Prevalence of Malaria Among ABO Blood Groups in Ghana: A case study of Adentan Municipality

ABSTRACT

The ABO blood group system is the most clinically recognized blood group and it is made up of A, B, AB and O antigens. Many studies have been done to determine the relationship between malaria and the ABO blood group system in terms of the susceptibility, intensity, resistance and frequency of the disease among the various blood groups and there have been variations in the findings thus; this study sought to determine the prevalence of malaria among the various blood groups among the residents of the Adentan municipality. A cross-sectional study was conducted and 208 participants were enrolled, out of which 147 (70.7%) and 61(29.3%) were females and males respectively and 194 (93.3%) and 14 (6.7%) participants were adults and children respectively. There were 69 malaria cases of which 13 (18.8%) were children and 56 (81.2%) were adults. 40.58% out of the 69 malaria cases were males while 59.42% were females respectively. Malaria was most prevalent among blood group O Rh positive (44%) and less in blood group B negative (0%). Blood group O positive (41%) was more prevalent among the residents. There was significant correlation between malaria and gender and malaria and age distribution ($P=0.012$ and $P<0.00$) respectively. In conclusion, children and the female gender type are more prone to malaria parasitemia than adults and the male gender type. Age is a significant risk factor in malaria infections. Although there was no significant relationship between malaria and blood group, malaria was most prevalent among those with blood group O Rh positive. Blood group O positive was the most common among the participants.

KEYWORDS: ABO blood group, Rhesus factor, Malaria

INTRODUCTION

Malaria is an infection caused by parasites of the *Plasmodium* species through an infected female anopheles mosquito's bite (Cox, 2010). These *Plasmodium* species include *Plasmodium (P) falciparum, P. malariae, P. ovale, P. knowlesi* and *P. vivax* (Queensland Health, 2016). *Plasmodium falciparum* is the dominant causative agent of malaria in sub-Saharan Africa and is accountable for most malaria related mortalities globally, whiles *Plasmodium vivax* is prevalent in the Eastern Mediterranean areas, Western Pacific and South-East Asia (WHO, 2018).

In the World Health Organization (WHO, 2017) report on malaria, 211 million estimated cases of malaria were reported globally in 2015 which increased to 216 million cases in 2016 for which Africa carried 90% of the disease burden, South East Asia - 7% and the Eastern Mediterranean regions - 2%. Out of these incidents in 2015 and 2016, 446000 and 445000 global deaths were recorded respectively. These statistics show how malaria continues to blossom as a global health problem especially in Africa. Report from the Ghana Health Service (GHS, 2017) shows that, malaria accounts for 32.5 % of all OPD (abbreviation) cases and 48.8% of disease incidence among ages under 5 years which has significantly decreased the economy's finances and resulted in low productivity of the country. In 2016 alone, the population with malaria parasitemia recorded was 28,830,000 out of which there were 11,880,000 estimated cases and 11,880 estimated deaths (SMO, 2016).

In the transmission of malaria, the infected female anopheles mosquito passes on sporozoites of Plasmodium protozoa to the host through its saliva. The sporozoites enter the liver cells to form

hepatic schizonts which grow into merozoites. The merozoites then invade red blood cells, breaking them down and causing the harmful by-products to be released into the bloodstream thus; the infected host exhibits symptoms of the malaria infection [43,44]. Most often, malaria parasitemia reoccur and this usually happens with *P. vivax* and *P. ovale* specie infections because *P. vivax* and *P. ovale* produces dormant hypnozoites in the liver that will continue to multiply and cause malaria re-infection later. (Siciliano *et al*.,2015).

The severity of malaria infection is grouped into 2; uncomplicated malaria, which presents with chills, fever, malaise, fatigue, headaches, nausea and vomiting, and complicated malaria [45-47], which presents with severe cases of anemia, convulsions or seizures, respiratory distress, metabolic acidosis, cerebral malaria/coma and liver, kidney and cardiovascular failure (NIAID, 2016). The intensity of the malaria infection may result in complications such as severe anemia, cerebral malaria, severe dehydration, splenomegaly, kidney and liver failure, acute respiratory distress syndrome, hypoglycemia and pulmonary edema (Herchline, 2019).

Incidentally, there are many factors that affect the transmission of malaria including the condition of the human host in regards to immune suppression and the various blood groups and other climate factors such as altitude, temperature, humidity and rainfall patterns (WHO, 2018) and amongst many techniques used to detect malaria parasitemia, Rapid Diagnostic Test is largely used comparatively however; microscopy is considered the "gold standard" laboratory technique for diagnosing malaria (Pedro *et al.*, 2018).

Most often, the ABO blood group is the clinically significant blood group for organ transplants and blood transfusions and it is made up of A, B, AB and O antigens (Dean, 2005). These antigens are carbohydrate terminals found on glycoproteins and glycolipids expressed on cell

surfaces for cell-to-cell interactions (Kuadzi *et al.,* 2011). Antigens A and B have antibodies; Anti-B, Anti-A respectively whiles antigen O has no antibodies altogether (Mitra *et al.,* 2014).

Moll *et al.*, (2015) research on 'evasion of immunity to *Plasmodium falciparum'*, revealed the mechanisms linking severe malaria to the ABO blood group. The study explained the concept of 'rosetting' as a phenomenon where uninfected red blood cells adhere to infected red blood cells forming clusters or a rosette which is one of the characteristics in severe malaria. Rossetting happens when malaria parasites secrete polypeptide proteins called RIFINs (repetitive interspersed family of proteins) and PFEMP1 (P. *falciparum* erythrocyte membrane protein 1) exhibited on the surface of infected red blood cells. Destruction of the rosette formation by antibodies becomes difficult because of restricted access to the infected cells surrounded by uninfected ones. These proteins were discovered to bind more to the surfaces of red blood cells belonging to blood group A than those of O which is able to produce antibodies to neutralize the effect of Pf EMP1 thereby interfering with rosette formation and the development of severe malaria and therefore concluding that blood group A is more prone to severe malaria infection than blood group O (Afoakwah *et at.*, 2016).

Similarly, studies conducted in Ethiopia (Tekeste *et al.*, 2010) and Cameroon (Kuete *et al.,* 2016) on ABO blood group and *Plasmodium falciparum* malaria also found that people with blood groups A and B are at a higher risk of experiencing intense symptoms of malaria compared to those having blood group O type. A study by Zerihun *et al.*, (2011) conducted in Southern Ethiopia showed that people with blood groups A, B and AB were more vulnerable to *Plasmodium falciparum* infection compared to those with blood group O. This study aimed at determining the relationship between malaria and the ABO blood groups among the Adentan

population in Ghana in terms of vulnerability to infection and also to unravel the correlation between malaria infection, gender and age.

NULL HYPOTHESIS

Malaria is more prevalent among people with blood groups A, B and AB compared to those with the blood group O.

METHODOLOGY

STUDY DESIGN

A cross-sectional survey also known as transverse or prevalence study was conducted in the Adentan community because it is a research tool used to capture information from a pool of participants on the spot at a particular place and at a particular time.

STUDY SITE

The Greater Accra Region covers an area of 1.4% of the total land area of Ghana and bears a population of 2,905,726 of which 1,436,135 and 1,469,591 are male and female populations respectively. Adentan municipality is one of the districts in Accra and covers a total surface area of 92.84 square kilometers. The total number of residents of the Adentan Municipality according to the housing census and population in 2010 is 78,215 with 39,366 males and 38,849 females.

STUDY TOOL

Materials that were used for the study include; RDT (abbreviation) cassette, gloves, lancet, cotton wool, alcohol swabs, methanol, Giemsa stain and blood group reagents.

DATA AND SAMPLE COLLECTION

Data was obtained by quantitative method (surveys) where the results were compared and analyzed. In sample collection, based on the sample size 208, the Adentan municipality was divided into 4 quadrants taking 52 participants from each quadrant.

Through snowball sampling also known as referral sampling where existing participants refer future participants from among their acquaintances, 9 houses were selected from each quadrant and 6 people were selected from each house.

LABORATORY TECHNIQUES

Capillary blood samples were obtained by finger pick and the RDT tests for malaria were done on the field. In determining the blood groups of the study participants, blood samples were obtained by finger prick and monoclonal antibodies against antigens A, B, O and Rh were dropped in the wells containing the blood samples. Agglutination occurred if the erythrocytes contained the corresponding antigen. This revealed the blood groups and Rh factors of the participants.

SAMPLE SIZE

In determining the sample size for the study, Kothari's formula (2004): $n=z^2.p.q.\ Ne^2\ (N-1) + z^2.p.q$ was used because the population was known. Thus; the sample size was 208. Kothari's formular; $n=z^2.p.q.\ Ne^2\ (N-1) + z^2.p.q$, where n is the sample size, N is the population size, n is the sample size, z is the value of standard variation at a specific confidence level, p is sample proportion, q is1-p and e is the margin of error, which in this study is 0.1 ie. 90% confidence level.

DATA ANALYSIS

Information was entered into Microsoft excel 2010 version and analyzed with SPSS statistical software. Pearson's chi-square test was used to compare the relationship between the variables.

RESULTS AND DISCUSSION

RESULTS

In this study, 208 participants were enrolled, out of which 147 (70.7%) and 61 (29.3%) were females and males respectively with 194 (93.3%) and 14 (6.7%) participants being adults and children respectively. Two third of the participants tested negative to the malaria parasite as depicted in the table below.

Table 1: Distribution of malaria among the participants of the Adentan Muncipality.

Status	Frequency	Percentage
Malaria Positive	69	33.2
Malaria Negative	139	66.8
Total	208	100.0

Thus, the prevalence of malaria in the Adentan Municipality was 33.2%. The most prevalent blood group observed in this study was O Rh D positive while the least prevalent blood group observed was B Rh D negative as shown in figure 1 below.

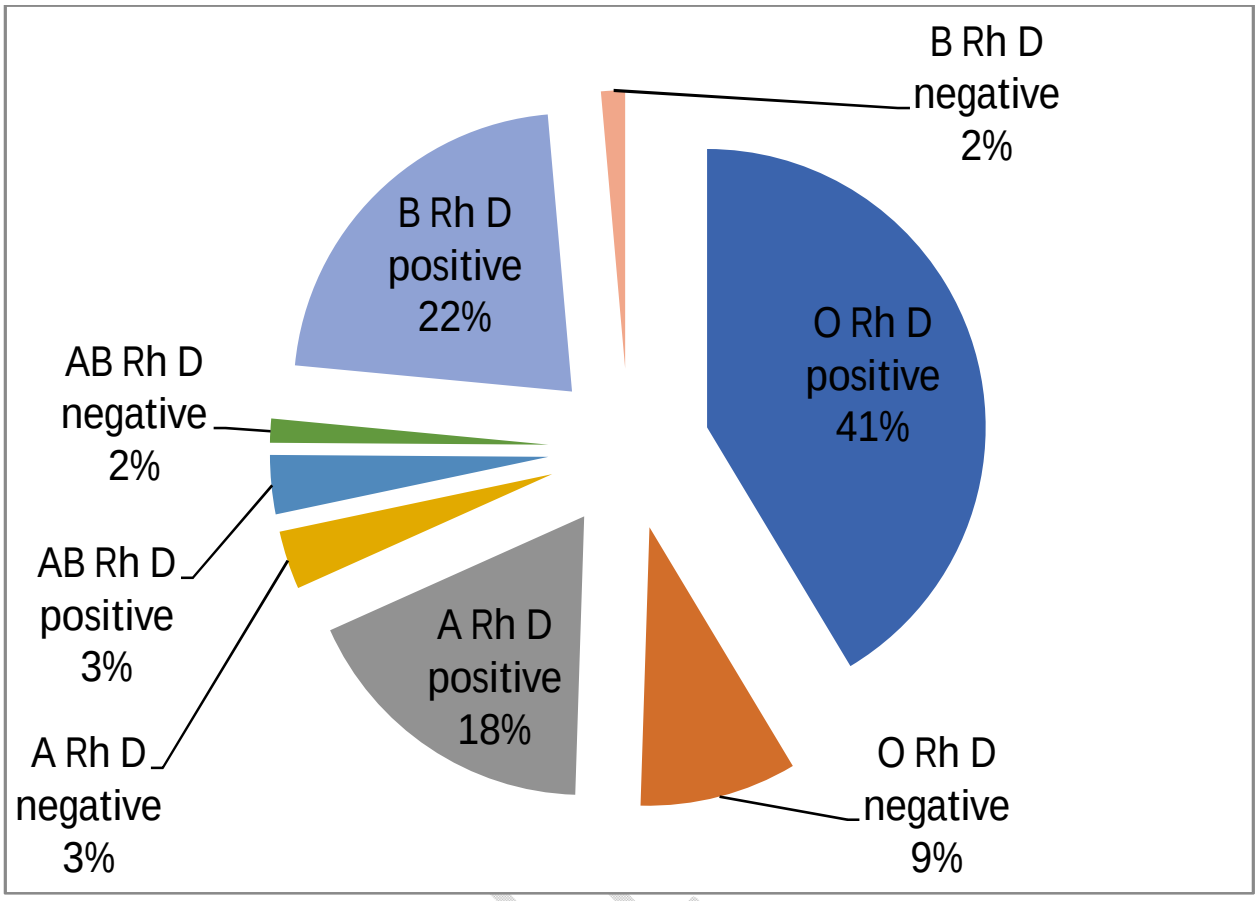

Figure 1: Distribution of the various blood groups among the participants

The 69 cases of malaria identified during the study were distributed amongst the various blood groups (table 2) with a higher prevalence occurring amongst females than males in this study (table 3).

Table 2: Prevalence rate of malaria among the various blood groups

Blood Groups	**Malaria Positive**	**Malaria Negative**	**Total**	**Percentage prevalence**
O Rh D positive	30 (34.9%)	56	86	43.48
O Rh D negative	3 (15.8%)	16	19	4.35

A Rh D positive	12 (32.4%)	25	37	17.39
A Rh D negative	2 (28.6%)	5	7	2.89
AB Rh D positive	3 (42.9%)	4	7	4.35
AB Rh D negative	1 (33%)	2	3	1.45
B Rh D positive	18 (39%)	28	46	26.09
B Rh D negative	0 (0%)	3	3	0
Total	**69**	**139**	**208**	**100.0**

Table 3: Prevalence rate of malaria among the various genders

Gender	**Malaria**		**Total**	**Percentage prevalence**
	Positive	**Negative**		
Male	28	33	61	13.5
Female	41	106	147	19.7
Total	69	139	208	100.0

Malaria was common amongst almost all the children enrolled in this study as 13 out of the 14 children (92.86%) who participated tested positive to malaria whiles adults had a lower prevalence of malaria compared to the children as 56 out of 194 adults (28%) tested positive to malaria. The correlation between malaria and age as well as malaria and gender was found to be statistically significant (table 4).

Table 4: Correlations among age, blood group, gender and malaria

s/n	Parameters	Gender	Blood group	Malaria
1	Blood group	.102		
2	Malaria	.012*	.656	
3	Age group	.079	.339	.000**

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

In a high transmission area such as Ghana, malaria remains a life-threatening disease that is responsible for much maternal and neonatal mortality (GHS, 2017). Children by the age of 3 months begin to lose their maternal immunity thus leaving them susceptible to infections (WHO, 2018). By the age of 6 years, they develop immunity to the infection due to continuous exposure and re-occurrence of the infections (Uneke *et al.*, 2006) which leads to increasing age-dependent immunity and less severity of disease manifestation (Sama *et al.*, 2006). In this study, 208 residents of the Adentan municipality were recruited randomly without consideration for gender or specific age-related immunity. There were 69 malaria cases of which 18.8% were children and 81.2% were adult, however their percentage prevalence was 92.86% and 28% respectively. Thus, the prevalence of malaria was observed to be higher among children compared to adults ($p=0.0157$). These findings are in concordance with data by Afoakwah *et al.*, (2016) on the results of a similar study that children are more susceptible to malaria infection than adults yet contradict the findings of Jenkins *et al.*, (2015) which showed a higher prevalence of malaria among adults than in children. The reason for the disparity is as a result of an unbalanced

sampling system practiced in both studies, i.e the number of children were much higher than the number of adults and vice versa. This study showed significant correlation between malaria parasite infection and the age of participants ($p<0.000$). The phenomenon of 'rosetting' introduced by Wahlgren (Carlson, 1990) explained the adherence of red cells to themselves to form clots due to secretions of RIFINs and PFEMP1 by malaria parasites to cause stickiness of red cell surfaces to aid adherence (Kuadzi *et al.*, 2011). His results showed that blood group A had more affinity for malaria infection than blood group O. However, in this study, the incidence rate of malaria parasitemia among the participants was higher in the blood group O Rh positive (44%) and lowest in blood group B negative (0%). This is similar to the findings of Tela *et al.*, (2015), a study conducted in Sri Lanka, Asia, yet in contrast with the findings of Afoakwah *et al.*, 2016 where blood group O Rh positive were reported to have some protection against complicated falciparum malaria with the possibility of possessing a survival advantage over their counterparts with other blood groups.

The relationship between malaria and gender has been a constant topic of research globally and varieties of information have emerged. However, there are variations in the findings and this may be due to differences in their innate characteristics in terms of genetic make-up, structural and chemical composition of the receptors on the red cell surfaces (Olukoya, 2005). Generally, the rate of malaria infection was higher among the females (59.42%) than in males (40.58%), which is similar to the findings of Tela *et al.*, (2015), Jenkins *et al.*, (2015) and Abdullahi *et al.*, (2009).

The distribution of blood group among the study participants showed the dominance of blood group O Rh D positive among the participants and blood group B Rh D negative as the least. This corresponds to the findings of Kretchy *et al.*, (2017). There was no significant correlation

between malaria and blood group. This agrees with the findings of (Xuan *et al*., 2017). However, there was a significant correlation between malaria parasitemia and age as children were observed to be more prone to malaria compared to adults and this is similar to the findings of Schwartz *et al.,* (2011).

The studies on gender as a risk factor for malaria parasitemia have produced conflicting results. This study showed significant correlation between malaria and gender (p=0.012). However, whether or not gender is a risk factor in malaria parasitemia remains inconclusive as the exposure of both genders would place them at equal amount of risk of acquiring malaria parasite infection.

5.0 CONCLUSION AND RECOMMENDATIONS

Malaria is more prevalent among children than in adults in the Adentan municipality, confirming that age is a significant risk factor in the spread of malaria infection. There was no significant correlation between malaria and blood group. However, individuals with the blood group O positive were predominantly infected by malaria parasites compared to those with blood group B negative. Blood group O Rh positive was the most prevalent among the residents. There was significant correlation between malaria and gender however the contribution of gender as a risk factor in malaria infection remains inconclusive. In the light of these findings, the authors recommend that a similar study should be done during the rainy season because climate change optimizes the rate of endemic malaria transmission. This may help to obtain higher number of malaria cases for clearer results. Also, similar research can be done in remote areas where mosquito nets and insecticide sprays are less used and where malaria infections are prominent.

DATA AVAILABILITY STATEMENT

All data regarding this research can be made available upon request.

ETHICAL APPROVAL AND CONSENT:

Ethical clearance for this study was obtained from Allied Health Ethical and Protocol Review Committee (AHEPRC) with number AHEPRC047/11/20 of Radford University College prior to data collection. Participants volunteered conscientiously after which they signed a consent form of authorization before being recruited in the study.

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