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Evaluation of Serum Ascorbic, Pantothenic Acid Level and Full Blood Count among *Plasmodium* Parasitized Pregnant Women in Sokoto Specialist Hospital, Sokoto, Nigeria

Erhabor Osaro[1]*, Sulaiman Sule Umar[1], Dangana Amos[2], Erhabor Tosan[3], Adias Teddy Charles[4] and Egenti Bibiana Nonye[5]

[1]*Department of Haematology, School of Medical Laboratory Science, College of Health Sciences Usmanu Danfodiyo University Sokoto, Nigeria*

[2]*Department of Haematology, University of Abuja Teaching Hospital Gwagwalada, Abuja, Nigeria*

[3]*Medical Laboratory Science Council of Nigeria, Nigeria*

[4]*Federal University Otuoke, Bayelsa State, Nigeria*

[5]*Department of Community Medicine, College of Health Sciences, University of Abuja, Nigeria*

***Corresponding Author:** Erhabor Osaro, Professor, Department of Haematology, School of Medical Laboratory Science, College of Health Sciences Usmanu Danfodiyo University Sokoto, Nigeria.

Received: February 21, 2022; **Published:** March 30, 2022

Abstract

Introduction: Malaria in pregnancy is a global public health problem with associated adverse outcome for mum and baby. Nigeria is a hyper endemic area for malaria and it is a major cause of anaemia in pregnancy aggravated by poor socioeconomic status.

Method: This study evaluated the some haematological parameters, ascorbic acid and pantothenic acid level among *Plasmodium*-parasitized pregnant women of African descent resident in Sokoto, North Western Nigeria. Participants in this study included 90 pregnant women made up of 60 *Plasmodium* parasitized women and 30 non-parasitized controls. Participants were recruited from Antenatal Clinic of Specialist Hospital Sokoto. We utilized an interviewer-administered questionnaire to collect socio-demographic data from the participants. Ethylene Diamine Tetra Acetic Acid (EDTA) anticoagulated blood were collected and used for malaria parasite testing. Haematological parameters (HCT, HGB, WBC, RBC and platelet count) were determined using an automated haematology analyzer (Genesis, HA6000). Ascorbic acid testing was carried out on serum samples from the participants using a standard chemical method while pantothenic acid levels was assayed using the ID-VIT pantothenic acid ELISA kit. Data collected was analyzed using the Statistical Package for Social Sciences (version 22.0 SPSS). In all statistical analysis, a p-value ≤ 0.05 was considered significant.

Result: We observed a statistically significant decrease in the HCT, HGB RBC and Platelet counts of the parasitized subjects compared to the non-parasitized controls (t = -3.060, -2.979, -3.354 and -7.840, p = 0.003, 0.004, 0.001 and 0.000) respectively. We observed a significant decrease in the ascorbic acid level of parasitized subjects compared with the non-parasitized controls (t = -5.893p = 0.000*). There were no statistically significant differences when the serum pantothenic acid level was compared between parasitized and non-parasitized controls (t = 0.681, p = 0.498). We observed a strong statistically significant correlation between ascorbic acid and platelet count (r = 0.413 and p = 0.00).

Conclusion: Findings of this study has shown that malaria in pregnancy causes decrease in vitamin C and some of the haematological parameters. There is need to monitor the vitamin C and full blood count of malaria parasitized pregnant women. There may be need to provide parasitized pregnant women with vitamin C supplement.

Keywords: *Maternal Malaria; Blood Disorders; Vitamin Anti-Oxidants*

Introduction

About 30 million women residing in malaria endemic parts of Africa become pregnant each year. Pregnant women are more predisposed to malaria because pregnancy reduces the immunity, increases susceptibility to *Plasmodium* malaria infection, the risk of illness (severe anaemia, puerperal sepsis, acute pulmonary oedema, renal failure and postpartum haemorrhage) which increases the risk of malaria-related mortality. Malaria in pregnancy is often associated with adverse outcomes including: spontaneous abortion, neonatal mortality and low birth weight children Malaria associated anaemia has been incriminated as a potential cause of poor growth and intellectual development in affected children [1].

Of all known parasitic infection in man, malaria is ranked number cause of mortality. An estimated 1 million individuals die of malaria particularly among children under 5 years and pregnant women. Also, a significantly greater than 80% of malaria-related deaths globally occur in sub-Saharan Africa [2]. Of all the *Plasmodium* species, *Plasmodium falciparum* is most dangerous and more hazardous among pregnant women. Pregnancy seems to compromise the immune processes in malaria, a disease which has been shown to significantly alters immune reactivity [3]. In malaria-endemic areas, semi-immune adults usually have substantially acquired resistance to local strains of plasmodia, the incidence of clinical malaria seems higher and its severity is significantly higher among pregnant compared to non-pregnant women [3].

Ascorbic acid also known as vitamin C is a water-soluble vitamin micronutrient. It is a well-known potent antioxidant which play key roles; fighting bacterial infections, in detoxification reactions and in the formation of collagen in tissues. It is commonly found in citrus and other fruits as well as in vegetables. The body need for vitamin c is obtained from the diet since the humans produces nor store it [4]. Deficiency of Vitamin C can potentially affect the immune system as well as cause anaemia. Micronutrients are an integral part of antioxidants. They have been found to affect host cellular and humoral immunological functions in malaria infection [5].

Pantothenic acid is also known as pantothenate or vitamin B5. It is a water-soluble B-complex vitamin [6]. Pantothenic acid has biologic significance in its incorporation into coenzyme A (CoA) and acyl carrier protein (ACP), on which the acetylation and acylation process and other interactions depend. Pantothenic acid is usually found in dietary supplements [6].

Full blood count (FBC) or Complete Blood Count (CBC) is one of the most clinically significant haematology tests. FBC results can provide vital information concerning the production of all the cellular element of blood. It identifies the oxygen carrying capacity through the evaluation of red blood cells (RBC) count, red cell indices, haemoglobin and packed cell volume or haematocrit. The white blood cells (WBC) count with differential also provides useful clinical information about the immune system of the patient. FBC results plays a key role in the diagnosis of anaemia, infection, acute haemorrhagic states, certain cancers, allergies and immune deficiencies as well as in the monitoring of adverse effects of drug that causes blood disorders [7].

Pregnant women and children under five years of age are more vulnerable to malaria. Malaria is a significant factor in the incidence of low birth weight children, prenatal mortality and maternal anaemia. Malaria diagnosis and management gulps a significant 40% of public health expenditure. It is responsible for a significant 30 - 50% of in-patient admissions and about 50% of out-patient visits in endemic areas [8].

Nigeria is a malaria endemic nation. It is a significant cause of morbidity and mortality, resulting in 25% of infant and 30% of childhood mortality [9]. Malaria was the highest cause of death in 1978 and 1982 [10]. The high malaria-related mortality among children under the age of five and pregnant women has remained a major barrier to Nigeria's development. An estimated 100 children less than one year and 203 children less than five years out of 1000 die annually from malaria [11]. An estimated one out of every five Nigerian children die before their fifth birthday [12].

Endemic diseases including malaria are associated with changes in haematological parameters with varied clinical presentations that can potentially affect the health and wellbeing of individuals. Malaria-related anaemia in pregnancy is a significant public health problem in developing countries (pronounced more in primigravidae compared to multigravidae). Previous report indicates that malaria -related anaemia is more severe in pregnant women [13]. Malaria-associated anaemia is often a product of destruction of parasitized red cells, the increased destruction of normal erythrocytes and abnormal and suboptimal erythropoiesis. Malaria anaemia can be monitored by the determination of haematocrit and haemoglobin level [14]. Pregnancy outcome is affected by a number of factors including; cultural, environmental, socioeconomic profile and accessibility to medical care services. The haematological status of pregnant women can play a significant role on pregnancy and its outcome [15]. The most clinically significant haematological index in malaria-related anaemia is the haemoglobin concentration. Anaemia defined as low haemoglobin than is required to maintain the physiologic processes is commonly identified as a haematologic abnormality and it plays a significant role in pregnancy outcome [16].

Malaria-associated haematological changes are some of the significant and common complications and it plays a major role in its pathogenesis. These changes can affect the major cellular elements of blood; erythrocytes, thrombocytes and leucocytes [17]. Malaria infection is often associated with a significant reduction in platelet counts, white cells, lymphocytes, eosinophils, erythrocyte count and haemoglobin level. Monocyte and neutrophil counts tend to be significantly higher in parasitized compared to non-parasitized individuals [18]. A previous report indicated that white cell count was higher in parasitized subjects compared with community non-parasitized controls [19]. The presence of low platelet count (thrombocytopenia) in individuals living in endemic areas is a very useful and vital diagnostic criteria for malaria. The second most common and significant complication associated with malaria is thrombocytopenia [20]. Previous report has shown that individuals with platelet counts of < 150,000/μL were 12 - 15 times more likely to have malaria compared to individuals with platelet counts > 150,000/ml [20]. Evidence has shown that the ratio of monocytes to lymphocytes correlated significantly with risk of clinical malaria during monitoring [21]. In Thailand, an estimated five million people are in the area of high malaria endemicity mostly in border area between Thailand and Burma [22].

Malaria-associated haematological changes including thrombocytopenia and leukocytosis or leucopenia are well reported. However, despite the diagnostic significance of these haematological changes and the fact that can be easily obtained and useful, many individuals living in malaria endemic regions do have access [23]. The most commonly altered parameters include: haemoglobin, platelet count, erythrocyte count, red cell indices (MCV, MCH, MCHC), leucocyte count, lymphocyte and neutrophil counts.

In Sokoto, North Western Nigeria, there has been a number of studies on malaria [24,25]. There is however paucity of published data on the level of ascorbic acid, pantothenic acid and full blood count among *Plasmodium*-parasitized pregnant women. This study is expected to provide local baseline data that can be used to formulate policies on adequate control measures and can by extension facilitate the achievement of the Millennium Development Goals (MDGs).

Aim of the Study

The aim of this current study was to determine the ascorbic acid, pantothenic acid and full blood count among *Plasmodium*-parasitized pregnant women of African descent resident in Sokoto attending the Specialist Hospital Sokoto.

Materials and Methods

Study area

This study was carried out in the Antenatal Clinic of Specialist Hospital and the haematology department of Usmanu Danfodiyo University in Sokoto, North-Western Nigeria. The Specialist Hospital Sokoto is a tertiary health institution located within the Sokoto metropolis.

Sokoto is the capital city of Sokoto State of Nigeria. It is located in the extreme part of Northwestern Nigeria. The terrain is dry Sahel in nature and it is surrounded by sandy savannah and hills. The average prevailing temperature is 28.3°C (82.9°F). Sokoto is, on the whole, a very hot area. The experienced maximum daytime temperatures are for a significant part of the year is usually under 40^0C (104.0^0F). The months February to April are the warmest with day time temperature often exceeding 45^0C (113.0^0F). The rainy season is usually from the month of June to October. The city is a major center in agricultural products and leather crafts. Evidence from the 2006 census indicated that the population of the state was 3.6 million [26]. The population is estimated to now stands at around 4.9 million based on assumed population annual growth rate of 3%.

Study population

The population for this case-control study included 60 malaria-parasitized pregnant women (subjects) and 30 age- matched non-parasitized pregnant women (controls). Both subjects and controls were recruited consecutively among women visiting the Antenatal Clinic in the Specialist Hospital, Sokoto.

Study subjects/Selection

Inclusion criteria

Women who meet the following inclusion criteria were consecutively recruited into the study:

- *Plasmodium* parasitized pregnant women attending the Antenatal Clinic of Specialist Hospital, Sokoto, Nigeria.
- Women who offered a written informed consent to participate in the study.

Exclusion criteria

The following individuals who did not meet the inclusion criteria were excluded from participating as subjects in the study:

- Non-pregnant and non-parasitized pregnant women.
- *Plasmodium*-parasitized pregnant women who refused to offer a written informed consent to participate in the study after counselling.

Study design

This present study was a case-control study to investigate the ascorbic acid, pantothenic acid and full blood count parameters of 60 *Plasmodium*-parasitized pregnant subjects and 30 age-matched healthy non-parasitized pregnant controls who were visiting the Antenatal Clinic Specialist Hospital, Sokoto. Whole blood samples were collected from each participant (subjects and controls) and analyzed for full blood count, ascorbic acid and pantothenic acid.

Sample size determination

The sample size was calculated using the standard formula used for calculating the minimum sample size in a population- based study:

$(n = z^2\ pq/d^2)$

n = Minimum sample size

z = Standard normal deviation and probability.

p = Prevalence of value to be estimated from previous studies.

q = Proportion of failure (= 1 - p)

d = Precision, tolerance limit, the minimum is 0.05.

Therefore $n = z^2 pq/d^2$

Where Z = 95% (1.96)

P = 4.8% (0.048) [27].

q = 1 - 0.048 (= 0.952)

d = 5% (0.05)

Therefore $n = (1.96)^2 (0.048) (0.952)/(0.05)^2$

n = 70.

Sample collection

Whole blood was collected via venipuncture, using BD vacutainer system into K_3 EDTA anticoagulated and plain tube under strict aseptic techniques. The EDTA anticoagulated blood sample was used for the determination of full blood count and malaria testing while sample from the plain tubes was allowed to clot naturally. The clotted sample was promptly centrifuged at 3000 rpm for ten minutes on a bench-top centrifuge. The serum obtained was subsequently transferred into sterile plastic tube and stored immediately until ready to be analyzed. These samples were tested in the haematology laboratory of Usmanu Danfodiyo University Teaching Hospital Nigeria.

Analytical method

Detection of malaria

Giemsa stain is a type of Romanowsky stain. It contains both acidic and basic components and thus can stain both the acidic and basic structures of the cell. When a blood film is stained using Giemsa stain, the nucleus and cytoplasm of white blood cells tend to take on a blue or pink colour.

Full blood count

The full blood count was analyzed using the Genesis HA6000 Auto Haematology Analyzer (Perlong Medical Equipment Company, China). The analyzer determines the haematological parameters; erythrocyte count, haemoglobin, haematocrit (HCT), Total White Cell Count and Platelet Count.

Estimation of pantothenic acid level (vitamin B5)

Serum samples were tested for pantothenic acid level (vitamin B5) using the Immunodiagnostic (Germany) ID-VIT pantothenic acid ELISA kit.

Estimation of ascorbic acid (vitamin C)

Serum vitamin C (ascorbic acid) was determined using a standard chemical method [28]. Ascorbic acid is oxidized by copper II ion to form dehydroascorbic acid, which reacts with acidic 2, 4-dinitrophenylhydrazine forming a red bis-hydrazone which is determined spectrophotometrically at 520 nm.

Questionnaire

A structured interviewer-administered questionnaire was distributed to all consenting participants in order to obtain their socio-demographic, nutritional and medical data.

Informed consent

All participants (subjects and controls) gave a written informed consent to participate in the study.

Statistical analysis

Data obtained was captured and analyzed using a statistical package (SPSS version 22). Data were expressed as percentages and mean ± standard deviation. Statistical analysis carried out included: chi-square, student's t-test, ANOVA depending on the nature (categorical or continuous) and distribution of data (normal or non-normal). Pearson's correlation was carried out to determine the relationship between sets of data. Probability ($p \leq 0.05$) was used to determine the level of significant for all statistical analysis.

Ethical consideration

Ethical approval for this study was sought and obtained from the Ethical Review Board of Specialist Hospital Sokoto.

Results

The result of 60 malaria parasitized pregnant women (subjects) recruited from the Antenatal Unit of Specialist Hospital Sokoto, and 30 apparently healthy pregnant women (controls) were analyzed. An interviewer administered questionnaire was used to obtain socio-demographic data of the subjects and their blood samples were analyzed for Full Blood Count (FBC), Ascorbic acid and Pantothenic acid levels in the laboratory.

Table 1 presents the socio-demographic data of the Malaria parasitized pregnant subjects and controls. A proportional comparison of, those that use mosquito net (86.7%) and those that are on medication (25%) showed statistically significant difference ($p < 0.05$). Age, gravidity, education status, fruit intake, occupation, ethnicity and residence show no statistical difference ($p > 0.05$).

Variables	Patients (n = 60)	Controls (n = 30)	X^2	p-value
Age group				
15 - 20	7 (11.7%)	5 (16.7%)	t = 1.2884	0.751
21 - 25	27 (45.0%)	10 (33.3%)		
26 - 30	14 (23.3%)	8 (26.7%)		
31 - 35	9 (15.0%)	4 (13.3%)		
36 - 40	3 (5.00%)	3 (10.0%)		

Use of mosquito net				
Yes	15 (25.0%)	26 (86.7%)	30.665	0.000*
No	45 (75.0%)	4(13.3%)		
Tribe				
Hausa	53 (88.3%)	25 (83.3%)	2.352	0.707
Yoruba	2 (3.3%)	3 (10.3%)		
Igbo	2 (3.3%)	1 (3.3%)		
Fulani	2 (3.3%)	1 (3.3%)		
Others	1 (1.7%)	Nil		
Gravidity				
Primigravidea	20 (33.3%)	5 (16.7%)	3.513	0.173
Multigravidea	34 (56.7%)	23 (76.7%)		
Grand multipara	6 (10.0%)	10 (6.7%)		
Educational Status				
No Formal Education	25 (41.7%)	10 (33.3%)	1.158	0.763
Primary	10 (16.7%)	4 (13.3%)		
Secondary	15 (25.0%)	9 (30.0%)		
Tertiary	10 (16.7%)	7 (23.3%)		
On Medication				
Yes	30 (50.0%)	Nil	22.500	0.000*
No	30 (50.0%)	30 (100%)		
Frequent Fruit intake				
Yes	41 (68.3%)	27 (90%)	5.084	0.24
No	19 (31.7%)	3 (10%)		
Place of Residence				
Rural	13 (21.7%)	5 (16.7%)	0.313	0.576
Urban	47 (78.3%)	25 (83.3)		
Occupation				
House wife	47 (78.3%)	21 (70.0%)	3.032	0.354
Business	6 (10.0%)	3 (10.0%)		
Civil Servant	2 (3.3%)	4 (13.3%)		
Teacher	5 (8.3%)	2 (6.7%)		

Table 1: *The socio-demographic data of subjects and controls.*

Data are presented as mean ± SEM for age and percentages for others. Figures in brackets are percentages of total

*Key: t = t-test, x^2 = Chi-square, * = Statistically significant.*

Table 2 revealed that RBC, HGB, HCT and Platelet levels was significantly lower among malaria parasitized pregnant subjects as compared to the non-parasitized controls ($p < 0.05$). However, there was no statistically significant difference in the WBC of malaria parasitized pregnant subjects when compared to the non-parasitized controls ($p > 0.05$).

Parameters	Patients	Controls	t-test	p-value
WBC ($x10^9$/l)	7.403 ± 0.2650	6.630 ± 0.3824	1.674	0.098
RBC ($x10^9$/l)	3.5072 ± 0.4082	3.7350 ± 0.5410	-3.354	0.001*
HGB (g/dl)	9.370 ± 0.1758	10.141 ± 0.1035	-2.979	0.004*
HCT (%)	28.378 ± 0.3146	29.840 ± 0.2426	-3.060	0.003*
PLT ($x10^9$/l)	194.13 ± 7.722	288.50 ± 7.103	-7.840	0.000*

Table 2: *Mean comparison of some haematological parameters for the subjects and controls.*

Data are presented as mean ± SEM.

Key: *RBC = Red Blood Cells, HCT = Haematocrit (Packed Cell Volume), HGB = Haemoglobin, WBC = White Cell, PLT = Platelet, * = Statistically significant.*

Table 3 revealed that ascorbic acid levels was significantly lower among malaria parasitized pregnant women subjects (0.2524 ± 1.1775 mg/L) as compared to the non-parasitized controls (0.4208 ± 0.1928 mg/L) ($p < 0.05$). The mean pantothenic acid levels of the parasitized subjects when compared to that of non-parasitized controls did not show any statistical significance ($p > 0.05$).

Parameters	Patients	Controls	t-test	p-value
Vit B_5 (µg/dl)	0.3257 ± 0.2466	0.2994 ± 0.2316	0.681	0.498
Vit C (mg/l)	0.2524 ± 0.1775	0.4208 ± 0.1928	-5.893	0.000*

Table 3: *Mean comparison of some Biochemical parameters for subjects and controls.*

Data are presented as mean ± SEM.

Key: *Vit C = Vitamin C (Ascorbic acid), Vit B_5 = Vitamin B5 (pantothenic acid), * = Statistically significant.*

Table 4 presents the correlation between the pattern of full blood count and some biochemical parameters. The platelet count and ascorbic acid levels showed a positive statistically significant correlation ($p < 0.05$). There was no significant correlation between platelet count and pantothenic acid level, HCT, HGB, WBC and RBC counts. Similarly, here was no significant correlation between ascorbic acid and pantothenic acid levels ($p > 0.05$).

Biochemical Parameters	WBC ($x10^9$/l)	RBC ($x10^9$/l)	HGB (g/dl)	HCT (%)	PLT ($x10^9$/l)
Vit B_5 (µg/dl)	r = -0.058 p = 0.588	r = 0.008 p = 0.938	r = 0.031 p = 0.771	r = -0.112 p = 0.292	r = -0.143 p = 0.178
Vit C (mg/l)	r = -0.099 p = 0.353	r = 0.149 p = 0.161	r = 0.130 p = 0.221	r = 0.117 p = 0.273	r = 0.413 p = 0.000*

Table 4: *Correlation between full blood count parameters and some biochemical parameters malaria parasitized.*

Key: *r = Pearson correlation, PCV = Packed cell volume, WBC = White blood cell, PLT = Platelet, Vit C = Vitamin C (Ascorbic acid), Vit B5 = Vitamin B5 (Pantothenic acid), * = Statistically significant.*

Table 2 shows the difference in haematological parameters of the subjects and control, there is a statistically significant decrease in HCT, HGB and Platelet of the subject compared to the controls. However, the WBC count is within the normal reference range.

Table 3 shows the difference in ascorbic acid and pantothenic acid of the subjects and controls, there is a statistically significant decrease in ascorbic acid level of the subjects compared to the control. Whereas the, pantothenic acid is within the normal reference range.

Table 4 shows correlation between ascorbic acid, pantothenic acid and haematological parameters. There was a positive and statistically significant correlation between platelet count and ascorbic acid whereas there was no correlation between all the other parameters.

Discussion

Malaria is a significant public health challenge in sub-Sahara Africa including Nigeria, where it is responsible for more cases of infection and death compared to other countries in the world. The aim of this study was to investigate the effect of malaria on some haematological and some biochemical indices in pregnant women attending antenatal clinic in Specialist Hospital Sokoto. A total of 90 pregnant women participated in this study. The subjects were aged 15 - 40 years. Our finding agrees with a previous report [29] in Sokoto which indicated that, young maternal age contributed to the seroprevalence of malaria parasitaemia among pregnant women.

We observed that younger women in the age group 21 - 25 years constituted a significant number of the subjects (45%) compared to older age group 36 - 40 (6%). This finding is in agreement with a previous report [30] which indicated that majority of the asymptomatic malaria positive pregnant women (84%) were aged between 20 and 34 years. A previous report [31] in Southern Nigeria also reported that individuals of age group 20-24 has the highest prevalence of maternal malaria (52%) while the least was recorded among those > 40 years. Similarly, Dolo and Colleagues [32] also reported that the pregnant women that are in the age range 21 - 25 years followed by 26 - 30 years and 31 - 35 years recorded high number of malaria parasitemia (28%). Susceptibility to malaria has been linked to the level of antibodies to placental sequestrated parasites [33]. This may be attributed to the fact that most of the younger pregnant women are likely to be primigravidae and thus more likely to have higher malaria parasitaemia. This also supports the existing knowledge that high prevalence at lower age is due to the existence of low natural immunity to infectious diseases including malaria at that age.

This study has also found that use of insecticide- treated mosquito net has great influence in preventing malaria and is significant ($p < 0.05$) as 75% of the study subjects happens not to be using mosquito net whereas 86.7% of the controls are users of mosquito net. Our finding agrees and confirms a previous report [34] which indicated that the use of insecticide- treated mosquito nets as a way of reducing the lethal impact of malaria.

In this study, the level of education was found to have influence on prevention of malaria in pregnancy. Majority of the study subjects has no formal education (41%), this is followed by those who attained secondary level education (25%) while women educated to primary and tertiary level each constituted 16% of the subjects. Our finding agrees with previous reports [35,36] in Karachi, India and Maiduguri Nigeria respectively. This is suggestive that the level of education can play a role in preventing malaria infection.

This study indicated that the HGB, HCT, RBC and Platelet counts were significantly lower ($p < 0.05$) in *Plasmodium*- parasitized pregnant women. This finding agrees with a previous report [37] which indicated that infected patients tended to have significantly lower platelets, haemoglobin and red blood cell count. Similarly, a previous report [38] indicated that among children infected with *Plasmodium falciparum* malaria, low platelet count and haemoglobin concentration were the two most important predictors of malaria infection. The lower HCT HGB and RBC observed in this study is a reflection of anaemia which has been shown to result mainly due to mechanical destruction of parasitized red blood cells as well as splenic removal of parasitized and defective red cells. The reduced platelet count seen

in malaria parasitized individuals is thought to be due to increased platelet activation, splenic pooling and associated decrease platelet life span [39,40].

We observed that the mean values of WBC count in both parasitized subjects and non-parasitized control women were within normal reference range. Previous report indicates that during labour and puerperium, WBC tend to more markedly elevated [41]. Our finding agrees favorably well with the findings of other workers in Jos and Ibadan, Nigeria [42,43]. Our finding however disagrees with a previous report [44] which shows that WBC count was significantly lower in malaria-infected patients compared to non-infected.

Our finding in this study showed a significant decrease in the ascorbic acid (vitamin C) level of malaria parasitized pregnant women when compared with control ($p < 0.05$). This observation agrees with a previous report [45] which indicated that the mean vitamin C level were lower in malaria parasitized children compared to non-parasitized control children. Malaria infection has been shown to be linked with increase production of ROS by phagocytes, this change may play a significant role in host defense against malaria and it can potentially render host tissue such as red cells more susceptible to oxidative stress and damage [46]. Ascorbic acid is potent water-soluble antioxidant and the biological system utilizes it in scavenging/neutralizing an array of Reactive Oxygen Species (ROS) which were produced at very high level because of increased activity of NADPH oxidase of immune cells [47]. The decrease in vitamin C is therefore attributed to increase in its consumption as antioxidant vitamin in clearing the Reactive Oxygen Species (ROS).

In this study, the pantothenic acid levels among malaria parasitized pregnant women subjects showed no significant difference when compared with the controls. There seems a paucity of information on pantothenic acid levels among malaria- parasitized pregnant women subjects. Pantothenic acid is a vital component of coenzyme A (CoA) and phosphopantetheine, both of which are both involved in fatty acid metabolism. It is widely distributed in foods and the deficiency is often seen in persons fed with synthetic diets or antagonist [48].

In this study, we observed that there was no statistically significant correlation between the haematological parameters and ascorbic acid and pantothenic acid except for a positive correlation between Platelet count and ascorbic acid level. There was no similar study in relation to these findings. This observation might be due to the fact that vitamin C functions to maintain healthy blood vessels which protect small vessels from damage and also helps in wound healing. It also prevents hardening of the vessels and blood clot [49].

Conclusion

Findings of this study has shown that there is a significant decrease in HCT, HGB, RBC and Platelet count of malaria parasitized pregnant women subjects. The subjects tended to have a normal WBC count, a normal pantothenic acid level and a lower ascorbic acid level compared to the controls. We observed a significant positive correlation between the Platelet count and the ascorbic acid level among malaria parasitized pregnant subjects. Vitamin C should therefore be assayed in conjunction with haematological parameters in routine antenatal diagnosis and appropriate supplement should be given depending on the laboratory test result.

What is Already Known about this Topic

- Malaria infection is associated with a statistically significant decrease in the HCT, HGB RBC and Platelet counts of *Plasmodium* Parasitized individuals.
- Deficiency of Vitamin C can potentially affect the immune system as well as cause anaemia.
- Vitamin C level are lower in malaria parasitized children compared to non-parasitized control children.

What this Study Adds

- This study has added to scientific knowledge that there is a statistically significant decrease in the HCT, HGB RBC and Platelet counts of *Plasmodium* Parasitized Pregnant Women of African descent in Sokoto Specialist Hospital, Sokoto, Nigeria.
- This study has added to scientific knowledge that there is a significant decrease in the ascorbic acid level of *Plasmodium* Parasitized Pregnant Women of African descent in Sokoto Specialist Hospital, Sokoto, Nigeria.
- This study has added to scientific knowledge that there is a strong statistically significant correlation between ascorbic acid and platelet count of *Plasmodium* Parasitized Pregnant Women of African descent in Sokoto Specialist Hospital, Sokoto, Nigeria.

Authors Contribution

Erhabor Osaro was responsible for the concept, design and definition of intellectual content. Sulaiman Sule Umar and Dangana Amos were responsible for literature search, clinical studies, experimental studies and data acquisition. Data and Statistical was carried out by Adias Charles Teddy. The manuscript preparation and editing were carried out by Erhabor Tosan and Erhabor Osaro. The manuscript was reviewed and approved by all authors.

Competing Interests

The authors declare that there is no conflict-of-interest issues associated with this study.

Acknowledgments

We are grateful to all the pregnant and non-pregnant participants in this study for their collaboration. We are also grateful to the Medical Director of Sokoto Specialist Hospital, Sokoto, Nigeria as well as the clinical and non-clinical staff of the Department of Obstetrics Sokoto Specialist Hospital, Sokoto, Nigeria. Our gratitude also goes to the staff of Haematology Department of Usmanu Danfodiyo University and Usmanu Danfodiyo University Teaching Hospital for all their support.

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