Original Research Article

Assessing the impact of Haemoparasites on Albumin and IgE blood levels in Transfused Blood at the Regional Hospital Bamenda, North West Cameroon.

ABSTRACT

Aims: This study aimed at assessing the prevalence of blood protozoans and their effect on IgE and Albumin levels among blood donors.

Study design: The study was a hospital-based cross-sectional analytical study

Place and Duration of Study: Sample: Department of Medicine (Medical Unit IV) and Department of Radiology, Services Institute of Medical Sciences (SIMS), Services Hospital Lahore, between June 2009 and July 2010.

Methodology: We included 337 blood donors (255men, 82 women) with age range of 19-57 years. Venous blood samples were collected and use to screen for malaria, the presence of *T. gondii* IgG and IgM antibodies. Immunoglobulin E (IgE) was determination using Enzyme-Linked Immuno-Sorbent Assay (ELISA) and Serum Albumin was measured by spectrophotometry.

Results: The prevalence of malaria, *Toxoplasma gondii* IgG and IgM was 13.6% (46/337), 30.9% (**104**/**337**) and 4.7% (16/337) respectively, *while* the prevalence of Malaria and *Toxoplasma* IgM co-infection was 0.9% (3/337). Prevalence of blood parasites showed no significant difference (p>0.05) with any of the socio-demographic factors. Malaria and toxoplasmosis co-infection prevalence were higher in males (1.3%), in the 31-40 years age group (1.6%), those with secondary level of education (1.3%), and those who were married (2.2%). Malaria-infected participants had significantly higher mean IgE levels (96.8UI/ml vs 47.9UI/ml; *p*=0.0001) and lower Albumin values (3.97g/dl vs 4.20g/dl; p=0.61). As regards *Toxoplasma gondii*, we observed a significant (*p*<0.05) higher mean IgE levels (144.3IU/ml vs 50.1 IU/ml) and mean Albumin (3.56g/dl vs 4.22g/dl g/dl) values among those who were infected.

Conclusions: The findings revealed the presence of malaria and *Toxoplasma gondii* among blood donors. Alteration of Albumin and IgE mean levels among infected patients showed that both parameters should be measured before blood transfusion. Thus, is of primed importance to screen blood for all haemoparasites before transfusion.

Keywords: Albumin, Blood parasites, blood transfusion, IgE, malaria, toxoplasmosis.

1. INTRODUCTION

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The need for blood and blood products is rising in all parts of the world especially in low income Countries like Cameroon. Blood donation is essential for the management of several conditions, including anaemia as a result of complications during pregnancy and childbirth, severe trauma, sickle cell disease, haemophilia, etc *(WHO,* 2021). Blood transfusion is considered a life-saving procedure but the presence of transfusion-transmitted infections (TTIs) is a major public health concern (Mattia and Andrade 2016; Abongwa et al., 2021). As such WHO recommends that all blood donations should be mandatorily screened for HIV, hepatitis B, hepatitis C, and syphilis before transfusion. However, blood recipients are at high risk of other haemoparasites such as protozoa which are not usually screened for. This is because many of the prospective donors with these parasites are asymptomatic (Bisetegen et al., 2016; Verra et al., 2018). In Cameroon, about 400,000 pints of blood are needed each year to meet up with medical needs (Abongwa et al., 2021). However current blood safety guidelines in Cameroon necessitate the routine testing of HIV, hepatitis B, and C viruses, and syphilis only. In sub-Saharan Africa, 12.5% of patients who receive blood transfusions are at risk of post-transfusion blood parasitic infections such as malaria and toxoplasmosis and this constitutes a serious threat to the human race due to the high endemicity recorded (Verra et al., 2018; Okocha et al., 2005; WHO, 2016). Infection with blood protozoan often presents with mild symptoms, however, the infection might be severe in children under-five years of age, pregnant women, immunocompromised persons leading to increase morbidity and mortality rates (Abongwa et al., 2021; Mwambe et al., 2013; CDC, 2021).

Immune responses to infection differ during the proliferative and dormant stages. Studies have shown that increased IgE level correlates with early acute inflammation (Matowicka-Karna et al., 2009). Albumin on the other hand helps to ensure blood stays in arteries and veins, maintain Oncotic pressure, and helps in the transportation of body substances such as hormones, vitamins, and enzymes (Nicholson et al., 2000). The concentration of these IgG and Albumin is altered in the course of a critical illness such as malaria, toxoplasmosis etc. and lower levels have been associated with high mortality rates in patients with critical illnesses (Dominguez et al., 1980; Minatoguchi *et al.,* 2018). Based on the complications associated with these blood protozoan, it is, therefore, necessary that blood be screened for these haemoparasites to prevent health complications in critically ill individuals. Unfortunately testing for these parasites or the measurement of IgE and Albumin levels before blood transfusion is not commonly done in Cameroon. Thus this study aimed to assess the prevalence of haemoparasites among blood donors attending the Bamenda Regional Hospital and to determine its effects on some immunological parameters. The result from this study will serve as a baseline study to evaluate the impact of haemoparasites on levels of IgE and Albumin.

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2. MATERIAL AND METHODS

2.1 Study area and study design

The study was a hospital-based cross-sectional analytical study carried out from March 2022 to May 2022 at the Regional Hospital Bamenda Blood Bank in the Northwest Region of Cameroon. Blood samples were collected from participants who signed the informed consent form to determine the prevalence of blood parasites and equally to measure the concentration of immunoglobulin E and total protein albumin.

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2.2 Study population

The population sample size was calculated using the population formula to be 337 participants. The sample size was determine using the formula z^2pq/e^2 where the blood parasites expected prevalence (p) = 0.5, q=1-p (0.5), Standard error (z) = 1.96, error margin (e) =0.05

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2.3 Selection criteria

The inclusion criteria were; all donors within the age group of 18 - 60 years, were healthy, came for blood donation, and signed the consent form. While the exclusion criteria were; people whose haemoglobin level was below 12 g/dl, who were currently on any medication, who had a recent history of operation, who had a serious illness, who weight < 45 kg, and people who refused to give their consent. The participants were recruited based on the sampling technique of first come.

2.4 Ethical considerations

Ethical clearance for the study was obtained from the institutional review board of the Faculty of Health Sciences of the University of Bamenda (2021/102H/UBa/IRB/UBa/IRB). Authorizations were obtained from the Regional Delegation of public health and the Regional Hospital Bamenda. An information sheet was prepared and used to explain the protocol, objectives, and usefulness of the study before the signing of the informed consent forms. Data collected was handled confidentially and the test results were returned to participants.

2.5 Sample collection

Three ml of venous blood were collected into tubes containing ethylene diamine tetraacetic acid (EDTA) and transferred to the laboratory for analysis. Each tube was labelled with the patient's unique identification number, date, and time of sample collection.

2.6 Laboratory procedure

2.6 .1 **Screening for malaria**

Thin and thick blood smears were prepared from whole blood. The thin blood smear was fixed with absolute methanol and both films were stained with 10% Giemsa. The smears were examined with a light microscope under oil immersion (X100 Objective) for the presence of malaria parasites. Parasite count was determined by counting the number of parasites per 200 leucocytes/µl assuming a mean leucocyte count of 8000 per µl as the standard. The number of parasites per 200 white blood cells was recorded and used to calculate the density using the formula below (Ayoola *et al.,* 2012).

The number of trophozoites was calculated as follows:

$$\text{Parasites per}/\mu\text{L blood} = \frac{Number\ of\ parasites\ counted\ x\ 8000\ WBC/\mu\text{L}}{\text{Number of WBC counted}}$$

2.6 .2 **Screening for *Toxoplasma gondii***

Plasma samples were screened for the presence of *T. gondii* IgG and IgM antibodies. The test was done using the bioelisa TOXO IgG kits (BIOKIT, S.A, Barcelona- Spain) as per the manufacturer's instructions. The concentration level for all the positive samples was measured by ELISA. The sera were considered positive if IgG/ or IgM antibodies were detected following the cut-off values provided by the manufacturer.

2.6 3 Determination of Immunoglobulin E (IgE) using Enzyme-Linked Immuno-Sorbent Assay (ELISA).

IgE was measured using Monocent, Inc.'s IgE ELISA Test System kit (Chatsworth, CA 91311, USA) as described in the manufacturer's procedure (www.monocent.com/covid19-elisa). All standards, controls, and samples were conducted in duplicates. The desired number of coated wells was secured in the holder. Twenty microliters of standard samples and controls were dispensed into appropriate wells. One hundred microliters of Zero Buffer were dispensed into each well. After mixing thoroughly for 10 seconds, they were then incubated at 37ºC for 30 minutes. The incubated mixture was removed by flicking the plate content into a waste container. Each microtiter plate well was washed three times with 300 µL of 1X washing solution to avoid spill over into neighboring wells. The microtiter plate was struck sharply onto absorbent paper to remove all residual water droplets. Fifty microliters of Enzyme Conjugate Reagent were dispensed into each well and were gently mixed for 5 seconds. Then it was incubated at 37ºC for 30 minutes. The incubated mixtures were removed by flicking the good contents into a suitable waste container. The wells were rinsed 5 times with running distilled water. The wells were struck sharply on absorbent paper to remove residual water droplets. One hundred microliters of TMB Substrate Reagent was dispensed into each well and was gently mixed for 5 seconds. Then it was incubated at 37ºC in the dark, for 15 minutes. The reaction was stopped by adding One hundred microliters of Stop Solution into each well. It was gently mixed for 30 seconds while ensuring that all the blue colour changed to yellow colour completely. The optical density was read at 450nm with a microtiter well reader within 5 minutes.

2.6 5 Determination of albumin

Serum Albumin was measured using Randox Monza AB362 (Randox, United Kingdom) as described by the manufacturer (www.randox.com/albumin). The standards were serially diluted in distilled water. A total of 100 µL of Blank, Standards, and the plasma was pipetted into the appropriately labeled tubes and 3000 µL of the working reagent (Bromocresol Green) was added into each tube. The tube was tapped lightly to mix, incubated for 5 min at room temperature, and then transferred into the cuvette. The absorbance of the sample (Asample) and the standard (Astandard) against the reagent blank at 630nm. The level of Albumin was calculated as follows

Albumin = $\frac{(Asample)X(\text{conc Standard})}{As\tan ard}$ g/dL. Samples with concentrations higher than 6 g/dL were diluted using a 1:2 dilution with saline and assayed again. The obtained results were multiplied by 2.

2.7 Statistical analysis

All data obtained were entered into Microsoft excel spreadsheet 2010, cleaned, filtered, and exported to Statistical Product and Service Solutions (SPSS) version 23 (IBM SPSS Inc. Chicago, IL, USA) for analysis. The Pearson Chi-Square test was used to compare and assess the level of association between variables. Mean differences between groups for normally distributed variables were assessed using the student t-test. The cutoff point for assessing all statistical significance between groups was set at probability level (p) ≤ 0.05.

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3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Demographic characteristics of the study population

A total of 337 blood donors participated in the study out of which 75.7% (255/337) were males. The mean (SD) age was 27.75(6.94) years and ranged from 19-57 years. The participants were divided into 3 age groups out of which the most represented was the 18-30 years age group 74.8% (252/337) while the least represented was the ≥ 41 years age group 7.1% (24/337). Most of the participants had attained the tertiary level of education 67.1% (226/337) and those who were single constituted the majority 70.0% (236/337).

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Table 1: Socio-demographic characteristics of the study population

Characteristics	Frequency (N=337)	Proportion (%)
Gender		
Females	82	24.3
Males	255	75.7
Age group (years)		
18 - 30	252	74.8
31 - 40	61	18.1
≥ 41	24	7.1
Level of education		
Primary	33	9.8
Secondary	78	23.1
Tertiary	226	67.1
Marital status		
Single	235	69.7
Married	102	30.3
Total	**337**	**100**

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3.1.2 Prevalence of blood parasites among blood donors

Among the 337 blood samples examined, two blood parasites were identified which included *Plasmodium falciparum* and *Toxoplasma gondii*. It was observed that 13.6% (46/337) of the samples were infected with *P. falciparum* while 30.9% (104/337) were positive for *Toxoplasma* IgG antibodies. Toxoplasma infection as determined by *Toxoplasma* IgM antibodies had a seroprevalence of 4.7% (16/337). Of the 16 samples that tested positive for *Toxoplasma* IgM antibodies, 3.3%(11/337) were positive for both IgG and IgM. Malaria parasite and *Toxoplasma* co-infection was found in 0.9% (3/337) participants (Figure 1).

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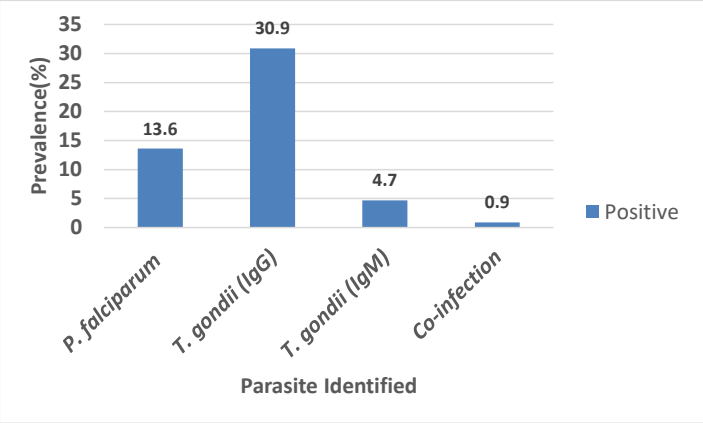

Figure 1: Prevalence of blood parasites among blood donors

3.1.3 Prevalence of blood parasites based on socio-demographic factors

Gender-based prevalence of malaria, T. *gondii* and malaria and *T. gondii* co-infection were not statistically significant (p >0.05). However, higher prevalence of malaria and *T. gondii* were recorded in females than males (17.1% Vs 12.5% p=0.299) and (7.3% vs 3.9%; p=0.208) respectively (table 2). On the contrary malaria and toxoplasmosis co-infection prevalence was insignificantly (p = 0.32) higher in males (1.3% vs 0%). The prevalence of malaria, *T. gondii* and malaria/ *T. gondii* co-infection was not statistically significant (p> 0.05) within the age groups. However, higher malaria 20.0% (5/24) and *T. gondii* 8.3% (2/24) prevalences were recorded in the ≥ 41 years age group while malaria and *T. gondii* co-infection prevalence was higher in the 31-40 years age group (1.6% (1/61)).

Based on educational level, the prevalence of blood parasites showed no significant difference (p> 0.05), but a higher prevalence of malaria, and toxoplasmosis, was seen among those with a tertiary level of education (15.9% (36/226); p=0.185) and (5.3% (12/226); p=0.242) respectively. On the other hand malaria and toxoplasmosis infection was higher among those who had attained secondary level of education (1.3% (1/78); p=0.978). As regards marital status, a higher prevalence of malaria (15.8% (16/100); p=0.443) and malaria and toxoplasmosis (2.2% (2/102); p=0.370) was seen among those who were married while toxoplasmosis, was higher among single participants (5.5% (13/235); p=0.578) as in table 2.

Table 2: Socio-demographic related prevalence of Blood parasites among blood donors.

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Parameters		Malaria parasite			*Toxoplasma gondii*			
		Number Examined	**Number infected** (%)	**Sig. level**	**Number infected (%)**	**Sig. level**	**Co-infection**	**Significant level**
Gender	Males	255	32(12.5)		10 (3.9)		3 (1.3)	**χ^2 = 0.973**
	Females	82	14(17.1)	χ^2 =1.077 p = 0.299	6(7.3)	χ^2 =1. 582 p = *0.208*	0 (0.0)	**p = 0.324**
Age gp (years)	18 – 30	252	32(12.7)		10 (4.0)		2 (0.8)	**χ^2 = 0.630**
	31 – 40	61	9 (14.8)	χ^2 =1. 307	4(6.6)	**χ^2 =1.463**	1 (1.6)	**p = 0.730**
	≥ 41	24	5 (20.8)	p = 0.520	2(8.3)	**p = 0.481**	0 (0.0)	
Level of education								
	Primary	33	2 (6.1)		1 (3.0)		0 (0.0)	**χ^2 = 0.451**
	Secondary	78	8 (10.3)	χ^2 =3.371 p = 0. 185	3 (3.8)	χ^2 =5.437 p = 0. 242	1 (1.3)	**p = 0.978**

Tertiary	226	36 (15.9)		12 (5.3)		2(0.9)	
Marital status							
Married	102	16 (15.8)		3(3.0)	χ^2 =1.095	2(2.2)	1.989
Single	235	30 (12.7)	.588	13 (5.5)	*p* = 0. 578	1 (0.4)	0.370
Total	337	46 (13.6)	0.443	16(4.7)		3(0.9)	

3.1.4 Evaluating Mean IgE and albumin levels among study participants

The mean ± Stand error of Mean (SEM) level of IgE was 54.56 ± 5.6 (UI/ml) and ranges from 0.00 to 477.23, while the mean ± SEM level of albumin was 4.17 ± 0.04 g/dl and ranges from 0.9-5.9 g/dl.

Our data showed that the parasite density of malaria parasites ranges between 100-4300 (Parasite/µl) with a geometric mean parasite density (GMPD) of 975 (Parasite/µl). Donors that were positive for *P. falciparum* had higher mean IgE levels (96.8UI/ml vs 47.9UI/ml). This difference was significant difference (*p*=0.0001). On the contrary, mean Albumin values were insignificantly (p=0.68) lower in P. *falciparum* patients compared to their negative counterparts (3.98g/dl vs 4.20g/dl). As regards toxoplasmosis, we observed a significantly (*p*< 0.05) higher mean IgE in positive patients (144.3IU/ml vs 50.1 IU/ml) while higher mean Albumin values were seen in negative patients (4.22 vs 3.56g/dl) as shown on table 3.

Table 3: Blood donors mean IgE and Albumin levels based on malaria status

	Mean ± SEM IgE levels (UI/ml)		**Mean ± SEM Albumin levels (g/dl)**	
	Malaria	**Toxoplasma**	**Malaria**	**Toxoplasma**
Positive	96.75± 192.1	144.3±31.9	3.98±0.09	3.56±0.2
Negative	47.9 ± 57.1	50.1±5.6	4.20±0.04	4.22±0.08
t value	13.24	5.011	0. 167	4.54
P value	0.0001	0.026	0.683	0.037

3.2 DISCUSSION

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Blood transfusion can be a life-saving exercise, but it has risks of containing infectious agents. The infectious agents can be transmitted through transfusion easily and that is why all donated blood requires the screening of major TTIs like HIV, HBV, HCV, and syphilis in blood banks. Donated blood should also be screened for blood parasites particularly in endemic areas to prevent their transmission through transfusion (WHO, 2010). An adequate supply of safe blood is therefore essential for reducing mortality and morbidity, especially among young children and pregnant women (Abongwa et al., 2021; WHO, 2021).

In this study, the parasitological profile of the blood to be transfused contained *P. falciparum* and *T. gondii* parasites with a prevalence of 13.6% and 4.7% respectively and a co-infection rate of 0.9%. This demonstrates that *P. falciparum* and *T. gondii* parasites are present in blood samples of blood donors in the study area.

The persistence of malaria infection is a serious public health problem in many parts of the world, particularly in sub-Saharan Africa (Ayoola *et al.,* 2012). It is therefore important to determine the blood donor's susceptibility to this infection to develop the capacity to address the burden of the disease. The low malaria parasite prevalence of 13.6% recorded in this study may not be unconnected with the fact that the study was conducted during the dry season when malaria infection is generally low compared to the end of the rainy season when the infection rate is quite high. Prybylski et al. (1999) had similar observations. However, this is not in line with the findings of Lehman et al., (Lehman *et al*., 2018) who had a prevalence of 45.47% in the Littoral region of Cameroon and 27.54% as reported by Mogtomo et al., (2009) at the University of Douala Cameroon. This could be due to the difference in socioeconomic status, climatic conditions, location of the donors, and the level of endemicity of the malaria parasite in different countries and different locations within the same country. However, this value was high as compared to similar studies carried out in some parts of Africa such as in Nigeria in the state of Ibadan at 10.0%

(Edington and Gillies, 2001) and. 4.1% in Ethiopia (Alemu and Mama 2018), 3% in Ghana (Adusei and Owusu-Ofori, 2018), 1.3% in Uganda (Inyimai et al., 2018), and none in Egypt (Bakr et al., 2017). The high or low prevalence of malaria in the blood depends on the transmission season, Anopheles species present, environmental conditions, climatic conditions, period of study, the study populations, and the diagnostic test methods used in the study. Similar conclusions have been made by another researcher (Otajevwo, 2013). As for blood donation, any trace of malaria parasites in blood to be transfused is a call for concern.

Also, the seroprevalence of *Toxoplasma* IgG and IgM antibodies were 30.9% and 4.7% respectively. Higher IgG positivity compared to IgM rates have been reported in other studies carried out elsewhere (Chiang et al., 2012; Mansouri et al., 2017; Sadooghian et al., 2017). However similar findings in Cameroon among immunocompromised patients (pregnant women, HIV patients and children) also showed a higher *Toxoplasma* IgG antibodies prevalence rate (23.08%-70.0%) compared to *Toxoplasma* IgM antibodies (0.85%-27.5%) (Assob et al., 2011, Wam et al., 2016; Fang et al. 2021).
The 4.7% seroprevalence rate for *Toxoplasma* IgM, signifies active infections in this study population. Therefore *T. gondii*-specific IgG is used as a marker for latent or chronic infection while IgM is used as a marker for exposure or acute infection since *T. gondii* specific IgM appear primarily and are absent in few months (Sadooghian et al., 2017; Agordzo et al., 2019; Cédric et al., 2022). This prevalence among blood donors is higher as compared 2.7- 3.3% range reported in similar studies carried out elsewhere (Mansouri et al., 2017, Sadooghian et al., 2017). This could be due to the hygienic level of the population, high ownership of cats in homes (as pets and to chase away rats), low level of economic development, and improvement in the quality of life as people pay increased attention to health and hygiene.
The results of this study also showed that the prevalence of malaria was influenced by the sex and age of the participants. Malaria was higher in females than males. These is in line with previous findings by Teh et al. (2019) in the mount Cameroon area who reported that malaria was more common among female blood donors, which could be because females spend more time outdoors at dusk and dawn than males to perform household chores, and are also involved in farming activities thereby sleeping in poorly constructed tents in farms and thus neglect to adequately protect themselves from vector bites. The results are in contrast with those reported by Kimbi et al. (2013) in which malaria was more common in males.

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Toxoplasmosis was more prevalent in females than males. The higher prevalence of toxoplasmosis in females than males could be because women consume undercooked meat when cooking (tasting the meat severally before it is ready) or fail to wash their hands after cleaning the house. Furthermore, it is because they are also more attached to cats as pet animals than males and are also frequently in contact with soil that may be contaminated with *T. gondii* oocysts. This is in contradiction with a previous study carried out by Alvarado et al. (2007) who reported a higher prevalence in males than females.
The prevalence of malaria was highest among participants within the ≥41years age group although not statistically significant. These results are in contrast to the finding of Gelaw and Mengistu (2008), who reported that the prevalence of malaria parasitemia in blood donors decreased with donor age. This might be since immunity to infection normally reduces with an increase in age.
The prevalence of toxoplasmosis was insignificantly higher among participants within the ≥41years age group. This could be justified by the fact that people in this age group are more involved in farming activities, which makes them be frequently in contact with soil that harbours the oocysts. They may also consume unwashed fruits and vegetables from the farms which predisposes them to infection.

The prevalence of malaria was found to be significantly higher among participants who were married. The most probable reason can be that married people don't sleep under mosquito nets because they prefer to give available mosquito nets to their children, thereby exposing themselves to mosquito bites (Ntonifor and Veyufambom, 2016; Arthi and Fenske, 2018;). Toxoplasmosis was equally significantly different in married participants; this is in contrast with a study carried out by Saraei (2010). This could be because married people are involved in farming or gardening activities to feed their families. The frequent contact with soil exposes them to parasitic infections, including handling raw meat when cooking food for the family and eating the undercooked meat.

The prevalence of malaria and toxoplasmosis was not significantly associated with the level of education. However, the prevalence was unexpectedly high among those with a university level of education. This could be because they don't put into practice their knowledge of this infection or it may be related to their daily or social activities that cause them to stay late at night (peak period for mosquito bite) and eat mostly outdoors such as consumption of unwashed or poorly washed fruits and vegetables, undercooked meat, consumption of unpasteurized milk, untreated water, and unwashed raw vegetables or fruits.

We reported for the first time the effect of *T. gondii and P. falciparum* on levels of Albumin and IgE among blood donors in Cameroon. This study supplements previous literature on the immunologic effects of malaria and *Toxoplasma* on the pathogenesis of the disease.

Our study revealed that the concentration of IgE antibodies in patients infected with *T. gondii and P. falciparum* was significantly ($p<0.05$) higher than in negative subjects. This high IgE level in infected patients might be a reflection of an increase in the capacity of the immune system to respond to parasitic infections and thus proposes that IgE antibodies may be contributing to the pathogenesis of malaria infection. It may also be due to environmental factors and genetic background which may predispose them to the development of IgE in the presence of allergens. Equally, the values could be high due to the presence of other parasitic infections (helminthiasis) which were not tested for in this study (Vouldoukis et al., 2011; Eze and Christian, 2016). To attest to this, our data showed that 13.1% (44/337) of participants who were negative for both parasites had detectable IgE levels. Elevations of IgE values in malaria patients have also been reported elsewhere (Wong et al., 1993; Calissano et al. 2003). Furthermore, IgE was detectable in 93.4% (15/16) of those who were positive for *Toxoplasm*a, indicating that detection of IgE may be used as a complementary test in the diagnosis of *Toxoplasma* as reported by Matowicka-Karna et al. (10) and Wong et al. (Wong et al., 1993)

Our results also showed a significant ($p<0.05$) decrease in albumin level in malaria and *T. gondii*-positive participants. Similar findings have been reported by (Nanjul, 2007; Minatoguchi *et al.,* 2018). Low levels of albumin are as a result of increased catabolism from cell damage, thus serum albumin can be used to predict disease progression. The normal mean level of albumin seen in this study is can be ascribed to the fact that these patients are asymptomatic as studies have shown that parasite density is negatively correlated to albumin levels. In addition, previous reports state that serum albumin is associated with increased mortality in individuals with certain critical conditions (such as the person who needs a blood transfusion) (Dominguez et al., 1980; Nanjul, 2007). Thus, the measurement of albumin levels is a serious call for concern in the blood bank.

4. CONCLUSION

Overall, our results suggest that blood parasites (*P.falciparum* and *T. gondii*) are present in the blood components that are being transfused at the Regional Hospital Bamenda Blood Bank. We also reported that high IgE and low serum albumin levels are associated with haemoparasite. Given that most recipients of blood are already sick or have a critical medical condition such as anaemia, acute kidney disease, or chronic kidney disease, their medical condition could further worsen if parasitic infected blood is being transfused to them. Considering that IgE and Albumin play a physiological role in immunity, the identification of haemoparasites among blood donors is vital prior to critically ill patients who need a blood transfusion.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

CDC: Centers for Disease Control, ELISA: Enzyme-linked immune-sorbent assay, Ig: Immunoglobulin, SD: standard deviation, SEM: standard error of the mean. SPSS: Statistical Product and Service Solutions, P: Plasmodium, T: Toxoplasma, WBC: white blood cell count

Consent of publication

Participants gave their consent for publication of results without being identified.

Ethical approval (where ever applicable)

All methods used in this study were carried out following relevant guidelines and regulations. All experimental protocols were approved by the study protocol and were reviewed and approved by The University of Bamenda

Institutional Review Board of the Faculty of Health Sciences (No:2021/102H/UBa/IRB). Written informed consent was obtained from all subjects.

REFERENCES

1. Abongwa, L.E., Alberic, S., Yengo, C., Konenyui, Z. P., Kah, K., Doh, J. (2021). Prevalence of transfusion-transmissible infections and associated Risk factors among blood donors in Bamenda, Cameroon. Haematology International Journal, 5 (2).
2. Adusei, K.A., Owusu-Ofori, A. (2018). Prevalence of Plasmodium parasitaemia in blood donors and a survey of the knowledge, attitude and practices of transfusion malaria among health workers in a hospital in Kumasi, Ghana. PloS one. 13(11),303.
3. Agordzo, S.K., Badu, K., Addo, M.G., Owusu, C.K., Mutala, A.H., Tweneboah, A., et al. (2019). Seroprevalence, risk factors and impact of Toxoplasma gondii infection on haematological parameters in the Ashanti region of Ghana: a cross-sectional study. AAS Open Research, 2.
4. Alemu, G., Mama, M. (2018). Asymptomatic malaria infection and associated factors among blood donors attending Arba Minch blood bank, Southwest Ethiopia. Ethiopian journal of health sciences, 28(3),315-22.
5. Alvarado-Esquivel, C., Mercado-Suarez, M.F., Rodríguez-Briones, A., Fallad-Torres, L., Ayala-Ayala, J.O., Nevarez-Piedra, L.J., et al. (2007). Seroepidemiology of infection with Toxoplasma gondii in healthy blood donors of Durango, Mexico. BMC Infectious Diseases, 7(1), 1-7.
6. Arthi, V., Fenske, J. (2018). Polygamy and child mortality: Historical and modern evidence from Nigeria's Igbo. Review of Economics of the Household, 16(1), 97-141.
7. Assob, J.C., Njunda, A.L., Nsagha, D.S., Kamga, H.L., Weledji, P.E., Che, V.B. (2011). Toxoplasma antibodies amongst HIV/AIDS patients attending the University Teaching Hospital Yaounde in Cameroon. African Journal of Clinical and Experimental Microbiology, 12(3).
8. Ayoola, O.O., Whatmore, A., Balogun, W.O., Jarrett, O.O., Cruickshank, J.K., Clayton *et al.,* (2012). Maternal malaria status and metabolic profiles in pregnancy and cord blood: relationships with birth size in Nigerian infants. Malaria Journal, 11(1),1-9.
9. Bakr, S., Edris, S., Fattah, N.S., Ibrahim, N.M., El-Khadragy, M.F.(2017) Molecular screening for malaria among blood donors in a who claimed region of egypt, fayoum governorate. Mediterranean Journal of Hematology and Infectious Diseases, 9(1).
10. Bisetegen, F.S., Bekele, F.B., Ageru, T.A., Wada, F.W. (2016). Transfusion-transmissible infections among voluntary blood donors at Wolaita Sodo University teaching referral hospital, South Ethiopia. Canadian Journal of Infectious Diseases and Medical Microbiology, 2016.
11. Calissano, C., Modiano, D., Sirima, B.S., Konate, A., Sanou, I., Sawadogo, A., et al. (2003). IgE antibodies to Plasmodium falciparum and severity of malaria in children of one ethnic group living in Burkina Faso. The American journal of tropical medicine and hygiene, 69(1),31-5.
12. Cédric, Y., Nadia, N.A., Ambe, N.F., Guy-Armand, G.N., Payne, V.K. (2022). Seroprevalence of Toxoplasma gondii IgG and IgM Antibodies and Associated Risk Factors among Pregnant Women Consulted at the Bamenda Regional Hospital, Cameroon. J Infect Dis Epidemiol, 8(288).
13. Chiang, T.Y., Hsieh, H.H., Kuo, M.C., Chiu, K.T., Lin, W.C., Fan, C.K., et al. (2012). Seroepidemiology of Toxoplasma gondii infection among healthy blood donors in Taiwan. PLOS one, 7(10),48139.
14. Dominguez de Villota, E., Mosquera, J.M., Rubio, J.J., Galdos, P., Diez, B. V., Serna, J.L., Tomas, M.I. (1980). Association of a low serum albumin with infection and increased mortality in critically ill patients. Intensive care medicine, 7(1),19-22.
15. Edington, G.M. and Gillies, H.M. (2001). Protozoan diseases: Pathology in the Tropics; Edington, GM, Gillies H M., *2nd Edition. Edward Arnolds: London, UK*, 197(690).

16. Eze, E.M., Christian, S.G (2016). Immunoglobulin levels in Plasmodium falciparum malaria infected subjects in Port Harcourt, Nigeria. Int. J. Adv. Multidiscip. Res, 3(5), 49-55.
17. Fang, E.E., Nyasa, R.B., Ndi, E.M., Zofou, D., Kwenti, T.E., Lepezeu, E.P., et al. (2021). Investigating the risk factors for seroprevalence and the correlation between CD4+ T-cell count and humoral antibody responses to Toxoplasma gondii infection amongst HIV patients in the Bamenda Health District, Cameroon. Plos one, 16(12),0256947.
18. Gelaw, B., Mengitsu, Y. (2008). The prevalence of HBV, HCV and malaria parasites among blood donor in Amhara and Tigray regional states. Ethiopian Journal of Health Development, 22(1), 3-7.
19. https://www.cdc.gov/malaria/about/disease.html. Access 5th October 2021
20. https://www.randox.com/albumin Accessed 5th January 2021
21. Inyimai, S.P., Ocan, M., Wabwire, B., Olupot-Olupot, P.(2018). Asymptomatic plasmodium parasites among adults in eastern uganda: a case of donor blood screening at mbale regional blood bank. Journal of Tropical Medicine, 9.
22. Kimbi, H.K., Nana, Y., Sumbele, I.N., Anchang-Kimbi, J.K., Lum, E., Tonga, C., et al. (2013). Environmental factors and preventive methods against malaria parasite prevalence in rural Bomaka and urban Molyko, Southwest Cameroon. J Bacteriol Parasitol, 4(162), 4172.
23. Lehman, L.G., Foko, L., Tonga, C., Nyabeyeu, H., Eboumbou, E.C., Nono, L.K., *et al*. (2018). Epidemiology of malaria using LED fluorescence microscopy among schoolchildren in Douala, Cameroon. Int J Trop Dis Health, 29(1),1-3.
24. Mansouri, A., Mojarad, M.R., Badfar, G., Abasian, L., Rahmati, S., Kooti, W., et al. (2017). Epidemiology of Toxoplasma gondii among blood donors in Iran: A systematic review and meta-analysis. *Transfusion and Apheresis Science*, 56(3),404-9.
25. Matowicka-Karna, J., Dymicka-Piekarska, V., Kemona, H. (2009). Does Toxoplasma gondii infection affect the levels of IgE and cytokines (IL-5, IL-6, IL-10, IL-12, and TNF-alpha) Clinical and Developmental Immunology, 2009.
26. Mattia, D., and Andrade S.R., (2016) Nursing care in blood transfusion: a tool for patient monitoring. Texto & Contexto-Enfermagem, 25.
27. Minatoguchi, S., Nomura, A., Imaizumi, T., Sasaki, S., Ozeki, T., Uchida, D., *et al.,* (2018). Low serum albumin as a risk factor for infection-related in-hospital death among hemodialysis patients hospitalized on suspicion of infectious disease: a Japanese multicenter retrospective cohort study. Renal Replacement Therapy, 4(1),1-7.
28. Mogtomo, M.L., Fomekong, S.L., Kuate, H.F., Ngane, A.N. (2009) Screening of infectious microorganisms in blood banks in Douala (1995-2004). Cahiers d'études et de recherches francophones/Santé, 19(1),3-8.
29. Mwambe, B., Mshana, S.E., Kidenya, B.R., Massinde, A.N., Mazigo, H.D., Michael, D., Majinge, C., Grob, U. (2013). Sero-prevalence and factors associated with Toxoplasma gondii infection among pregnant women attending antenatal care in Mwanza, Tanzania. Parasites & vectors, 6(1),1-5.
30. Nanjul G.O.(2007). Albumin Level Among HIV/AIDS-Patients in Jos, Nigeria. J. Med. Sci, 7(7), 1187-91.
31. Nicholson, J.P., Wolmarans, M.R., Park, G.R. (2000). The role of albumin in critical illness. British journal of anaesthesia, 85(4),599-610.
32. Ntonifor, N.H., Veyufambom, S. (2016). Assessing the effective use of mosquito nets in the prevention of malaria in some parts of Mezam division, Northwest Region Cameroon. Malaria journal, 15,1-8.
33. Okocha, E.C., Ibeh, C.C., Ele, P.U., Ibeh, N.C. (2005). The prevalence of malaria parasitaemia in blood donors in a Nigerian teaching hospital. Journal of Vector Borne Diseases, 42(1), 21.

34. Otajevwo, F.D. (2013). Prevalence of malaria parasitaemia and its association with ABO blood grouping among students of Igbinedion University Okada, Nigeria. British Journal of Medicine and Medical Research, 3(4),1164-77.
35. Pinon, J.M., Toubas, D., Marx, C., Mougeot, G., Bonnin, A., Bonhomme, A., et al. (1990). Detection of specific immunoglobulin E in patients with toxoplasmosis. Journal of Clinical Microbiology, 28(8), 1739-43.
36. Prybylski, D., Khaliq, A., Fox, E., Sarwari, A.R., Strickland, G.T.(1999). Parasite density and malaria morbidity in the Pakistani Punjab. The American journal of tropical medicine and hygiene, 61(5),791-801.
37. Sadooghian, S., Mahmoudvand, H., Mohammadi, M.A., Sarcheshmeh, N.N., Kareshk, A.T., Kamiabi, H, et al. (2017). Prevalence of Toxoplasma gondii Infection among healthy blood donors in Northeast of Iran. *Iranian Journal of Parasitology*, 12(4),554.
38. Saraei, M. (2010). Seroprevalence of Toxoplasma gondii in unmarried women in Qazvin, Islamic Republic of Iran. EMHJ-Eastern Mediterranean Health Journal, 16 (1), 24-28.
39. Teh, R.N., Sumbele, I.U., Asoba, G., Meduke, D.N., Ojong, S.T., Kimbi, H.K. (2019). Concurrence of CareStart™ Malaria HRP2 RDT with microscopy in population screening for Plasmodium falciparum infection in the Mount Cameroon area: predictors for RDT positivity. Tropical medicine and health, 47(1), 1-1.
40. Total human IgE ELISA test system available https://www.monocent.com/covid19-elisa/ Accessed 5th January 2021
41. Verra, F., Angheben, A., Martello, E., Giorli, G., Perandin, F., Bisoffi, Z. (2018). A systematic review of transfusion-transmitted malaria in non-endemic areas. Malaria Journal, 17(1), 1-4.
42. Vouldoukis, I., Mazier, D., Moynet, D., Thiolat, D., Malvy, D., Mossalayi, M.D. (2011). IgE mediates killing of intracellular Toxoplasma gondii by human macrophages through CD23-dependent, interleukin-10 sensitive pathway. PLoS One, 6(4), 8289.
43. Wam, E.C., Sama, L.F., Ali, I.M., Ebile, W.A., Aghangu, L.A., Tume, C.B. (2016). Seroprevalence of Toxoplasma gondii IgG and IgM antibodies and associated risk factors in women of child-bearing age in Njinikom, NW Cameroon. BMC research notes, 9:1-8.
44. WHO. (2016). Blood transfusion safety. Safe and appropriate use. Available at *http://www.who.int/bloodsafety/clinical_use/en/* Accessed on 21th March 2022.
45. Wong, S.Y., Hajdu M.P., Ramirez R., Thulliez P., McLeod R., Remington J.S .(1993). Role of specific immunoglobulin E in diagnosis of acute toxoplasma infection and toxoplasmosis. Journal of Clinical Microbiology, 31(11),2952-9.
46. *World Health Organization (*2021). Blood transfusion safety. Safe and appropriate use. Available at *http://www.who.int/bloodsafety/clinical_use/en/* Accessed on 11th December 2021
47. World Health Organization. Screening donated blood for transfusion-transmissible infections: recommendations. World Health Organization; 2010.