

DISTRIBUTION OF ABO BLOOD GROUPS AND SELECTED DISEASES AMONG STUDENTS OF FEDERAL UNIVERSITY BIRNIN KEBBI, NIGERIA

Tajudeen Yahaya^{1,*}, Esther Oladele², Hikmat Ahmed¹, Sandra Obhiojeifoh³, Abdulhakeem Haruna¹ and Oluwatosin Akinola¹

Received: December 23, 2020; Revised: March 11, 2021; Accepted: March 12, 2021

Abstract

ABO and Rhesus blood groups influence the prevalence of some diseases and can be used as a management strategy. However, the association varies geographically, necessitating the need to establish the nature of the association in every locality. This study determined the distribution of ABO and Rhesus blood groups and their susceptibility to malaria, typhoid, and hepatitis B among students of Federal University Birnin-Kebbi, Nigeria. Demographic data of 1,005 participants (575 females and 430 males) were obtained using questionnaires, after which their health records were obtained from some medical facilities in the city. The results showed that 97% of the participants were Rhesus positive. Group O was the most prevalent among the ABO blood groups (45%), followed by B (21%), A (19%), and AB (15%). Malaria was more prevalent among group O carriers (49%), followed by AB (20%), A (19%), and B (12%). Among participants with recurrent typhoid, O was the most prevalent (48%), followed by B (22%), AB (16%), and A (14%). Hepatitis B was dominant among group O individuals (45%), followed by B (35%), AB (20%), and A (0.0%). Moreover, 94, 88, and 91% of the participants that expressed malaria, typhoid, and hepatitis B, respectively, were Rhesus positive. The results indicate that ABO group O and Rhesus positive antigen carriers in the institution were more susceptible to the diseases. As such, carriers of the blood groups in the institution should pay more attention to the diseases.

Keywords: ABO blood groups, blood Group O, hepatitis B virus, malaria, rhesus blood groups

Introduction

Many diseases, including malarial fever, typhoid fever and hepatitis B remain a global health burden, especially in developing nations. Malaria is caused by five *Plasmodium* species, of which *Plasmodium falciparum* and *Plasmodium vivax* pose the greatest risk (WHO, 2013). *P. falciparum* is the most

virulent and responsible for the majority of deaths (WHO, 2013). In 2018, almost 228 million people worldwide had malaria, causing 405,000 deaths, most of which occurred in Africa (Nureye and Assefa, 2020). Typhoid fever is a waterborne disease caused by *Salmonella typhi* (Crump, 2019).

¹ Biological Sciences, Federal University Birnin Kebbi, PMB 1157, Birnin Keb bi, Nigeria. Tel. +234-8033550788; E-mail: yahaya.tajudeen@fubk.com; yahayatajudeen@gmail.com

² Biology Unit, Distance Learning Institute, University of Lagos, Nigeria.

³ Department of Pure and Applied Sciences, National Open University of Nigeria, Lagos.

* Corresponding author

At the minimum, 14.3 million people worldwide expressed typhoid and paratyphoid fevers in 2017, resulting in about 139,000 deaths, mostly in low-income countries (Stanaway *et al.*, 2019). Hepatitis B virus causes both acute and chronic diseases of the liver. In 2015, 257 million people worldwide had chronic hepatitis B infection, resulting in about 887,000 deaths (WHO, 2020). Definitely, more need to be done to reduce the burden of these diseases.

Fortunately, some studies revealed that certain blood groups influence susceptibility to some diseases, and can be used to predict and manage the diseases. There are over 30 human blood group systems, of which the ABO and Rhesus blood group systems are the most important in clinical applications (Tekade *et al.*, 2011). The ABO blood group system is controlled by a gene on chromosome 9 known as ABO gene or immunoglobulin denoted by letter 'I' (Zahid *et al.*, 2016). The gene has three alleles, which are A, B, and O alleles (I^A , I^B and i alleles). The A and B alleles produce slightly different glycoproteins (antigens), named antigen A and B, respectively, while O allele produces none. The I^A and I^B alleles are codominant and are both dominant over O allele, which is recessive (Murphy *et al.*, 2003). Blood groups are hereditary, and an individual's ABO blood phenotype depends on the antigen on the surface of red blood cells, tissues, body fluid, and other vascular structures (Franchini and Maria, 2013). Thus, antigen A means group A, antigen B (group B), a combination of both antigens (group AB), and absence of both antigens (group O) (Zahid *et al.*, 2016). In all, there are four blood phenotypes (A, B, AB, and O) from six allelic combinations (genotypes) (Khalid *et al.*, 2013). The six genotypes are OO (type O), OA (type A), OB (type B), AA (type A), BB (type B), and AB (type AB) (Khalid *et al.*, 2013). In the Rhesus blood group system, there are over 50 antigens but the main Rhesus antigens of medical importance are D, C, E, c, and e (Gundrajukuppam *et al.*, 2016). Individuals possessing a Rhesus antigen are said to be Rhesus positive while those lacking the antigens are Rhesus negative (Jahanpour *et al.*, 2017). When someone that is negative received Rhesus positive blood, a potentially fatal hemolytic reaction will occur due to the production of antibodies (Jahanpour *et al.*, 2017).

ABO and Rhesus antigens can be used in population genetics to study migration pattern, inheritance of traits, paternity, crime, among others (Jahanpour *et al.*, 2017). ABO blood group is also important in determining compatibility between donors and recipients in blood transfusions and organ transplantation (Jahanpour *et al.*, 2017). Studies also linked certain ABO blood phenotypes

with the occurrence of some diseases (Anstee, 2010). For example, stomach ulcer is more common among individuals with type O, while gastric cancer is more common among group A individuals (Dean, 2005). Studies have also reported an association among ABO blood groups and the diseases under current investigation. In a study by (Otoikhian and Okoror, 2012), blood group O individuals were the most susceptible to typhoid fever, while AB was the least. In another study by (Zerihun *et al.*, 2011), individuals of blood groups A, B and AB were more susceptible to *P. falciparum* infection as compared with individuals of blood group O. (Oladele *et al.*, 2020) also reported that type O individuals could be more susceptible to hepatitis B infection.

Overall, these show that ABO and Rhesus blood groups can provide preliminary data for managing an individual's health as well as determine most prevalent diseases in a population. However, the distribution of ABO and Rhesus antigens varies globally, even among ethnic groups (Fufa and Debelo, 2019). Therefore, to effectively use ABO and Rhesus blood systems to predict and manage diseases, there is a need to determine the distribution of the blood groups in the population. To the best of our knowledge, such a study has not been conducted in Birnin Kebbi, Nigeria. Furthermore, the few studies that were conducted in neighboring states did not determine the susceptibility or otherwise of the blood groups to diseases. This study, therefore, determined the distribution of ABO and Rhesus blood phenotypes and their susceptibility to malaria fever, typhoid fever, and hepatitis B among students of Federal University Birnin Kebbi, Nigeria.

Materials and Methods

Description of the Study Site

This study was carried out at the permanent site of Federal University Birnin Kebbi, Nigeria (FUBK). The university is multiethnic, comprising Hausa, Fulani, Yoruba, Nupe, and Igbo, among other tribes. Most of the students of the institution are native or resident in the state, while some others came from neighboring states. The multiethnic nature of the institution informed its choice as the study area. The university was established in 2013 with its permanent site along Kalgo-Bunza Road, Birnin Kebbi. Birnin Kebbi is the capital of Kebbi State and headquarters of Gwandu Emirate on latitude 12° 27' 57.8808" N and longitude 4° 11' 58.2864" E (Yahaya *et al.*, 2019). The indigenous people of the state, mainly Hausa, Fulani, and Zuru are predominantly cereal farmers and animal breeders. The vegetation of the state comprises

a mixture of grasses and sparse trees, characteristics of Sudan Savannah. The climate is mainly dry, occurring between October and May, and the remaining months are wet. The average annual rainfall is 740 mm, while the temperature may be as high as 41°C and as low as 15°C (Amusuk *et al.*, 2016). Infectious diseases such as malaria, typhoid, and hepatitis B are prevalent in the state (Amusuk *et al.*, 2016), which could be a consequence of the high population of mosquitoes and scarcity of potable water in the area.

Study Population and Data Collection

Federal University Birnin Kebbi (FUBK) is heterogeneous, comprising students with different backgrounds, tribes, sexes, and ages, among other indices. The population of the study was 5,100 registered students of the university. A multi stage sampling procedure was used to select the sample for the study. First, stratified random sampling was adopted to put the students into two strata (male and female). Then, purposive sampling was used to select 1,005 (575 females and 430 males) that indicated interest across the school. After given informed consent, each participant was given a copy of the researchers' designed 4-point Likert scale structured questionnaire to indicate sex, ethnicity, and medical facility used in the city. To ascertain the reliability of the instrument, a trial testing of the instrument (pilot study) was done with 50 students who were not part of the sampled respondents. A cronbach alpha reliability co-efficient of 0.78 was obtained for the questionnaire and this was high enough to justify its use for data collection for this study. Thereafter, the health records and ABO blood groups of the participants were checked in the health facility used by each participant in the city as indicated on the questionnaires.

Criteria for Selection of Participants

Criteria considered for selection of participants for the study include:

- Must be willing to participate.
- Must be a student of FUBK.

- Must have done their ABO blood group test and health status in Birnin Kebbi for easy confirmation.
- Individuals that gave consent to check their health records and blood groups.

Ethics Approval and Consent to Participate

The study was approved by the Ethics Committee of Federal University Birnin Kebbi, Nigeria. A written consent was also obtained from the participants before recruitment into the study. Guidelines for teaching and research as outlined by the Committee were strictly followed in the course of the research.

Data Analysis

Descriptive statistics were used to present data as numbers and percentage. The graphs were drawn using Minitab software version 7.0.

Results and Discussion

Distribution of ABO Blood Groups among Ethnic Participants in FUBK

Table 1 shows the distribution of the ABO blood groups among ethnic groups in FUBK. Blood group O was the most common among Hausa males and females, followed by B, AB, and A, respectively. Group O was also the most common blood group among the Fulani participants, followed by B, A, and AB among males, as well as A, AB, and B among females, respectively. Among the Yoruba females, A was the most common, followed by O, AB, and B, while in the males, B was the highest, followed by O, A, and AB, respectively. Among the Nupe females, group A was the most prevalent, followed by AB, O, and B, while among the males of the tribe, B was the most frequent followed by O, A, and AB, respectively. Group O was the commonest among Igbo females, followed by B, A, and AB, while among the males of the tribe, O was common, followed by A, B, and AB, respectively. There were not enough participants to

Table 1. Distribution of ABO blood groups among ethnics in FUBK

Ethnic	Females				Males			
	A n(%)	B n(%)	AB n(%)	O n(%)	A n(%)	B n(%)	AB n(%)	O n(%)
Hausa	30(14.3)	50(23.8)	35(16.7)	95(45.2)	25(10)	65(26)	35(14)	125(50)
Fulani	30(26.1)	10(8.7)	20(17.4)	55(47.8)	10(15.4)	25(38.5)	-	30(46.2)
Yoruba	50(40)	10(8)	25(20)	40(32)	5(12.5)	20(50)	5(12.5)	10(25)
Nupe	20(36.4)	-	20(36.4)	15(27.3)	5(12.5)	5(12.5)	20(50)	10(25)
Igbo	-	10(28.6)	-	25(71.4)	5(25)	5(25)	-	10(50)
Badakare	-	-	-	5(100)	-	5(50)	5(50)	-
Tiv	5(33.3)	-	-	10(66.7)	-	-	-	-
Kambari	5(100)	-	-	-	-	-	-	-
Bussa	-	-	-	5(100)	-	-	-	5(100)

draw inferences on Badakara, Tiv, Kambari, and Bussa tribes. Overall, 19, 21, 15, and 45% of the participants were Group A, B, AB, and O, respectively (Figure 1). These show that group O was the most prevalent ABO blood group among FUBK students, followed by B, A, and AB ($O > B > A > AB$). This result is consistent with (Chima *et al.*, 2012) who reported $O > B > A > AB$ order of prevalence in northwest, Nigeria, same zone as the current study. The result is also consistent with (Sharma *et al.*, 2013; Etim *et al.*, 2017) who reported $O > B > A > AB$ order of prevalence in Adamawa, northeast Nigeria, and in India, respectively. However, the results is inconsistent with the findings of (Anifowoshe *et al.*, 2017) who observed more group A blood than B among blood donors in southwest Nigeria, resulting in $O > A > B > AB$ order of prevalence. Similarly, (Apecu *et al.*, 2016) also reported more group A than B among Ugandans, resulting in the order of $O > A > B > AB$. The dominance of group O blood over other blood groups in this study might be influenced by natural selection. According to (Cheng *et al.*, 2005), environmental triggers such as diseases or disorders may influence natural selection to favor or hinder the expression of certain ABO blood groups in the populations. This implies that natural selection may favor a blood type that is protective or resistant to an unfavorable condition, while a less resistant blood type will be less successful. (Fufa and Debelo, 2019) stated that the global dominance of O blood group indicates an evolutionary success, owing to its fitness in certain environmental triggers such as diseases. However, another school of thought also suggests that type O blood is more common because it is the ancestral ABO blood form (Cserti and Dzik, 2007). This claim was corroborated by a DNA sequence analysis which dates the emergence and development of the group O allele to a period of evolution before humans migrated out of Africa (Cserti and Dzik, 2007; Villazon, 2020) suggests that A and B mutations appeared in the last 20,000 years and have not spread as much as O in the population.

Occurrence of Malaria Among Various ABO Blood Groups

Table 2 reveals the prevalence of malaria among the ABO blood groups. Group O was more common among the female participants with malaria, followed by A, B, and AB in that order ($O > A > B > AB$). Group O was also the most prevalent blood group among the male participants, followed by AB, and followed jointly by A and B ($O > AB > A$ and B). Taken together, 48% of the participants that expressed malaria were group O, 20.8% were AB, 17.6% were A, and 13.6% were B (Figure 2).

This shows that malaria was more prevalent among group O individuals, followed by AB, A, and B, respectively ($O > AB > A > B$). This result is consistent with some earlier studies conducted in the country, including (Onanuga and Lamikanra, 2016; Abah *et al.*, 2016). However, it contradicts some other studies in the country such as (Ilozumba and Uzozie, 2009; Oche and Aminu, 2012) reported more group AB among malaria patients. It also contradicts (Moise and Robert, 2017) who reported more malaria incidence among blood groups A and B in Bauchi State, Nigeria. Outside Nigeria, the result contradicts (Cserti and Dzik, 2007) who reported a high prevalence of malaria among blood group O donors in Ethiopia compared to those with other ABO blood groups. Additionally, the result is inconsistent with (Panda *et al.*, 2011) who reported a high prevalence of group A among malaria patients in Odisha, India. These inconsistencies show that the association between ABO blood groups and malaria prevalence varies geographically.

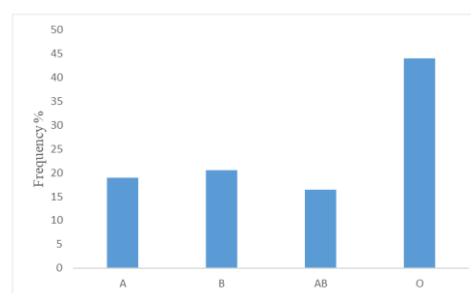


Figure 1. Prevalence of ABO blood groups among FUBK participants

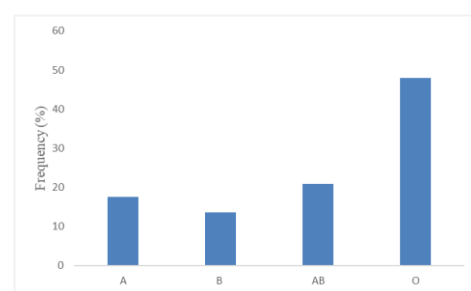


Figure 2. Prevalence of ABO blood groups among FUBK participants with frequent malaria

Table 2. Distribution of ABO blood groups among FUBK participants with recurrent malaria fever

Gender	A n(%)	B n(%)	AB n(%)	O n(%)
Females	80(26.7)	55(18.3)	35(11.7)	130(43.3)
Males	30(9.2)	30(9.2)	95(29.2)	170(52.3)

However, group O blood is more common among malaria patients in malaria-endemic regions, including Nigeria, than in non-endemic areas (Lemu *et al.*, 2017). According to (Cserti and Dzik, 2007), selective genetic pressure from infection might have influenced the distribution of blood groups and preference for group O in the region. The dominance of group O could indicate its resistance or protection from malaria, a selective advantage (Fufa and Debelo, 2019). Antigens of groups A and B enhance cytoadherence of parasites, but erythrocytes of group O lack antigens (Fufa and Debelo, 2019). Hence, cytoadherence and rosetting by *P. falciparum* (most prevalent malaria parasite) are reduced in individuals with group O (Fufa and Debelo, 2019). Thus, chronic malaria is likely to be less prevalent among group O compared to group A and B individuals (Fufa and Debelo, 2019). Furthermore, the lack of cell adherence by erythrocytes of group O results in low parasitaemia compared to the other blood groups (Afoakwah *et al.*, 2016). This may give group O individuals with complicated malaria a survival advantage over other blood groups with complicated malaria (Afoakwah *et al.*, 2016). Moreover, while the immune systems of group A blood develops antibodies for B antigen and group B have antibodies for A antigen, group O has antibodies for both, and AB group has none (Mangin, 2020). Thus, in the ABO blood group system, group O blood is the richest in antibodies (Mangin, 2020), which, in part, could be the reason group O blood protects against certain microbial infections. Some other scientists suggest that the protein of group O blood is tasty and more appetizing to mosquitoes, thus group O individuals are more pestered than other people. In a study conducted at the Institute of Pest Control Technology, mosquitoes significantly landed on the skin of group O individuals compared to other blood groups (Mosquito Squad, 2015). In a related study by (Wood, 1974; Prasadini *et al.*, 2019), mosquitoes landed more on group O blood than other blood groups.

Occurrence of Typhoid Fever Among Various ABO Blood Groups

The frequency of typhoid fever among the ABO blood groups is shown in Table 3. Group O was the most common blood group among the female participants with typhoid fever, followed by AB, and followed jointly by A and B. Among the male participants with typhoid fever, groups O and B were jointly the most prevalent, followed jointly by A and AB. Overall, group O was the most prevalent blood group among the participants with typhoid fever (46.3%), followed by B (22%), AB (17.8%), and A (14.6%) (O > B > AB > A)

(Figure 3). This result is in line with (Aniashi *et al.*, 2019) who reported O > B > AB > A order of prevalence among typhoid fever patients in Cross Rivers State, Southsouth, Nigeria. However, the result is inconsistent with a study conducted in the Southwest, Nigeria, by (Adias *et al.*, 2010) in which group A blood was the most abundant after group O. The result also contradicts (Banik *et al.*, 2018) who reported a higher prevalence of group B blood than other blood groups among typhoid patients in Bangladesh. These contrasting results showed that the relationship between typhoid fever prevalence and ABO blood groups depends on the geographical locations. There is a dearth of literature on the mechanisms by which ABO blood groups protect or dispose to typhoid fever. However, (Aniashi *et al.*, 2019) suggest that foreign agents (antigens) like *Salmonella typhi* (the causative agent of typhoid fever) may resemble the blood antigen antagonizes by group A or B blood, causing the immune system of the carriers to respond negatively, destroying tissues and organs. On the other hand, group O lacks any antigen and so may not induce any immune response or provides surface adherence to *Salmonella typhi*.

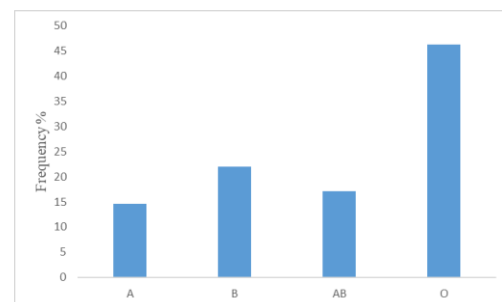


Figure 3. Prevalence of ABO blood groups among FUBK participants with frequent typhoid

Table 3. Distribution of ABO blood groups among FUBK participants expressing typhoid fever

Gender	A n(%)	B n(%)	AB n(%)	O n(%)
Females	15(13)	15(13)	20(17.4)	65(56.5)
Males	15(16.7)	30(33.3)	15(16.7)	30(16.7)

Occurrence of Hepatitis B Among Various ABO Blood Groups

Table 4 shows the prevalence of hepatitis B among the ABO blood groups. Hepatitis B was more common among the female participants with B blood, followed by O, AB, and A, respectively. Among the male participants, hepatitis B was more frequent among individuals with group O, followed jointly by B and AB, and then A, respectively.

Overall, hepatitis B was more common among group O individuals (42.9%), followed by B (35.7%), AB (21.4%), and A (0.0%) (Figure 4). This result is consistent with (Oladele *et al.*, 2020), who reported a higher prevalence of group O blood among hepatitis B patients than non-O blood groups in Lagos, Nigeria. The result is also in line with a meta-analysis comprising 38 articles and 241,868 hepatitis B patients, but group B was the least frequent in the study (Jing *et al.*, 2020). However, the result contradicts a study conducted in Turkey by (Genc, 2017) in which group A was the most frequent, followed by O, B, and AB. These inconsistencies suggest that the relationship between hepatitis B prevalence and ABO blood groups may be influenced by geographical locations. However, in hepatitis B endemic areas, group O is more common and less frequent among group B (Jing *et al.*, 2020). The dominance of group O blood in endemic areas may be protective. According to (Batool *et al.*, 2017), group A increases the severity of hepatitis B, while group O may be protective. The protective effects of group O may be connected with the lack of surface antigens explained earlier. Additionally, it may be connected with abundant antibodies expressed by group O blood compared to non-O blood groups.

Distribution of Rhesus Blood Groups Among the FUBK Participants

The distribution of Rhesus blood groups among the participants is shown in Table 5. Of the total FUBK participants, 89% were Rhesus positive (Rh +ve), while 11% were Rhesus negative (Rh -ve). Among the participants that had recurrent malaria, 86% were Rh +ve, while 14% were Rh -ve. Of the participants that frequently experienced typhoid fever, 89% were Rh +ve, while 11% were Rh -ve. Among the participants that were hepatitis B positive, 81% were Rh +ve, while 19% were Rh -ve. These results are consistent with most of the studies conducted on the subject in Nigeria and many other countries. For instance, (Chima *et al.*; 2012) reported a high prevalence of Rh +ve among blood donors in Kano, northwestern Nigeria. (Iyiola *et al.*, 2012) also reported more Rh +ve among blood donors in southwest Nigeria. Outside Nigeria, in the United Kingdom and Tanzania and among the black

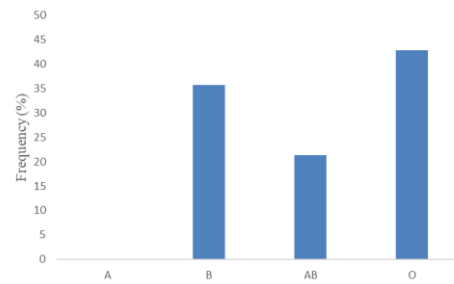


Figure 4. Prevalence of ABO blood groups among hepatitis B positive FUBK participants

Table 4. Distribution of ABO blood groups among hepatitis B positive FUBK participants

Gender	A n(%)	B n(%)	AB n(%)	O n(%)
Females	-	15(50)	5(16.7)	10(33.3)
Males	-	10(25)	10(25)	20(50)

Americans and Caucasians, Rh +ve is also prevalent (Jahanpour *et al.*, 2017; NHS, 2020). The dominance of Rh +ve has also been reported among subgroups of human populations. In particular, (Singh *et al.*, 2015; Bamou and Sevidzem, 2016) reported a high prevalence of Rh +ve among malaria patients in India and Cameroon, respectively. (Batool *et al.*, 2017; (Oladele *et al.*, 2020) also reported a high prevalence of Rh +ve among hepatitis B patients in Pakistan and Lagos, Nigeria, respectively. Notably, in all the mentioned studies, the prevalence of Rh +ve was above 80%. Overall, the results of the present and past studies revealed the global dominance of Rh +ve over Rh -ve. Unfortunately, there is a scarcity of mechanistic information for this occurrence. However, selection pressure could have favored Rh +ve allele and passed down to the present generation.

Recommendations

Based on the findings of the present study, the following suggestions are proposed:

- The school's blood bank should contain more group O blood as it is the most prevalent blood group among the students of the school.
- Type B and AB individuals expressing

Table 5. Distribution of Rhesus blood groups among FUBK participants

Diseases	Female (%) + ve - ve	Male (%) + ve - ve	Total Positive (%) + ve
Total Selected	550 (96) 5 (4)	420 (98) 10 (2)	970 (97)
Malaria	280 (93) 20 (7)	310 (95) 15 (5)	590 (94)
Typhoid	101 (88) 14 (12)	80 (89) 10 (11)	181 (88)
Hepatitis B	27 (10) 3 (10)	37 (93) 3 (7)	64 (91)

malaria fever, typhoid fever, and hepatitis B should seek medical assistance timely as they are highly at risk of developing severe or complicated conditions.

- There is a need to create a public awareness among the students of the school on the association between ABO blood groups and the prevalence and severity of malaria fever, typhoid fever, and hepatitis B.

- Similar studies should be carried out to cover some other diseases.

Conclusions

The results showed that ABO blood group O was the most prevalent among the participants, followed by B, A, and AB, respectively ($O > B > A > AB$). Rh +ve was also the most dominant Rhesus blood group among the participants. Moreover, variations were observed in the blood groups distribution along ethnic and gender lines, suggesting that the ethnic groups had been subjected to different environment-induced selection pressure. Mechanistic patterns were also observed between the blood groups (ABO and Rhesus) and the prevalence of malaria, typhoid, and hepatitis B. The majority of the individuals expressing these diseases are Rh +ve and ABO group O. These show that selection pressure must have favored Rh +ve and group O and are thus passed down to the present population. The success of group O may be connected to its lack of antigens, thus it may not bind parasites or induce a negative immune response. Researchers and health workers may use these results as primary data to formulate health policies in the study areas. However, more studies particularly involving larger populations are needed to ascertain our claims.

References

- Abah, A.E., Grey, A., and Onoja, H. (2016). Plasmodium malaria and abo blood group among blood donors in Yenegoa, Bayelsa State, Nigeria. *Prim. Health Care.*, 6(4):1000251. doi:10.4172/2167-1079.1000251.
- Adias, T.C., Jeremiah, Z.A., and Ilesanmi, A.O. (2010). Distribution of antibodies to Salmonella in the sera of blood donors in the south-western region of Nigeria. *Blood Transfus.*, 8(3):163-169. doi:10.2450/2009.0115-09.
- Afoakwah, R., Aubyn, E., Prah, J., Nwaefuna, E.K., and Boampong, J.N. (2016). Relative susceptibilities of abo blood groups to plasmodium falciparum malaria in ghana. *Adv. Hematol.*, 2016:Article ID 5368793. http://dx.doi.org/10.1155/2016/5368793.
- Amusuk, D.J., Hashim, M., and Pour, A.B. (2016). Reclamation of mosquito breeding sites using Landsat-8 remote sensing data: A case study of Birnin Kebbi, Nigeria. *Earth Environm. Sci.*, 37:1-10 doi:10.1088/1755-1315/37/1/012022.
- Aniashi, S.O., Marcellus, I.O., Godwin, E.O., and Bassey, E.B. (2019). The Prevalence of Symptomatic Typhoid in Obanliku Local Government Area of Cross River State, Nigeria. *Int. J. Sci. Eng. Res.*, 10(2):1,549-1,553.
- Anifowoshe, A.T., Owolodun, O.B., Akinseye, K.M., Iyioloa, O.A., and Oyeyemi, B.F. (2017). Gene frequencies of ABO and Rh blood groups in Nigeria: A review. *Egypt. J. Mel. Hum. Genet.*, 18 (3):205-210. https://doi.org/10.1016/j.ejmhg.2016.10.004.
- Anstee, D.J. (2010). The relationship between blood groups and disease. *Blood.*, 115:4635-43. https://doi.org/10.1182/blood-2010-01-261859.
- Apecu, R.O., Mulogo, E.M., Bagenda, F. and Byamungu, A. (2016). ABO and Rhesus (D) blood group distribution among blood donors in rural south western Uganda: a retrospective study. *BMC Res Notes.*, 9(1):513. doi:10.1186/s13104-016-2299-5.
- Bamou, R. and Sevidzem, S.L. (2016). ABO/Rhesus blood group systems and malaria prevalence among students of the University of Dschang, Cameroon. *Malar. World J.*, 7(4):1-4.
- Banik, A.K., NurulKabir, A.T.M., and Alam, J. (2018). An association between typhoid fever and Age, Sex and Blood Phenotypes ABO and Rh among Children – a Study in a Tertiary Care Hospital, Dhaka, Bangladesh. *IOSR-JDMS* 2018., 17(9):63-69.
- Batool, Z., Durrani, S.H., and Tariq, S. (2017). Association of abo and rh blood group types to hepatitis b, hepatitis c, hiv and syphilis infection, a five year' experience in healthy blood donors in a tertiary care hospital. *J. Ayub. Med. Coll. Abbottabad.*, 29(1):90-92.
- Cheng, Y., Cheng, G., Chui, C.H., Lau, F.Y., Paul, K.S., Chan, Margaret, H.L., Ng, Joseph, J.Y., Sung, Raymond, Wong, S.M. (2005). ABO blood group and susceptibility to severe acute respiratory syndrome. *J. Am. Med. Associat.*, 293(12):1,450-1,451. https://doi.org/10.1001/jama.293.12.1450-c.
- Chima, O.K., Mohammed, T.B, Aisha, K.G., Alhaji, S.A., Muhammad, B.M., and Kwaru, A.H. (2012). ABO and rhesus blood groups among blood donors in Kano, North-Western Nigeria. *Nig. J. Basic. Clin. Sci.*, 9:11-13. DOI:10.4103/0331-8540.102105.
- Crump, J.A. (2019). Progress in typhoid fever epidemiology. *Clin. Infect. Dis.* 68(Suppl 1):S4-S9. doi: 10.1093/cid/ciy846.
- Cserti, C.M. and Dzik, W.H. (2007). The ABO blood group system and Plasmodium falciparum malaria. *Blood.*, 110(7):2,250-2,258. https://doi.org/10.1182/blood-2007-03-077602.
- Dean, L. (2005). Blood groups and red cell antigens. Bethesda (MD): National Center for Biotechnology Information (US). Chapter 5, The ABO blood group. Available from: https://www.ncbi.nlm.nih.gov/books/NBK2267/.
- Etim, E.A., Akpotuzor, J.O., and Ohwonigbo, A.C. (2017). Distribution of ABO and rhesus blood groups among selected tribes in Adamawa State, Nigeria. *Hematol. Transfus. Int. J.*, 4(6):149-152. DOI: 10.15406/htij.2017.04.00102.
- Franchini, M. and Maria, G.M. (2013). ABO blood group: old dogma, new perspective. *Clin. Chem. Lab. Med.*, 51:1,545-1,553. DOI: 10.1515/cclm-2013-0168.
- Fufa, A.W. and Debelo, D.G. (2019). Distribution of ABO and Rh (D) blood groups among students attending secondary and preparatory schools in Bote town, Oromia national regional state, Ethiopia. *Int. J. Sci. Technol. Educ. Res.*, 10(1):1-8. DOI: 10.5897/IJSTER2019.0448.
- Genc, O. (2017). Hepatitis B virus infection and ABO/Rh blood groups *Int. J. Res. Med. Sci.*, 5(9):3782-3785. DOI: http://dx.doi.org/10.18203/23206012.ijrms20173949.
- Gundrajukuppam, D.K., Vijaya, S.B., Rajendran, A., and Sarella, J.D. (2016). Prevalence of principal Rh blood group antigens in blood donors at the blood bank of a Tertiary

- Care Hospital in Southern India. *J. Clin. Diagnostic. Res.*, 10(5):EC07-10. doi: 10.7860/JCDR/2016/16621.7726.
- Ilozumba, P.C. and Uzozie C.R. (2009). Prevalence of malaria parasitaemia and its association with ABO Blood Group in Odoakpu Area of Onitsha South Local Government Area, Anambra State Nigeria. *Nig. Ann. Nat. Sci.*, 8(2):1-8.
- Iyiola, O.A., Igunnugbemi, O.O., and Bello, O.G. (2012). Gene frequencies of ABO and Rh(D) blood group alleles in Lagos, South-West Nigeria. *Egypt. J. Med. Hum. Genet.*, 15 (2):147-153. <https://doi.org/10.1016/j.ejmhg.2011.08.006>.
- Jahanpour, O., Pyuza, J.J., and Ntiyakunze, E.O. (2017). ABO and Rhesus blood group distribution and frequency among blood donors at Kilimanjaro Christian Medical Center, Moshi, Tanzania. *BMC Res. Notes.*, 10:738. <https://doi.org/10.1186/s13104-017-3037-3>.
- Jing, W., Zhao, S., Liu, J., and Liu, M. (2020). ABO blood groups and hepatitis B virus infection: a systematic review and meta-analysis. *BMJ Open* 2., 10(1):e034114. doi: 10.1136/bmjopen-2019-034114.
- Khalid, M., Aslam, N., Aslam, M., and Ahmad, R. (2013). Distribution of ABO and Rh (D) blood groups among blood donors in district Mardan, Pakistan. *J. Saidu. Med. Coll.*, 3(2):318-322.
- Lemu, G., Arega, T., Berhanu, E., and Hassen, M. (2017). High rhesus (Rh(D)) negative frequency and ethnic group based ABO blood group distribution in Ethiopia. *BMC Res. Notes.*, 10(1):330. DOI 10.1186/s13104-017-2644-3.
- Mangin, L. (2020). Do Your Genes Predispose You to COVID-19? *Scientific America*. Available from: <https://www.scientificamerican.com/article/do-your-genes-predispose-you-to-covid-19/>. Accessed date: June 11, 2020.
- Moise, M. and Robert, H. (2017). Occurrence of plasmodium falciparum malaria associated with abo blood group in darazo, bauchi state, Nigeria. *Electron. J. Biol.*, 13:3.
- Mosquito Squad (2015). The Blood Types Mosquitoes Find Most Appetizing. Available from: <https://www.mosquitosquad.com/greater-dc/about-us/blog/2015/january/the-blood-typesmosquitoes-find-most-appetizing/>. Accessed date: Jan 10 2020.
- Murphy, W.J., Fronicke, L., O'Brien, S.J., and Stanyon, R. (2003). The origin of human chromosome 1 and its homologs in placental mammals. *Genome Res.*, 13(8): 1,880-1,888. doi: 10.1101/gr.1022303.
- NHS. (2002). Blood Groups. Available from: <https://www.nhs.uk/conditions/blood-groups/>. Accessed date: October 11, 2020.
- Nureye, D. and Assefa, S. (2020). Old and recent advances in life cycle, pathogenesis, diagnosis, prevention, and treatment of malaria including perspectives in Ethiopia. *Sci. World J.*, Article ID 1295381. <https://doi.org/10.1155/2020/1295381>.
- Oche, A.O. and Aminu, M. (2012). The prevalence of malarial parasitaemia among blood donors in Ahmadu Bello University Teaching Hospital, Shika, Zaria, Nigeria. *Nig. J. Med.*, 21(4):445-449.
- Oladele, E.O., Yahaya, T.O., Adewunmi, O.O., David, B., and Oladipo, A.J. (2020). Distribution of ABO/Rhesus blood groups among hepatitis B Virus (HBV) Positive Patients In Lagos, South-Western, Nigeria. *FUDMA J. Sci.*, 4(3):196-200. DOI: <https://doi.org/10.33003/fjs-2020-0403-127>.
- Onanuga, A. and Lamikanra, A. (2016). Association of abo blood group and plasmodium falciparum malaria among children in the federal capital territory, Nigeria. *Afri. J. Biomed. Res.*, 19:24-29.
- Otoikhian, C.S.O and Okoror, L.E. (2012). Prevalence of typhoid and paratyphoid in relation to their genotype among student of novena university, ogume. *Int. J. Pharm. Med. Bio. Sc.*, 1(2):218-224.
- Panda, A.K., Panda, S.K., and Sahu, A.N. (2011). Association of ABO blood group with severe falciparum malaria in adults: case control study and meta-analysis. *Malar. J.*, 10:309. <https://doi.org/10.1186/1475-2875-10-309>.
- Prasadini, M., Dayananda, D., Fernando, S., Harischandra, I., and De Silva, N. (2019). Blood feeding preference of female *aedes aegypti* mosquitoes for human blood group types and its impact on their fecundity: implications for vector control. *Am. J. Entomol.*, 3(2):43-48. doi: 10.11648/j.aje.20190302.13.
- Sharma, D., Rai, S., Iyenger, S., Jain, B., and Sao, S. (2013). Prevalence and distribution of ABO and Rh-D antigens along with its subgroups and rare types in greater Gwalior region. *Open J. Blood Dis.*, 3(2):69-73. DOI: 10.4236/ojbd.2013.32015.
- Singh, G., Urhekar, A.D., and Singh, R. (2015). A study on correlation of malaria infection with A, B, O, RH blood group system. *J. Parasitol. Vector. Biol.*, 7(4):67-73.
- Stanaway, J.D., Reiner, R.C., Blacker, B.F., Goldberg, E.M., Khalil, I.A. and Troeger, C.E. (2019). The global burden of typhoid and paratyphoid fevers: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet. Infect. Dis.*, 19(4):369-381. DOI: [https://doi.org/10.1016/S1473-3099\(18\)30685-6](https://doi.org/10.1016/S1473-3099(18)30685-6).
- Tekade, R., Warghat, N., Sharma, N., Wankhade, A., and Baig, M. (2011). Gene diversity among some endogamous population of amravati district. *J. Biotechnol.*, 2(5):558-567. DOI:10.1038/NPRE.2010.5379.
- Villazon, L. (2020). Why is type O the most common blood type? *Science Focus*. Available from: <https://www.sciencefocus.com/the-human-body/why-is-type-o-the-most-common-blood-type/>. Accessed date: February 25, 2020.
- Wood, C. (1974). Preferential feeding of anopheles gambiae mosquitoes on human subjects of blood group O: A relationship between the ABO polymorphism and malaria vectors. *Hum. Biol.*, 46(3):385-404. <http://www.jstor.org/stable/41459967>.
- WHO. (2013). World Malaria Report. 2013. Available from: http://www.who.int/malaria/publications/world_malaria_report_2013/report/en/w. Accessed date: June 6, 2020.
- WHO. (2020). Hepatitis B. 2020. Available from: <https://www.who.int/news-room/factsheets/detail/hepatitis-b>. Accessed date: Oct 1, 2020.
- Yahaya, T., Doherty, V. F., Akinola, O.S., and Shamsudeen, A. (2019). Heavy metal profiles and microbial count of selected water brands in birnin kebbi metropolis. *Ife. J. Sci.*, 21(1):229-233. DOI: 10.4314/ijss.v21i1.20.
- Zahid, H., Yahyaoui, A., Uwingabiye, J., El Khazraji, A., El Hadeif, R., and Messaoudi, N. (2016). Phenotypic and allelic distribution of ABO and Rh-D blood Groups in Blood Transfusion Center of Avicenna Military Hospital, Marrakech, Morocco. *Int. J. Med. Health. Res.*, 2(1):1-9.
- Zerihun, T., Degarege, A., and Erko, B. (2011). Association of ABO blood group and Plasmodium falciparum malaria in Dore Bafeno Area, Southern Ethiopia. *Asian Pac. J. Trop. Biomed.*, 1(4):289-294. doi:10.1016/S2221-1691(11)60045-2.