60
61 – 70	891.94	373.87	627.57	1156.3
71 – 80	869.96	445.18	555.17	1184.8
81 – 90	473.17	669.16	0.0000	946.33
91 – 100	506.00	715.59	0.0000	1012.0
<b>Unimaid Medical Centre</b>				
Body Weights	Mean	SD	Minimum	Maximum
40 – 50	380.00	311.13	160.00	600.00
51 – 60	835.81	58.718	794.29	877.33
61 – 70	1028.0	4.8083	1024.6	1031.4
71 – 80	1009.0	285.67	807.00	1211.0
<b>81 – 90</b>	<b>0.0000</b>	<b>0.0000</b>	<b>0.0000</b>	<b>0.0000</b>



**Chi-square Table for Parasites Density and AST, ALP and ALT in Relation to Gender of Patients**

ALP, and ALT by gender for both hospitals. The (P-values: 0.571) at SSH is greater than the common significance threshold (0.05), indicating no statistically significant relationship. Similarly the (P-value 0.987) at the UMC is even higher, further suggesting an extremely weak association. This implies that there is no statistically significant relationship between gender and distribution of AST, ALP and ALT level.

**Table 5: Chi-square table for PD, AST, ALP and ALT in relation to gender of patients**

GENDER	CHI- SQUARE	PD	AST	ALP	ALT	TOTAL
<b>State Specialist Hospital</b>						
Female	Observed	628	13	32	13	<b>686</b>
	Expected	634.70	11.66	26.82	12.83	
	Cell X <sup>2</sup>	0.07	0.15	1.00	0.00	
Male	Observed	1005	17	37	20	<b>1079</b>
	Expected	998.30	18.34	42.18	20.17	
	Cell X <sup>2</sup>	0.04	0.10	0.64	0.00	
	<b>Total</b>	<b>1633</b>	<b>30</b>	<b>69</b>	<b>33</b>	<b>1765</b>
	Overall X <sup>2</sup>					2.01
	<b>P-value</b>					<b>0.571</b>
<b>Unimaid Medical Centre</b>						
Female	Observed	766	13	34	13	<b>826</b>
	Expected	764.28	13.33	34.56	13.82	
	Cell X <sup>2</sup>	0.00	0.01	0.01	0.05	
Male	Observed	782	14	36	15	<b>847</b>
	Expected	783.72	13.67	35.44	14.18	
	Cell X <sup>2</sup>	0.00	0.01	0.01	0.05	
	<b>Total</b>	<b>1548</b>	<b>27</b>	<b>70</b>	<b>28</b>	<b>1673</b>
	Overall X <sup>2</sup>					<b>0.14</b>
	<b>P-value</b>					<b>0.987</b>

**Correlation between Parasite Densities with AST, ALT and ALP in Relation to Body Weight of Patients**

Table 6 shows no significant correlations between PD and AST (0.0680), ALP (0.1509), or ALT (0.1533) at SSH, compared to UMC which showed Significant correlations between PD and AST (0.6086), ALP (0.5270), and ALT (0.5065) at (P< 0.05). (P-value 0.0000). In UMC, malaria parasite densities were positively correlated with liver enzymes. Body weight was not significantly (P>0.05) correlated with parasite density or liver enzymes.

**Table 6:** Correlation matrix showing the relationship between malaria parasite densities (PD) with AST, ALT and ALP in relation to body weight of patients

<b>State Specialist Hospital, Maiduguri (SSH)</b>					
	PD	AST	ALP	ALT	Body weight
PD	-				
AST	0.0680ns	-			
ALP	0.1509ns	0.4745ns	-		

ALT	0.1533ns	0.5307ns	0.4315ns	-	
Body weight	0.1141ns	0.0680ns	-0.0146ns	0.0442ns	-
<b>Unimaid Medical Centre (UMC)</b>					
	PD	AST	ALP	ALT	Body weight
PD	-				
AST	0.6086*	-			
ALP	0.5270*	0.6114*	-		
ALT	0.5065*	0.78753**	0.7119**	-	
Body weight	0.1110ns	-0.0764ns	0.0545ns	-0.0410ns	-

Number of pairs of observation used in computation of r value, i.e, **N = 21 (for SSH). N = 16 (for UMC).**

\* = **significant at (P<0.05).** \*\* = **significant at (P<0.01).** . ns = not significant. (**P-values 0.0000**).

\* = **significant** \*\* = **highly significant**

ns = not significant

AST – Aspartate Amino Transferase

ALT – Alanine Amino Transferase and ALP – Alkaline Phosphates

### **Effect of *P. falciparum* Parasitemia on Liver sizes of Patients in Relation to Age**

Table 7 shows higher parasite densities were associated with increased liver sizes, particularly in specific age groups. The highest parasites densities were observed among 21 – 30 and 71 – 80 age group (1118.6a ) and (1678a), with largest liver size (27.925a)cm and (20.1a), while lowest parasitemia were observed among 41 – 50 age group (549.6g ) and (150f ) with smallest liver size (15.7a ) and (13.1d ). The consistent ‘a’ indicates certain groups differ significantly from others, suggesting age-related susceptibility or response to infection.

**Table 7:** Effect of *P. falciparum* parasitemia on liver sizes of patients in relation to their age

AGES	PARASITE DENSITIES	SIZE OF LIVER
<b>State Specialist Hospital</b>		
10 –20	918.3d	18.475d
21 – 30	1118.6a	27.925a
31 – 40	722.4f	17e
41 – 50	549.6g	15.7g
51 – 60	809.4e	17.575e
61 – 70	1023.5c	19.525c
71 – 80	1110.3b	20.275b
<b>SE±</b>	<b>0.5802</b>	<b>7.607</b>
<b>Unimaid Medical Centre</b>		
10 –20	460d	14.75c
21 – 30	901.2c	17.925b
31 – 40	1037.8b	19ab
41 – 50	150f	13.1d
51 – 60	300e	15.3c
61 – 70	139.8f	17.55b
71 – 80	1678a	20.1a
<b>SE±</b>	<b>6.669</b>	<b>0.498</b>

### Chi-square test for malaria Parasite Densities and sizes of Liver of Patients Relation to Gender

Table 8 shows no significant differences between observed and expected malaria parasite counts by gender for both hospitals SSH (P-values: 0.5367) and UMC (P-value 0.9317). No

significant differences among male and female in malaria prevalence. The no significant association of malaria infection with gender indicates that transmission has no gender preference, as individuals of both genders have equal risk of infection.

**Table 8:** Chi-square test for malaria parasite densities and sizes of liver among patients attending state specialist hospital and unimaid medical centre relation to their gender

Gender	Chi-Square	<u>State Specialist Hospital, Maiduguri</u>			<u>Unimaid Medical Centre</u>		Total
		Parasite Density	Size of Liver	Total	Parasite Density	Size of Liver	
Female	Observed	628	20	<b>648</b>	766	18	<b>748</b>
	Expected	631.21	20.0		764.44	18.77	
	Cell X <sup>2</sup>	0.02	0.00		0.00	0.03	
Male	Observed	1005	32	<b>1037</b>	782	20	<b>802</b>
	Expected	1001.79	31.0		783.56	19.23	
	Cell X <sup>2</sup>	0.01	0.00		0.00	0.03	
<b>Total</b>		<b>1633</b>	<b>52</b>	<b>1685</b>	<b>1548</b>	<b>38</b>	<b>1582</b>
<b>Overall X<sup>2</sup></b>				<b>1.24</b>			<b>0.14</b>
<b>P-value</b>				<b>0.265</b>			<b>0.708</b>

### Chi-square test for Parasite Densities and sizes of Liver Patients in Relation to Body Weight

The results in Table 9 of this study demonstrate *P. falciparum* parasitemia was strongly and significantly correlated with body weights of

patients. With significant differences between observed and expected malaria parasite counts in relation to body weight for both hospitals, At SSH, (P- value 0.0000) and UMC (P-value 0.0000). Those in the 81-100 kg category have no recorded parasite densities.

**Table 9:** Chi-square test for malaria parasite densities and of liver size among patients in relation to their body weight

Body weight (kg)	Chi-Square	<u>State Specialist Hospital, Maiduguri</u>			<u>Unimaid Medical Centre</u>		Total
		Parasite Density	Size of Liver	Total	Parasite Density	Size of Liver	
40 -50	Observed	1074	14	<b>1088</b>	30	15	<b>45</b>
	Expected	1079.27	11.87		57.15	1.43	
	Cell X <sup>2</sup>	0.03	0.38		12.90	129.31	
51 – 60	Observed	882	16	<b>898</b>	819	18	<b>837</b>
	Expected	894.33	9.83		814.39	20.31	
	Cell X <sup>2</sup>	0.17	3.87		0.03	0.26	
61 – 70	Observed	892	18	<b>910</b>	1028	18	<b>1046</b>
	Expected	907.05	9.97		1013.46	25.27	
	Cell X <sup>2</sup>	0.25	6.46		0.21	2.09	
71 – 80	Observed	807	18	<b>825</b>	850	17	<b>867</b>
	Expected	823.88	9.06		842.01	21.00	
	Cell X <sup>2</sup>	0.35	8.83		0.08	0.76	

81 – 90	Observed	4246	18	<b>4264</b>	0	0	<b>0</b>	
	Expected	4188.88	46.06					
	Cell X <sup>2</sup>	0.78	17.09					
91 – 100	Observed	1012	14	<b>1026</b>	0	0	<b>0</b>	
	Expected	1019.58	11.21					
	Cell X <sup>2</sup>	0.06	0.69					
<b>Total</b>		<b>8913</b>	<b>98</b>	<b>9011</b>	<b>2727</b>	<b>68</b>	<b>68</b>	<b>2795</b>
<b>Overall</b>				<b>75.93</b>				<b>278.06</b>
<b>X<sup>2</sup></b>								
<b>P-value</b>				<b>0.0000</b>				<b>0.0000</b>

## DISCUSSION

Table 1 shows that the highest parasites densities were recorded in patients between age group 21 – 30 and 71 – 80 years, with mean SD (1118.6±7.3625) and (1678.0±1.1547) respectively, lowest in 41 – 50 age group mean SD (549.6±4.4279) and (150.00±1.1547) accordantly. This study is in line with study conducted by Mangusho *et al.* (2023). The researchers discovered that young adult had a higher vulnerability to *P. falciparum* malarial infection than older expectant age group; the study further explained that older acquire immunity to malaria over time due to frequent infections, leading to lower levels of malarial parasites in adult by Mangusho *et al.* (2023). Similarly the finding is in tandem with an earlier study by Lucien *et al.*, (2010) which observed a high rate of parasitaemia among patients between 71 and 80 years. The subjects of said age group were considered as immunocompromised individuals (WHO, 2015) and lowest among 41 – 50 age group with mean SD The study's low parasite density counts are comparable with findings from Nkuo *et al.* (2002), who found with 41-50 years in Buea had a high proportion of asymptomatic malaria cases and low hemoglobin levels. This study concurred with the studies of Ohalete *et al.* Okoroiwu (2002), (2020) and Bolaji *et al.* (2023) who reported that the occurrence of malaria is not influenced by age. But agrees with Oladimeji *et al.*, (2023) where observed significant differences in *P. falciparum* malaria infection among the subjects.

Furthermore, the result in Table 2 shows male had a significantly higher parasites densities of *P. falciparum* malaria infection

compared to their female counterparts in both hospitals respectively, with mean SD (1005.6±215.21 and 628.01±328.31) and (782.65±904.04 and 766.61±613.46). This result is consistent with study conducted by Okafor and Oko-ose, (2012), which noted a greater incidence in men than in females. Krogstad (1996), attributed sex based variations in *P. falciparum* malarial infection to genetic and hormonal variables. But results of the present study contradict those of Mbanugo and Ejim (2000), who reported that sex had no bearing on the frequency of *P. falciparum* malarial infection. However WHO, (2005; 2006) reported higher prevalence in males than females with no evidence to gender susceptibility as malaria infection is not influenced by gender Gilks and warell, (1993) observed that higher prevalence rate among male could just be by chance.

Table 3 shows patients weighing 40-50 and 61-70 kg range had the highest mean parasite density mean SD (1150.2±214.75) and (1028 ± 4.81), while those in the 81-90 and 40-50 kg range mean SD (473.17 ± 669.16) and (380.00 ± 311.13) had the lowest parasites densities. This finding is in agreement with Umba *et al.*, (2011) whose study observed that lighter patient had more parasites density than heavier patients. Rosso *et al.* (1990) also observed that lack of apatite lead to under-nutrition and inadequate accumulation of fat stored can render malaria patients incapable of meeting the substantial metabolic demands Those in the 81-100 kg category had no recorded parasite densities, indicating that no cases were observed in that group.

The result in Table 4 show a significant correlations between PD and liver enzymes (AST, ALP, ALT) with (p-values of 0.5439, 0.7225 and 0.6464) and (p-values of 0.5323, 0.5439 and 0.3759ns), at ( $p < 0.05\%$ ) suggesting that higher parasite densities were associated with liver dysfunction. This result is in line with earlier studies by Onyesom *et al.* (2011), which demonstrated significant different levels of ALP, AST, and ALT in *P. falciparum* malarial infection based on ages and sex categories. But the relationship between PD and ALT was not significant with ALT. This is similar to the earlier study by Akanbi (2015), who reported that ALT level did not significantly differ with *P. falciparum* malaria infected patients.. Age does not appear to influence PD or liver enzyme levels significantly in either setting because the variables under study are more then ( $P = 0.05$ ). This means there is significant correlations between *P. falciparum* densities and liver enzymes (AST, ALP, ALT) in malaria patients, studies also demonstrated that serum activities of liver enzymes increased with the increase in malarial parasite density (Onyesom, 2012; Baheti *et al.*, 2003).

Table 5 shows no significant differences between *P. falciparum* parasite counts and AST, ALP, and ALT by gender in both hospitals (P-values: 0.571) UMC (P-value 0.987). The no significant association of malaria infection with gender indicates that transmission has no gender preference and gender is not factor to determine malaria burden, as individuals of both gender have equal risk of infection (Deshwal *et al.*, 2012). This finding is inconsistent with the study of Wasnik *et al.*, (2012), and Aundhakar *et al.* (2017) who reported that males had higher prevalence of malaria than females significantly Melhotra *et al.*, (1997) who reported malaria prevalence to be higher in females than males.

Table 6 shows no significant correlations between PD and AST (0.0680), ALP (0.1509), and ALT (0.1533). The result of this study is in line with the study conducted by Coker *et al.* (2003) whose investigation also demonstrated that the liver enzymes (AST, ALP and ALT) of malaria patients were not significantly affected by malaria parasites density. However, Significant correlations existed between PD and

AST (0.6086), ALP (0.5270), and ALT (0.5065) at ( $P < 0.05\%$ ). It was observed that aberrant cell activation brought on by the parasites could contribute to an elevation in liver enzyme (ALT) levels (Jarike *et al.*, 2002). This result is in line with earlier studies by Onyesom *et al.* (2011), which demonstrated significantly different levels of ALP, AST, and ALT in *P. falciparum* malaria infection on body mass categories. But is not in line with the reported of Pratt *et al.*, (2000) that the body weight ratio had a negative correlation with parasite densities among patient of all body weight

Table 7 shows parasitemia are associated with increased liver sizes, particularly in specific age groups, the highest parasites densities were observed among 21 – 30 and 71 – 80 age group (1118.6a ) and (1678a), with largest liver size (27.925a) and (20.1), cm. lowest PD were observed among 41 – 50 (549.6g ) cm age group with lowest liver size (15.7a) and (13.1d). These results are in agreement with a previous study (Okoye *et al.*, 2005) where the liver size increased linearly with age until the middle age had a maximum of 12 cm, and thereafter undergoes gradual diminution, and a phenomena documented by Bisset *et al.* (2008). ELSharkawy *et al.* (1997) found all the measured parameters increased with age till 30 years. Previously, Arore *et al.* (2010) showed a rapid growth in splenic length up to age 30 years, followed by a mild decrease. The result of the study indicates certain groups differ significantly from others. This finding is in line with previous studies of Urata *et al.* (1995) who reported different patterns of age-associated changes in liver size among children and adults. This finding also tallies with Hoefs *et al.* (1999) who found a linear correlation of splenic volume with age. The results of the present study agree with the study of Adler *et al.* (2011) who found that a splenic size also moderately correlated with age. Table 8 shows no significant differences between observed and malaria parasite counts by gender for both hospitals, SSH (P-values: 0.5367) and UMC (P-value 0.9317). The result showed no gender preference, as individuals of both gender have equal risk of infection. The higher prevalence rate among male or female could be by chance (Wasnik *et al.* 2012). This was different when

compared with findings of Prassopoulos *et al.* (1997), Elsharkawy *et al.* (1997), Hoefs *et al.* (1999) Kanekoj *et al.* (2002) and Ramak *et al.* (2010). They observed that there were no differences in liver size between male and females. This finding is not comparable with the reports of Deshwal (2012) and Aundhakar *et al.* (2017) who emphasized males tended to have higher prevalence than females and Melhotra *et al.* (1997) reported malaria prevalence to be higher in females than males.

Table 9 shows that *P. falciparum* parasitemia were strongly and significantly correlated with body weights of patients. Significant differences existed between malaria parasite counts by BW for both hospitals, at SSH, (P- value 0.0000) and UMC (P-value 0.0000). This finding is in line with previous studies of Urata *et al.* (1995) who reported different patterns of age-associated changes in liver size among children and adults. Our findings here corroborate with those studies which evaluated BW, BH, and BSA independently V a u t h e y *et al.*, (2002) and Chouker *et al.*, (2004). Those in the 81-100 kg category have no recorded parasite densities, indicating that no cases were observed in that group. This is also in concordance with the use of only body weight as reference in determining the adequacy of the size of the liver graft from studies of North America by Ben-Haim *et al.*, (2001) and Troisi *et al.*, (2003).

#### CONCLUSION

In this study, there was a very high *P. falciparum* parasite density, which significantly influenced some biochemical parameters as evidenced by enlarged liver among the patients. Although age of the patients did not influence the properties assayed, patients' lifestyle should not be undermined more especially that organ enlargements were observed irrespective of the patients' age. Health education programme on the need to reduce breeding sites of mosquitoes. As well as regular and consistent monitoring of some liver enzymes derangement by performing full liver function tested. Further studies on molecular detection and PCR sequencing should be carried out

#### Ethical consideration

Ethical approval/clearance was obtained from the Research and Ethical Committee of State Specialist Hospital and Unimaid Medical

Center, Maiduguri, Borno State, Nigeria, before the commencement of the work. This is to protect the interest of patients to ensure that the patients and the community are not harmed in any form by the procedure. Only subjects that volunteered themselves for the study were recruited.

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