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Research Article

Prevalence of malaria parasites among blood donors in Kaduna, Nigeria

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ABSTRACT

Background: Transmission of malaria parasites through blood transfusion is a well-known serious risk. Screening of blood donors for malaria as recommended by WHO is currently not included in the protocols of many Nigerian blood banks. Presence of asymptomatic *Plasmodium* species carriers (APCs) in some northern parts of the state has already been demonstrated using rapid diagnostic tests (RDTs) and microscopic examination of Giemsa stained blood films. This research was undertaken to determine the prevalence of malaria parasites among blood donors in Kaduna state, Nigeria.
Methods: A cross sectional study was conducted among the blood donors in the three selected Hospitals of Kaduna state. A well-structured questionnaire was used to collect the data regarding demographic profile. Written informed consent was obtained and questionnaire was completed by respondents selected through simple random sampling. 360 blood donors were tested for malaria parasites through microscopic examination of Giemsa stained thick and thin blood films. The data were analysed using Statistical analysis system (SAS) and statistical software for social sciences (SPSS) version 20.
Results: A total of 27 (7.5%) of the blood donors had malaria parasites in their blood. *Plasmodium falciparum* was the only malaria parasite species encountered. There were no mixed infections and no other blood parasites were observed. The prevalence of malaria parasites in the blood donors was significantly associated with occupation (χ^2=24.0845, df=6, p= 0.0005) and blood group (χ^2=10.589, df=4, p= O.032). The infected subjects had parasites densities of between 88-250 parasites/µl with a mean parasite density of 126 parasites/µl of blood.
Conclusions: The prevalence of malaria parasites among blood donors was 7.5% Blood donors should be routinely screened for malaria parasites and the blood marked negative or positive as the case may be. Recipients of malaria parasites positive blood should be given prophylactic treatment to prevent transfusion related malaria (TRM).

Key words: Prevalence, Malaria, Parasites, Blood donor, Kaduna state

INTRODUCTION

Malaria remains an acute public health problem in many regions of the world despite tremendous progress in its control. There were 214 million new cases of malaria and approximately 438,000 died of the disease in 2015.[1] More than two-thirds of malaria deaths globally were in children under 5 years of age. About 3.2 billion people (almost half of the world's population) are at risk of malaria.[1] Fifteen countries mainly in sub-Saharan Africa, accounted for 80 % of cases and 78% of deaths globally in 2015.[1] Malaria has been the second leading cause of

death from infectious diseases in Africa, after HIV/AIDS and is the 5th leading cause of death from infectious diseases in low-income countries, which are vastly concentrated in sub-Saharan Africa.[2,3]

In Nigeria, malaria is a major public health problem where it accounts for more cases and deaths than any other country in the world. There are estimated 100million cases of malaria with over 300,000 deaths and 50% of the population has at least one episode of malaria every year.[4] Malaria is a risk for 97% of Nigeria's population, accounts for 60% of outpatient visits, 30% of hospitalizations, 11 % of maternal mortality, 10% of low birth weight and tops the mortality table, with pneumonia, measles and dysentery in that order.[4] Furthermore, the nation loses over 132 billion naira annually in form of treatment costs, prevention, loss of man-hours etc.[4]

Malaria is caused by sporozoan parasites of the genus *Plasmodium*. The species of *Plasmodium* that infect humans are: *P. falciparum*, *P. vivax*, *P. malariae*, *P. knowlesi*, *P. ovale curtisi* and *P. ovale wallikeri*.[5] *Plasmodium falciparum* is the most prevalent and lethal.[1] *Plasmodium falciparum* accounts for about 98% of malaria cases in Nigeria while *P. malariae* occurs as mixed infection with *P. falciparum*.[2]

The infection is transmitted naturally through the bite of infected *Anopheles* mosquitoes. It can also be transmitted through blood transfusion, sharing of needles and syringes and from infected pregnant mother to the foetus.[6] Clinical manifestations of malaria include headache, pains in the back and limbs, anorexia, nausea, chill, and fever.[3] Blood transfusion is a lifesaving venture that is used for the management of severe anaemia, deficiency of blood clotting factors, thrombocytopenia, immunodeficiency states, hypoalbunaemia and emergencies involving surgery.[7]

However, it also poses problems such as the risks of immunological adverse reactions and transmission of large amounts of malaria parasites and other blood borne pathogens to persons whose immunity is compromised by disease and treatment. Post transfusion malaria may not only compound the already deplorable health condition of recipients but may also be fatal.[8,9]

Prevalence rates of malarial parasitaemia of between 4.1 % and 77.4% have been reported in blood donors in Nigeria.[10,11] Compared with other transfusion-transmitted infections, the very high prevalence of malaria among blood donors has been almost totally ignored.[12] The critical lack of convincing evidence about the clinical impact of transfusion-transmitted malaria and the absence of effective and feasible screening methods are being blamed for lack of rational decision-making on whether or not to screen blood for malaria.[13] This study was undertaken to assess the prevalence of malaria among blood donors in order to highlight the potential risk associated with transfusion related malaria (TRM) in the study area.

METHODS

The study was a cross-sectional facility based study conducted in Kaduna State. The state is in North-western geo-political zone of Nigeria with a population of 6,066.562 and 23 local government areas (LGAs) which are further grouped into 3 senatorial districts (north, central and south).[14] It is a metropolitan as well as a cosmopolitan industrialized state with over 80 commercial and manufacturing industries. It is one of the education centers in Nigeria with many colleges and most recognized university in Nigeria.

Agriculture is the mainstay of the state with about 80% of the people actively engaged in farming. It is defined by longitude 10°20' N and latitude 9° 03' E. The vegetation characteristic is that of the guinea savanna with scattered trees and shrubs. There are two distinct seasons the wet (rainy) which lasts from April to October and dry season that occurs from November to March. It experiences a rainfall of 1530mm in Kafanchan-Kagoro in the southeast and 10 15mm in Ikara/Makarfi districts in the northeast.[14]

Ethical approval

Approval for the research was obtained from the ethical committee of the Kaduna state ministry of health. Patients' anonymity and good laboratory practice were maintained. The findings were treated with utmost confidentiality and for the purpose of this research only.

A total of 360 apparently healthy individuals who came to donate blood from January to December 2013 were recruited for the study. This comprised of 120 donors each from General Hospital Kafanchan, Mamman Tsoho Memorial Hospital, Tudun Wada, Kaduna and Hajiya Gambo Sawaba Memorial Hospital, Zaria representing the southern, central and northern senatorial districts of the state respectively.

These hospitals were considered because they have facilities for and were most patronized for blood transfusion services in their respective senatorial districts. Participants considered were individuals who gave consent, were negative for HIV, HBV and HCV, were between 18 and 65 years, weighted 50kg and above and had a Haematocrit ≥36%.

Prior to sample collection, a structured questionnaire was used to obtain clinical information, socio-demographic data and information on some risk factors likely to be associated with TRM. Two milliliters (2ml) of whole venous blood was aliquot into ethylene diamine tetra acetic acid (EDTA) bottles out of the 5ml collected from each of the donors for routine preliminary screening and haematological investigations to determine the fitness of the donor.

Identification and density estimation of the parasites

Malaria parasites were identified through microscopic examination of Giemsa stained thin and thick blood films as previously described.[9] The malaria parasite numbers/µl of blood was estimated by counting the number of malaria parasites seen against 100 white blood cells (WBC) in a Giemsa stained thick film and result expressed using this formula described by Cheesbrough.[9]

Number of parasites/µl of blood=

$$\frac{8000\ x\ Number\ of\ parasites\ counted\ against\ 100\ WBC}{100}$$

Data analysis

All statistical analysis was carried out using the Statistical analysis system (SAS) and statistical software for social sciences (SPSS) version 20. The Chi-square test was used to determine the associations between the variables with the level of significance set at $p \leq O.05$.

RESULTS

Out of the 360 blood donors studied, 27 had malaria parasites giving prevalence rate of 7.5%. The 27 microscopy positive donors had parasite densities of between 80-240 parasites/µl of blood with an average of 126 parasites/µl of blood.

Only the asexual stages (ring forms) of malaria parasites were seen. *Plasmodium falciparum* was the only malaria parasite species encountered. In relation to the study facility, the highest prevalence rate of 9.2% (11/120) was obtained in Kafanchan, while the least (5.0%: 6/120) was recorded in Zaria. The difference was not statistically significant (χ^2=1.6817, df=1, p=0.4313) as shown in Table 1.

Table 1: Prevalence of malarial parasites among blood donors in Kaduna state by study facility.

Study facility	Number examined	Number positive (%)	P-value
Zaria	120	6 (5.0)	0.4313
Kaduna	120	10 (8.3)	
Kafanchan	120	11 (9.2)	
Total	360	27(7.5)	

With respect to gender, the female donors had a higher prevalence rate of 8.7% (4/46) while the male donors had a lower prevalence rate of 7.3% (23/314). However, this difference was not statistically significant (χ^2=1.1087, df=1, p=0.2512). Donors who were <20 years had the highest prevalence rate (10.5%: 2/19), while those within age group 20-29 years had the least prevalence (6.1%: 8/131). However, this difference was not statistically significant (χ^2=0.8616, df=4, p=0.9300).

In relation to marital status, the prevalence was highest among the married donors (10.1%: 21/204) while no infection was detected among the divorced donors. The difference was not statistically significant (χ^2= 4.9563, df =2, p= 0.0839).

Based on type of settlement, donors who lived in the semi-urban areas had the highest prevalence of (9.7%: 3/31) while those who lived in the rural areas had the least of (5%: 2/40). The difference was not statistically significant (χ^2=0.5775, df=2, p=0.7492). In relation to the educational status, those who had informal education had the highest prevalence rate of 15.7% (8/51) while no infection was recorded among the donors who were not educated donors. The difference was not statistically significant (χ^2=0.5775, df =4, p= 0.7492).

The result in relation to occupational status in the study area showed that donors who belonged to undisclosed occupational groups had the highest prevalence rate of 33.3% (2/6) while those who belong to the business class had the least prevalence rate of 5(3.9 %). The difference was statistically significant (χ^2=24.0845, df=6, p=0.0005). This result is shown in Table 2.

Also, in relation to the Body mass index (BMI), the under weighted (<18.5 kg/m^2) donors had the highest prevalence rate of 11.1% (1/9) while the obese donors had no parasite in their blood. This difference was not statistically significant (χ^2=1.8031, df=3, p=0.6143). This result is shown in table 3.

The result of this study also showed that a higher prevalence rate of 9.2% (20/218) of the malaria parasite infection was recorded in wet season compared to prevalence rate of 4.9% (7/142) recorded in the dry season. However, this difference was not statistically significant (χ^2=2.2333, df =2, p=0.1351).

In relation to the use of insecticide treated nets (ITNs), participants who sleep under insecticide treated bed nets had the highest prevalence of 10.3% (16/157) compared to those who do not sleep under insecticide treated bed

nets with the prevalence of 5.4% (11/203) (χ^2 = 0.0571, df =1, p=0.2169). This result is shown in table 4.

Table 2: Prevalence of malarial parasites among blood donors in Kaduna in relation to demographic and socio-economic factors.

Factor	Number Examined	Number Positive (%)	P value
Gender			
Male	314	23(7.3)	0.2512
Female	46	4(8.7)	
Age group			
<20	19	2(10.5)	0.9300
20-29	131	8.(6.1)	
30-39	144	12(8.3)	
40-49	54	4(7.1)	
50-59	1	1(10)	
Marital status			
Single	151	6(4.0)	0.0839
Married	204	21(10.1)	
Divorced	2	0(0)	
Settlement type			
Urban	289	22(7.6)	0.7492
Semi-urban	31	3(9.7)	
Rural	40	2(5.0)	
Educational status			
None	9	0(0%)	0.7492
Informal	51	8(15.7)	
Primary	34	2(5.9)	
Secondary	118	7(5.9)	
Tertiary	148	10(6.8)	
Occupation			
Unemployed	129	5(3.9)	0.0005
Civil servants	54	8(14.8)	
Business	116	5(4.3)	
Artisans	6	1(16.7)	
Farmers	49	6(12.2)	
Others	6	2(33.3)	

With respect to ABO blood group and donation history, blood group B donors had the highest prevalence rate of 12.8% (10/78) while no infection was detected among blood group AB donors by both techniques. This difference was statistically significant (χ^2 = 10.589, df =4, p= 0.032). Relation or replacement donors had the highest prevalence rate of 8.8% (24/273) while no parasite was detected in the commercial donors. Furthermore, regular donors had the highest prevalence rate of 9.7% (11/114) while first time donors had the least prevalence rate of 6.5% (16). There was no statistically significant difference in the difference in the prevalence rate obtained for both donor type (χ^2 =3.1892, df =2, p=0.2030) and donation frequency (χ^2 = 1.1107, df =1, p=0.2030) (Table 5).

Table 3: Prevalence of malarial parasites in the blood of blood donors in Kaduna state in relation to body mass index (BMI).

BMI	Number Examined	Number Positive (%)	P value
<18.5	9	1 (11.1)	
18.5-249	244	18 (7.4)	
25-29.9	90	8 (8.9)	
30≤	17	0 (0)	0.6143
<18.5	9	1 (11.1)	
18.5-249	244	18 (7.4)	
25-29.9	90	8 (8.9)	
30≤	17	0 (0)	

Table 4: Prevalence of malarial parasites in the blood of blood donors in Kaduna in relation to some risk factors.

Factor	Number Examined	Number Positive (%)	P Value
Season			
Wet	218	20(9.2)	0.1351
Dry	142	7(4.9)	
ITN use			
Yes	157	16(10.3)	0.2169
No	203	11(5.4)	

ITN= insecticide treated nets

Table 5: Prevalence of malarial parasites in the blood of blood donors in Kaduna state in relation to blood group and donation history.

Factor	Number Examined	Number Positive (%)	P-Value
Blood group			
A.	57	2(3.5)	0.032
B.	78	10(12.8)	
AB.	7	0(0)	
O.	218	15(6.9)	
Donor Type			
Commercial	21	0(0)	0.2030
Replacement	273	24(8.8)	
Voluntary	66	03(4.6)	
Donation frequency			
First time	246	16(6.5)	0.2030
Repeat	114	11(9.7)	

DISCUSSION

The malaria parasites prevalence rate of 7.5% obtained in the present study, though not very high poses some concerns. This is a reflection of the potential role that blood transfusion could play in the transmission of malaria in the state. This result is similar to that reported by Garba DD et al who had a prevalence of 6.8% among blood donors in Ahmadu Bello University Teaching Hospital, Zaria.[15] Also, Chikwem JO et al reported a

prevalence of 4.1% among blood donors at the University of Maiduguri Teaching Hospital, Maiduguri.[10] In a similar study, Ikeh EI et al reported a slightly higher prevalence rate of 11% at the Jos University Teaching Hospital, Jos.[16] Similar values of 7.8% and 12.56% have been reported in the southwest and South-South regions of the country, by Akinboye DO et al and Pondei K et al respectively.[17,18]

These regional prevalence differences in the country could be attributed to variation in the pre-disposing factors such as *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 previous researchers.[7,19,20]

The low levels of parasitaemia with an average density of 126 parasites/µl recorded among the infected donors is similar to the values of between 10-400 parasites/µl and 285 parasites/µl of blood average reported by Chigozie JU et al and Aina OO et al respectively.[21,22] This is higher than the density of 20 obtained by Garba DD et al. However, other studies have reported higher densities of 10,000 - 250,000 parasites/µl of blood.[18,23] The low parasitaemia levels observed in our study is not unusual because of the climate and the savanna vegetation type of the study area compared to the tropical rainforest areas of Ibadan and Niger delta studied by Alli JA et al and Pondei K et al respectively.[18,23] Worthy of note also is the fact that the study subjects were apparently healthy individuals.

The higher prevalence of the parasites seen in southern senatorial district represented by the General Hospital Kafanchan could be due to the higher rainfall of 1530mm usually experienced in Kafanchan-Kagoro in the southeastern part compared to 1015mm in Ikara/Makarfi districts in the northeastern part of the state.[14] Incidence of malaria has been found to be significantly and positively correlated with rainfall.[24] Rainfall provides sufficient breeding sites and relative humidity enhancing reproduction and survival of adult mosquitoes.

The detection of *Plasmodium falciparum* as the sole *Plasmodium* species identified in this study is neither surprising nor solitary. This findings is consistent with other reported studies where *P. falciparum* was either the predominant or only *Plasmodium* species detected.[10,17,21,25] *Plasmodium falciparum* has been the most endemic species of malaria parasite in sub-Saharan Africa.[3]

The higher prevalence rate observed for the females in this study is in concordance with the findings of several other researchers.[19,20,23,26,27,28] This is also consistent with the assertion that females are more vulnerable to this disease in Africa.[29] The reason for higher prevalence among the females may be a reflection of differences in disease susceptibility or reporting. There appears to be no scientific evidence linking malaria prevalence to gender.[28] The higher prevalence rate reported among females in this study could just be by chance.[23] Evidence from some countries indicates that restricted mobility of women may also impede their attendance at primary health care clinics for malaria testing thereby increasing their risk of infection.[30]

In relation to the age group, the highest prevalence rate was recorded among participants that were <20years. This finding is in agreement with the reports of Inabo and Umaru ML et al.[25,26] This buttresses the assertions that younger ones are more disposed to the infection than older individuals in malaria endemic areas of sub-Saharan Africa. These young individuals may become relatively protected against disease after repeated exposure to multiple malaria infections as they grow older. [25,26]

The findings from this study indicated a higher prevalence among married donors compared to the unmarried ones. This is finding is similar to that reported by Alli JA et al The reason for this present outcome could be by chance.[23]

The results also showed that the prevalence was highest among urban dwelling donors. This finding is similar to the report of Okonko IO et al who reported higher prevalence in blood donors from the urban areas of Ibadan.[18] It has been shown that high population densities and possible lower immunity may result in more disease impact in urban setting.[28]

The preponderance of the infection among donors with informal education is in consonance with the findings of Ndawala J et al and Alli JA et al who reported that women with lower levels of education were likely to have fewer than those with higher levels of education. Education has been found to be one of the potentially protective socio-economic factors against malaria risk.[31]

In this study, those with undisclosed occupation had significantly highest prevalence. It may be that these individuals are engaged in activities that predispose them to contact with mosquitoes especially if such are nocturnal in nature. It could also be by chance.

In relation to the Body Mass Index (BMI), the underweighted donors (BMI>18.5Kg2/m) were most infected. This is in agreement with the findings of Shulman CE et al in Kenya who found increased presence of placental malaria among women of low body mass index.[32] Also, Godana IM et al reported that the severely thin were at a higher risk of malaria.[33] This observation could be due to the fact that nutrient deficiencies impair resistance to infection. Also, low BMI has been associated with the pathogenesis of severe malaria.[34] Parasitaemia has also been reported to have a detrimental effect on nutritional status through host elaboration of pro-inflammatory cytokines.[35,36]

The preponderance of this infection in the rainy season in this study is consistent with reports by other previous researchers attributing it to the peak of mosquito density occasioned by favourable conditions for mosquito vector breeding during the warm humid summer associated with the high rainfall.[11,7,37]

The higher prevalence of infection among donors who use insecticide treated bed nets could be attributable to factors such as presence of pyrethroid resistant *Anopheles* in the area, inconsistent use of ITNs, incorrect hanging of ITNs, use of expired ITNs, proportion of those using ITNs in the study area and the biting behaviour of some *Anopheles* mosquitoes.[3,38] These are factors that could undermine effectiveness of ITNs in the study area. More than half of the people in a community must use ITNs for it to be effective.[3] Promoting the culture of appropriate net use based on effective education, promotion and marketing is essential to the success of the use of ITNs as far as public health is concerned.[39] There is need for a deeper investigation on the use of ITNs in the study area in order to unravel the possible cause of this finding.

The result of this study also showed that replacement or family-related donors were most infected as earlier observed.[31] This is similar to the findings of Ikeh EI et al and Alli JA et al Replacement donors are usually family members and friends who usually prefer their blood be transfused to their loved ones by all means and may not want to be disqualified even when they have slight fever or headaches. Repeat or regular donors were most infected according to the outcome of this research. This is in concurrence to the report of Alli JA et al However it may not be unconnected with the fact that first time donors are usually apprehensive and those who are positive could be discouraged with the slightest feel of unwell.[23]

When malarial parasitaemia was associated with ABO, blood group B donors were most infected. This difference was statistically significant. The finding in this study is similar to the findings of Chigozie JU et al who reported a higher prevalence among blood group B donors in India and south-eastern Nigeria respectively.[21] It has also been observation that individuals with A and B group cells are at greater risk of developing severe cerebral malaria.[40] A research using a larger sample size may be necessary to validate this finding.

CONCLUSION

In conclusion, the results of this study indicated a prevalence rate of 7.5% of malarial parasitaemia among blood donors in the study area. This reflects the potential risk of transfusion induced malaria in Kaduna state. All the infected donors had low levels of parasitaemia with an average density of 126 parasites/µl of blood. Though low, the parasite density is significant considering the malaria parasites infective dose of 1-10 parasites/unit of blood.[25] *Plasmodium falciparum* was the only malaria parasite species encountered. There were no mixed infections and no other blood parasites were observed. Statistical analysis indicated that malarial parasitaemia in blood donors was significantly associated with occupation and blood group.

We concur to earlier suggestions that donor blood should be screened for malaria parasites and the blood marked negative or positive as the case may be. Malaria infected blood could be given to recipients whose conditions allow for concurrent prophylactic treatment of malaria. This is because malaria is a treatable disease and discarding malaria-infected blood could compound the current problem of scarcity of donor blood in the country. Blood donors should be included in the groups of people targeted for free ITNs distribution. This will serve as an incentive for blood donation and also increase the span of ITNs usage in the state.

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