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Gene Frequency of ABO Blood Group and Rh Factor Allele among the People of Sylhet, Bangladesh

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Knowledge of blood grouping is very important, especially for safer blood transfusions. The blood group and Rh factor of an individual is determined by the presence or absence of different antigens and Rh factor on the surface of the RBC, respectively. It can be determined in many ways, and we used the slide-method. Most of the study done in Bangladesh was based on donor-based data. So, we conducted a cross-sectional study based on the volunteer sampling method, focusing on the gene, allele, and phenotypic frequencies of the ABO blood group and Rh factor among the population of Sylhet, comprising more than 30 ethnic groups, with only one published report on the blood group. A total of 908 samples were collected, of which 180 were female and 728 were male. Blood group O was the most frequent (36.9%), followed by B (30.0%), A (24.9%), and AB (8.3%) group. In both genders, blood group frequency follows the same order (O>B>A>AB) but with a different percentage. In the current study, Rh+ve was dominant (95.5%) over Rh-ve. The Hardy-Weinberg law was used to find out the allele and gene frequency. The most frequent allele was r[O] (0.60439), while the least frequent was p[A]. In case of gene frequency, heterozygous genes (AO, BO, AB) showed a higher frequency than homozygous genes, and among homozygous, O gene showed the highest frequency compared to others (AA, BB). This is the first-ever study found in the Sylhet region within the mass population to find out the gene and allele frequency along with blood group and Rh factor. Though the result of our study differs from most of the studies found in Bangladesh and South-East Asian region, these results can be useful to study population genetics and form a safer and more reliable organ, tissue, and blood donation database.

Introduction

Based on the presence or absence of different inherited antigenic proteins on the surface of RBC there are around 300 human blood group antigens, which can be determined by 33 different systems (Lögdberg et al., 2005). Among them, ABO is the most popular system that is discovered by Landsteiner in 1901, and the Rh system by Landsteiner and Weiner in 1937 (Landsteiner & Wiener, 1940). The Rh(D) gene is placed on chromosome 1p34-p36 (Cartron, 1994), while the ABO gene is found on the long arm of the ninth human chromosome (9q34.1) (Al-Arrayed et al., 2001). The ABO gene produces the enzyme glycosyltransferase, and variations in the DNA

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sequence of this gene cause polymorphisms in the enzyme that affect whether it attaches galactose (Ag-B), N-acetyl-galactosamine (Ag-A), or no sugar at all (type O) (Saleh & Abood, 2016). Based on this, blood groups can be divided into A, B, AB, and O according to ABO system, Rh-positive (+ve) and Rh-negative (-ve) according to the presence of Rh factor.

Rh antigens are highly immunogenic, and 49 Rh antigens have been confirmed so far (Westhoff & Siegel, 2016). The D antigen is the most important because D negative persons create anti-D if they come into contact with the D antigen via transfusion or pregnancy, which causes hemolytic transfusion responses or hemolytic diseases of the fetus and infant (Hendrickson & Delaney, 2016). As a result, the Rh status of blood donors, transfusion patients, and pregnant women is regularly determined.

Studies on blood group predominance are necessary for a variety of reasons, including the fact that contemporary medicine is increasingly interested in how they relate to diseases and the environment in addition to their importance in evolution (Mohammadali & Pourfathollah, 2014). The likelihood that an individual's ABO blood group would develop one or more hereditary disorders, including cancer, has increased (Abegaz, 2021). Early independent studies showed individuals with blood groups A, AB, or B were more likely to have an elevated risk of pancreatic cancer than individuals belonging to blood group O (Amundadottir et al., 2009; Greer et al., 2010; Wolpin et al., 2009). However, further work is still required to define the exact mechanisms by which the ABO blood group or other genetic variants may influence cancer risk in humans.

ABO blood type frequencies differ from one community to the next and occasionally within a particular region. Knowledge of the distribution of ABO and Rh blood types at the local and regional levels aids in efficiently operating blood banks and provide safe blood transfusion services (Patel et al., 2012).

Currently, O is the most frequent blood type globally, followed by A, B, and AB (Simpson, 2020). In Bangladesh, the first report of blood grouping was in 1975 by Rahman M (Rahman, 1975), where B was the most frequent. Some other studies showed a higher number of B blood types in case of Rh positive (Dipta et al., 2017; Rashaduz et al., 2015; Sultana et al., 2013) and O blood type in Rh negative (Dipta et al., 2017), whereas some showed type O (Akhter et al., 2011; Talukder & Das, 2010). The dominance of A blood type was also found in a study among the tribals of southern Bangladesh (Dewan, 2015). In 2010, a single case study of the rarest Bombay blood group was reported (Banu & Ali, 2014). In the case of allelic frequency among blood donors in Bangladesh A (0.3694) had the highest frequency followed by O (0.3040) and B (0.2300) (Dipta et al., 2017). Sylhet district is enriched by almost 30 different ethnic groups, along with the majority of Bengalis (Akter et al., 2019; Pal et al., 2017). To the best of the authors knowledge, only one published report on blood group is available in Sylhet region based on tribal communities (Begum et al., 2011). A major portion of this dimensional population remains unexplored, and no study has reported allele and gene frequency of this population. Additionally, most of the studies mentioned were done using the donor-based data, which is prone to uneven sampling. Again, the gene frequency was not discussed by none of those studies. Therefore, to find out the comparative blood group and Rh factor frequency, along with its allele and gene frequency, among the people of Sylhet, the present study was performed.

Materials & Methods

Study area

This observational cross-sectional study was conducted at different places of Sylhet Sadar Upazilla namely Amborkhana, Airport area, Foridabad, Baluchar, Chowhatta, Dakshin Surma, Noyasharak, Osmaninagar, Shibgonj, and Tilagorh from July 2021 through November 2021. People of the study area were announced previously informing that their blood grouping would be done with free of cost. A voluntary sampling method was used to collect blood sample from the target population.

Sample Collection

Three drops of blood were collected on aseptically washed, grease free clean and clear glass slide, by pricking in aseptic finger from each participant with a sterile lancet. Blood was collected from the tip of ring finger (middle or index finger in case deformities in ring finger) of left hand. A single glass slide was used to determine blood type which

minimize the errors. Consent was taken from each individual before collecting blood.

Determination of blood type and Rh factor

Type of RBC antigen was determined according to the principle of glass slide method (Malomgré & Neumeister, 2009). A drop of each of the antisera, anti-A, anti-B and anti-D was added and mixed with each blood drop. Blood groups were determined on the basis of agglutination. Test that did not show agglutination within two minutes

blood cells in the presence of anti-serum was considered as positive test result. Similarly, if agglutination reaction appeared with Anti-D, the test was read as positive and presence of Rh factor was confirmed.

Data Collection and Analysis

All participants were briefed before collection of data and their name, age, sex and ABO and Rh-D blood groups of the samples were recorded. Particulars of each participant was transferred to Microsoft Office Excel 2019 sheet. SPSS version 25.0 was used for data analysis. The frequency of each major ABO and rhesus blood group was recorded and compared among different sex groups. Frequency distribution of Rh factors in different blood groups also compared. Statistical formula for genetic analysis was used to derive results. Bernestein's modified formula (1930) was used to determine allele frequency of ABO groups. There are two Hardy–Weinberg formulas; one for allele frequency and the second one for genotype frequency determination. The Hardy-Weinberg equation was used to ascertain genetic equilibrium. Gene frequency and Rh phenotypes were calculated using Hardy- Weinberg equation. For ABO allele frequency Hardy- Weinberg equation states that $p+q+r= 1$; and if the population is in equilibrium and there is no external force (mutation, migration and selection), the second generation is expected to show $(p+q+r)^2 = p^2+q^2+r^2+2pq+2qr+2rp=1$; where p, q, and rare allelic frequency of A, B, and O respectively (Mayo, 2008). Here p, q, and r is measured by S2 ABO estimator (Silva, n.d.).

On the other hand, for Rh allele frequency Hardy-Weinberg equation sates that $P+Q=1$, and if the population is in equilibrium, the second generation will show $(P+Q)^2= P^2+2PQ+Q^2$; where P and Q are the allelic frequency of D and d respectively. For calculation of P and Q the following equation was used,

$$P=\sqrt{\frac{recessive\ individual}{total\ individual}}$$ (Mayo, 2008)

$Q= 1-P$ (Mayo, 2008)

Chi-square test was used to compare observed frequency distributions of the blood group and Rh antigens to that expected under Hardy–Weinberg law. The observed and expected value was analyzed for goodness-of-fit X^2tests at a confidence interval of 95% by using the following equation.

$$\chi^2=\frac{(Observed-Expected)^2}{Expected}$$

Results

There were 908 samples collected for determining both blood type and Rhesus factor and no missing value was reported. In our study, 180 were female and 728 were male which is 19.8% and 80.2%, respectively. The age range of the study population was between 6 and 68 years.

From the Table-1, we can observe that O blood type dominates with 36.9% (335 out of 908), followed by type B, A, and AB. Similarly, in both sex O blood type was reported higher and the value was 36.7% in female and 37% in male whereas, AB blood type frequency was observed lowest for both sexes just like overall population.

Table 1- Table-1: Frequency distribution of ABO and Rh blood groups in Sylhet

Sex	Blood Type				Rh Factor	
	A (%)	B (%)	AB (%)	O (%)	Rh +Ve (%)	Rh –Ve (%)
Female (180)	44 (24.4)	59 (32.8)	11 (6.1)	66 (36.7)	168 (93.3)	12 (6.7)
Male (728)	182 (25.0)	213 (29.3)	64 (8.8)	269 (37.0)	699 (96.0)	29 (4.0)
Total (908)	226 (24.9)	272 (30.0)	75 (8.3)	335 (36.9)	867 (95.5)	41 (4.5)

This study revealed that, Rh factor positive had the highest frequencies (95.5%) as well as in both sexes also. Rh factor positive was estimated comparatively higher in male but Rh factor negative was counted slightly lower than female in Sylhet (Fig. 1).

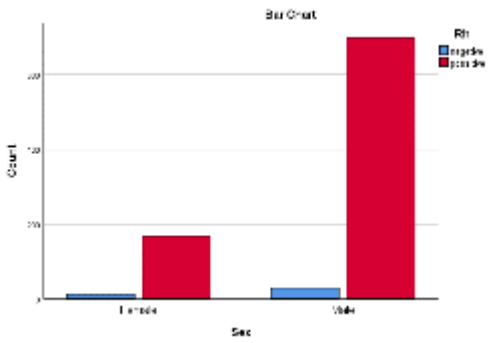


Fig.-1: Rh-factor frequency in male and female in Sylhet.

Table-2 shows rhesus factor also varied with in different ABO blood type. Rh positive was recorded higher (96.7%) in O blood type followed by AB, B and A. Rhesus factor negative in different blood type was estimated and it appears just opposite direction to the Rh positive (Fig. 2).

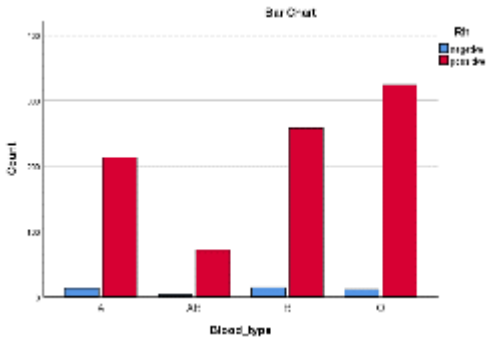


Figure-2: Rh-positive vs Rh-negative frequency of different blood groups.

Table-2: Frequency distribution of Rh factors in different blood groups in Sylhet.

Blood type	*Rh Factor*	
	Rh +Ve (% frequency)	Rh –Ve (% frequency)
A (226)	94.2	5.8
B (272)	94.9	5.1
AB (75)	96.0	4.0
O (335)	96.7	3.3

This study revealed that, blood group O has the highest allele frequency (0.60439) followed by B and A group. In case of Rh factor, Rh D counted the higher allelic frequency than Rh d (Table 3).

Table-3: The allelic frequencies of ABO blood groups and Rh factors in Sylhet.

Blood Group		Frequency
A	p[A]	0.182037
B	q[B]	0.213569
O	r[O]	0.60439
Rh D	P	0.787868
Rh d	Q	0.212132

In current study, the genotypic frequency of homozygous and heterozygous of ABO blood group were estimated. Homozygous O shows the highest frequency (0.365287) followed by homozygous B and homozygous A (0.033137). On the other hand, heterozygous B was calculated as the highest frequency followed by heterozygous A and heterozygous AB. However, homozygous Rh+ve (DD) has the higher frequency followed heterozygous Rh+ve (Dd) gene and homozygous Rh-ve (dd) gene (0.045) (Table 4).

Table-4: Genotypic Frequencies of ABO blood groups and Rh factors in Sylhet.

Blood Group			Frequency
A	AA	p^2	0.033137
	AO	2pr	0.220043
B	BB	q^2	0.045612
	BO	2qr	0.258158
AB	AB	2pq	0.077755
O	OO	r^2	0.365287
Rh+ve	DD	$P^{2`}$	0.620736
	Dd	2PQ	0.334264
Rh-ve	dd	Q^2	0.045

The phenotypic proportion of observed and expected frequencies and percentages of different blood type and Rh factor were estimated in this study (Table 5, fig 3). The higher phenotypic frequency of group O (0.365287) and Rh+ve (0.955) in Rh system were observed. The second generation, according to Hardy Weinberg equation, $(p + q + r)^2 = p^2 + q^2 + r^2 + 2pq + 2pr + 2qr = 1$. The summation of our findings is equal to 1, which shows that the population is on equilibrium. The difference of observed and expected blood group frequency from our study is not statistically significant (p-value= 0.2243).

Table-5: Phenotypic frequencies of ABO blood groups and Rh factors in Sylhet.

Blood Group		Expected Frequency	Percentage (%)	Observer frequency	Percentage (%)
A	p^2+2pr	0.25318	25.318	0.249	24.9
B	q^2+2qr	0.30377	30.377	0.3	30.0
AB	2pq	0.077755	07.775	0.083	8.3
O	r^2	0.365287	36.528	0.369	36.9
Rh+ve	P^2+2PQ	0.955	95.5	0.955	95.5
Rh-ve	Q^2	0.045	4.5	0.045	4.5

The frequencies and percentages of ABO blood type do not significantly differ under Hardy-Weinberg equilibrium (χ^2 = 0.0005; df=3; p= 0.999). Again, frequencies and percentages of Rh factor also do not differ statistically (χ^2 = 0; df=3; p=1), which confirms that population is on equilibrium according to the Hardy-Weinberg law.

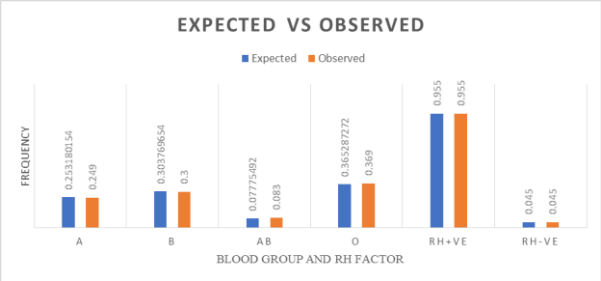


Figure-3: Comparison between expected and observed phenotypic frequencies of ABO & Rh among individuals sampled in Sylhet.

Discussion

Understanding blood types and the Rh factor is crucial since it is a requirement for various life-saving medical interventions including blood transfusions, organ transplants, bone marrow transplants, etc (Chandra & Gupta, 2012a). Although the link between certain diseases and blood types is still debatable, it is significant nonetheless (Anstee, 2010; Jassim, 2012). Our research aimed to determine the frequency of each blood group's gene, allele, and phenotype. By creating a donor database, the information from this study will be extremely helpful for the aforementioned medical operations. A study of the population genetics of the Sylhet area will also be aided by the findings of the Hardy-Weinberg equilibrium.

The order of blood group found in our study on the basis of highest frequency is O>B>A>AB which is similar to a study of Bangladesh (Akhter et al., 2011) and another in India (Rao & Shetty, 2014). Though most of the study all over the world (Golassa et al., 2017; Iyiola et al., 2012; Saleh & Abood, 2016) as well as some of the studies of Bangladesh (Hira et al., 2015; Talukder & Das, 2010) shows the dominance of O blood group (O>A>B>AB), our study differs from the mostly common blood group order. Another different order of blood group has been found in South-East Asia reported in India (Sidhu, 2003), Pakistan (Khattak et al., 2008) along with Bangladesh (Dewan, 2015; Rashaduz et al., 2015; Sultana et al., 2013) which is B>O>A>AB but most of them are data of hospital based blood donors and people of different ethnic groups which doesn't represent the true population of a country. A study of tribal population of Sylhet (Begum et al., 2011) reported another different order of blood group which is A>O>B>AB.

Male-female blood group shows a similar order of our study (O>B>A>AB) but with different percentage. In male most of the studies show dominance of O blood type but with a different order (O>A>B>AB) (Saleh & Abood, 2016; Talukder & Das, 2010). Our study result of male blood group order was reported in India (Patel et al., 2012). One another order (B>O>A>AB) was also reported by some studies (Giri et al., 2014; Khattak et al., 2008). In female, our study order is supported by (Patel et al., 2012; Talukder & Das, 2010). A different order with dominancy of O blood type was found by several studies (Giri et al., 2014; Saleh & Abood, 2016).

Based on Rh factor our study found dominance of Rh-positive factor (95.5%) over Rh negative (4.5%) factor, which is similar to all study available and also with world data. But some study found higher Rh positive factor than our study (Begum et al., 2011; Dewan, 2015; Iyiola et al., 2012; Sidhu, 2003; Sultana et al., 2013). In contrast, (Golassa et al., 2017; Khattak et al., 2008; Rashaduz et al., 2015; Saleh & Abood, 2016; Tesfaye et al., 2015) found comparatively less Rh positive factor than current study. In female Rh-factor negative was a bit higher (6.7%) than male (4.0%) and Rh-factor positive was slightly lower (93.3%) than male (96.0%) (Figure-2). In case of male similar findings was also reported at Dinajpur

district (Talukder & Das, 2010) and by an Indian study (Patel et al., 2012). Slightly less frequent Rh-positive was reported by two studies in Iraq (Saleh & Abood, 2016) and Pakistan (Khattak et al., 2008). Likely, in female, similar to our study findings was reported in a couple of studies (Patel et al., 2012; Talukder & Das, 2010). Two studies reported higher frequency of Rh- negative (Khattak et al., 2008; Saleh & Abood, 2016).

Our study shows order of blood group & Rh factor in combination as O+ve > B+ve > A+ve > AB +ve > B-ve > A-ve > O-ve > AB -ve with a percentage of 35.7%, 28.4%, 23.5%, 7.9%, 1.59%, 1.4%, 1.2%, and 0.4% respectively, making the O+ve blood group most available and AB -ve blood group rarer blood group. Some study (Akhter et al., 2011; Rao & Shetty, 2014) in support of this order has been found.

Allelic frequency in this study showed A=0.182037; B=0.213569, and O= 0.60439 (O>B>A) which is similar with the findings of Dewan et. al (Dewan, 2015) and with couple of Nigerian study (Kulkarni et al., 1985). Our sequence varies with some findings from Nigeria also. Iyiola et. al. (Iyiola et al., 2012) found A= 0.14 followed by B= 0.13. Again, Faduyile et. al. (Chandra & Gupta, 2012b) also found higher frequency of A (0.1303) than B (0.1066). This study findings is completely different from another study done based on a donor-based data where allelic frequency was higher in A followed by O and B (Dipta et al., 2017). Rh+ve shows the dominance over Rh-ve all over the world (Simpson, 2020) which is also found in this study with a percentage of 95.5% and allele frequency of 0.787868. Other study of Bangladesh showed the similar result but with a different frequency (Dewan, 2015). Our study result is similar to some of the international studies like in India(Hussain et al., 2013), England (Klein & Anstee, 2013) and the United States(Greer et al., 2010). However Rh-ve found to be as low as 0.69% in one of the study of India (Reddy & Reddy, 2005).

Our study also confirms the Hardy-Weinberg law while gene frequency is determined. The sum of frequency of different homozygous and heterozygous gene is 1 which means the population is on equilibrium. There was no study found in Bangladesh determining gene frequency of ABO blood group. The order found by our study (OO>BO>AO>AB>BB>AA) shows similarity with some of international studies (Iyiola et al., 2012; Saleh & Abood, 2016). Order of gene frequency of Rh system found by our study is DD>Dd>dd which is similar to all available studies in the world. But our study result varies from one similar study (Dewan, 2015) findings which is 0.4591, 0.4367 and 0.1038 respectively.

According to Hardy-Weinberg law, for second generation, our study confirms both ABO blood group and Rh factor are in equilibrium. The chi-squared tests show that there are no significant statistical differences between expected and observed value (p-value=0.2243) (Figure-3). The findings in this study agree with the findings of some previous researches where they also reported the negligible significance differences (Chandra & Gupta, 2012b; Golassa et al., 2017).The study data herein, provided complete information on the blood group, Rh factor, gene and allelic frequencies in the population of Sylhet, hoping that it will be beneficial as a reference for forthcoming studies.

Conclusions

The research findings of this study expand the understanding of the genetic variation and polymorphism of the ABO and D antigens among the population in Sylhet region, Bangladesh. There is Hardy-Weinberg equilibrium in the study population. This information can be very useful for studying population genetics and the participants of this study can be a potential source of safer blood donation as they know their own blood groups now. The results might be also helpful to build up a regional blood bank information system, population migration study and anthropological research. It may also reflect possible disease burden in relation to the blood group which will help define future health policies. However, we suggest further study with larger sample size and covering larger area of study to find out the hemoglobin variants of different sexes.

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References

Abegaz, S. B. (2021). Human ABO blood groups and their associations with different diseases. *BioMed Research International*, *2021*, 1–9.

Akhter, S., Kibria, G. M., Akhter, N. R., Habibullah, M. M., Islam, S. M. K., & Zakariah, M. (2011). ABO and Lewis blood grouping with ABH secretor and non-secretor status: a cross sectional study in Dhaka. *Faridpur Med Coll J*, *6*(1), 38–40.

Akter, S., Mazumder, M. S., Pal, N., Alam, M., & Khatun, M. A. (2019). *Factors Responsible for the Current Contraception of Khasia Ethnic Women of Factors Responsible for the Current Contraception of Khasia Ethnic Women of Sylhet District , Bangladesh*. *April*. https://doi.org/10.9790/5933-0805032431

Al-Arrayed, S., Shome, D. K., Hafadh, N., Amin, S., Al Mukhareq, H., Al Mulla, M., Sanad, H., & Darwish, F. A. (2001). ABO blood group and RhD phenotypes in Bahrain: Results of screening school children and blood donors. *Bahrain Medical Bulletin*, *23*(3), 112–115.

Amundadottir, L., Kraft, P., Stolzenberg-Solomon, R. Z., Fuchs, C. S., Petersen, G. M., Arslan, A. A., Bueno-De-Mesquita, H. B., Gross, M., Helzlsouer, K., Jacobs, E. J., LaCroix, A., Zheng, W., Albanes, D., Bamlet, W., Berg, C. D., Berrino, F., Bingham, S., Buring, J. E., Bracci, P. M., … Hoover, R. N. (2009). Genome-wide association study identifies variants in the ABO locus associated with susceptibility to pancreatic cancer. *Nature Genetics*, *41*(9), 986–990. https://doi.org/10.1038/ng.429

Anstee, D. J. (2010). The relationship between blood groups and disease. *Blood*, *115*(23), 4635–4643. https://doi.org/10.1182/blood-2010-01-261859

Banu, T., & Ali, S. (2014). Rarest of rare bombay blood group in bangladesh: a case report. *Journal of the Bangladesh Society of Anaesthesiologists*, *23*(1), 34–36. https://doi.org/10.3329/jbsa.v23i1.18157

Begum, D., Amin, M. R., Khatun, F., Ahmed, S. S., Sinha, S. K., & Rahman, M. A. (2011). Distribution of ABO and Rh blood groups among tribal population of Sylhet. *Bangladesh. J Dhaka Med Coll*, *20*(1), 44–50.

Cartron, J.-P. (1994). Defining the Rh blood group antigens. *Blood Reviews*, *8*(4), 199–212. https://doi.org/10.1016/0268-960x(94)90108-2

Chandra, T., & Gupta, A. (2012a). Association and Distribution of Hypertension, Obesity and ABO Blood groups in Blood Donors. *Iranian Journal of Pediatric Hematology and Oncology*, *2*(4), 140–145. http://www.ncbi.nlm.nih.gov/pubmed/24575254%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC3915431

Chandra, T., & Gupta, A. (2012b). Frequency of ABO and rhesus blood groups in blood donors. *Asian Journal of Transfusion Science*, *6*(1), 52–53. https://doi.org/10.4103/0973-6247.95057

Dewan, G. (2015). Comparative frequency and allelic distribution of ABO and Rh (D) blood groups of major tribal communities of southern Bangladesh with general population and their determinants. *Egyptian Journal of Medical Human Genetics*, *16*(2), 141–147. https://doi.org/10.1016/j.ejmhg.2015.01.002

Dipta, T. F., Iqbal, M. R., Hossain, A. Z., Rahman, M. T., & Chowdhury, S. (2017). Distribution Of Phenotypic And Genotypic Abo And Rhesus Blood Groups Among Bangladeshi Population. *Ibrahim Medical College Journal*, *5*(2), 59–62. https://doi.org/10.3329/imcj.v5i2.10101

Giri, P. a, Yadav, S., Singh, G., & Phalke, D. B. (2014). Frequency of ABO and Rhesus Blood Groups : A Study from a Rural Tertiary Care Teaching Hospital in India. *Nitte University Journal of Health Science*, *4*(3), 57–60.

Golassa, L., Tsegaye, A., Erko, B., & Mamo, H. (2017). High rhesus (Rh(D)) negative frequency and ethnic-group based ABO blood group distribution in Ethiopia. *BMC Research Notes*, *10*(1), 1–5. https://doi.org/10.1186/s13104-017-2644-3

Greer, J. B., Yazer, M. H., Raval, J. S., Michael Barmada, M., Brand, R. E., & Whitcomb, D. C. (2010). Significant association between ABO blood group and pancreatic cancer. *World Journal of Gastroenterology*, *16*(44), 5588–5591. https://doi.org/10.3748/wjg.v16.i44.5588

Hendrickson, J. E., & Delaney, M. (2016). Hemolytic disease of the fetus and newborn: modern practice and future investigations. *Transfusion Medicine Reviews*, *30*(4), 159–164.

Hira, R., Dhali, L., Dhali, N., & Akash, D. (2015). ABO and Rh-D blood group distribution in a rural population of Bangladesh. *Mediscope*, *2*(1), 22–26. https://doi.org/10.3329/mediscope.v2i1.24736

Hussain, R., Fareed, M., Shah, A., & Afzal, M. (2013). Prevalence and gene frequencies of A1A2BO and Rh(D) blood group alleles among some Muslim populations of North India. *Egyptian Journal of Medical Human Genetics*, *14*(1), 69–76. https://doi.org/10.1016/j.ejmhg.2012.06.001

Iyiola, O. A., Igunnugbemi, O. O., & Bello, O. G. (2012). Gene frequencies of ABO and Rh(D) blood group alleles in Lagos, South-West Nigeria. *Egyptian Journal of Medical Human Genetics*, *13*(2), 147–153. https://doi.org/10.1016/j.ejmhg.2011.08.006

Jassim, W. E. (2012). Association of ABO blood group in Iraqis with hypercholesterolaemia, hypertension and diabetes mellitus. *Eastern Mediterranean Health Journal*, *18*(8), 888–891. https://doi.org/10.26719/2012.18.8.888

Khattak, I. D., Khan, T. M., Khan, P., Shah, S. M. A., Khattak, S. T., & Ali, A. (2008). Frequency of ABO and Rhesus blood groups in District Swat, Pakistan. *Journal of Ayub Medical College, Abbottabad : JAMC*, *20*(4), 127–129.

Klein, H. G., & Anstee, D. J. (2013). *Mollison's blood transfusion in clinical medicine*. John Wiley & Sons.

Kulkarni, A. G., Peter, B., Ibazebo, R., Dash, B., & Fleming, A. F. (1985). The ABO and Rhesus groups in the north of Nigeria. *Annals of Tropical Medicine and Parasitology*, *79*(1), 83–88. https://doi.org/10.1080/00034983.1985.11811891

Landsteiner, K., & Wiener, A. S. (1940). An agglutinable factor in human blood recognized by immune sera for rhesus blood. *Proceedings of the Society for Experimental Biology and Medicine*, *43*(1), 223.

Lögdberg, L., Reid, M. E., Lamont, R. E., & Zelinski, T. (2005). Human blood group genes 2004: Chromosomal locations and cloning strategies. *Transfusion Medicine Reviews*, *19*(1), 45–57. https://doi.org/10.1016/j.tmrv.2004.09.007

Malomgré, W., & Neumeister, B. (2009). Recent and future trends in blood group typing. *Analytical and Bioanalytical Chemistry*, *393*(5), 1443–1451. https://doi.org/10.1007/s00216-008-2411-3

Mayo, O. (2008). *A Century of Hardy – Weinberg Equilibrium*. *11*(3), 249–256.

Mohammadali, F., & Pourfathollah, A. (2014). Association of ABO and Rh blood groups to blood-borne infections among blood donors in Tehran-Iran. *Iranian Journal of Public Health*, *43*(7), 981.

Pal, N., Mazumder, M. S., Akter, S., Khatun, M. A., & Alam, M. (2017). Socio Economic Status of the Ethnic Community in Bangladesh: An Analysis Using Socio Economic Index. *IOSR Journal of Economics and Finance*, *08*(03), 92–97. https://doi.org/10.9790/5933-0803029297

Patel, P. A., Patel, S. P., Shah, J. V, & Oza, H. V. (2012). Frequency and distribution of blood groups in the blood donors in western

Ahmedabad - a Hospital based study. *National Journal of Medical Research*, *2*(2), 202–206.

Rahman, M. (1975). *Incidence of important blood groups in Bangladesh*.

Rao, C., & Shetty, J. (2014). Frequency of Abo and Rhesus (D) Blood Groups in Dakshina Kannada District of Karnataka - a Study From Rural Tertiary Care Teaching Hospital in South India. *Journal of Health and Allied Sciences NU*, *04*(03), 057–060. https://doi.org/10.1055/s-0040-1703802

Rashaduz, Z., Mohammad, P., Md, J., & Mohammed, A. S. (2015). Study of ABO and Rh-D blood group among the common people of Chittagong city corporation area of Bangladesh. *Journal of Public Health and Epidemiology*, *7*(9), 305–310. https://doi.org/10.5897/jphe2015.0727

Reddy, B. K. C., & Reddy, C. S. (2005). ABO and Rh (D) Blood Group Distribution Among Voddes, A Backward Caste Population of Andhra Pradesh. *The Anthropologist*, *7*(3), 235–236. https://doi.org/10.1080/09720073.2005.11890914

Saleh, S. M., & Abood, A. S. (2016). ABO and Rh (D) blood groups' distribution and gene frequencies in North Baghdad population–Iraq. *Int J Sci Eng Res*, *7*(August), 2–4. //www.researchgate.net/publication/308174619

Sidhu, S. (2003). Distribution of the ABO Blood Groups and Rh(D) Factor Among the Scheduled Caste Population of Punjab. *The Anthropologist*, *5*(3), 203–204. https://doi.org/10.1080/09720073.2003.11890806

Silva, P. J. N. (n.d.). *S2 ABOestimator*. http://webpages.fc.ul.pt/~pjns/Soft/ABOestimator/

Simpson, V. (2020). *World Population By Percentage Of Blood Types*. https://www.worldatlas.com/articles/what-are-the-different-blood-types.html

Sultana, R., Rahman, Z., Helali, A. M., Yousuf, R., Mustafa, S., Salam, A., & Haque, M. (2013). Study of abo and RH-D blood groups among the common people of capital city of Bangladesh. *International Journal of Pharmacy and Pharmaceutical Sciences*, *5*(3), 814–816.

Talukder, S., & Das, R. (2010). Distribution of ABO and Rh blood groups among blood donors of Dinajpur district of Bangladesh. *Dinajpur Med Col J*, *3*(2), 55–58. http://www.dinajmc.org/journal/djmcj_v3_i2/06_djmcj_v3i2_Talukder_SI.pdf

Tesfaye, K., Petros, Y., & Andargie, M. (2015). Frequency distribution of ABO and Rh (D) blood group alleles in Silte Zone, Ethiopia. *Egyptian Journal of Medical Human Genetics*, *16*(1), 71–76. https://doi.org/10.1016/j.ejmhg.2014.09.002

Westhoff, C. M., & Siegel, D. L. (2016). Rh and LW blood group antigens. *Rossi's Principles of Transfusion Medicine*, 176–184.

Wolpin, B. M., Chan, A. T., Hartge, P., Chanock, S. J., Kraft, P., Hunter, D. J., Giovannucci, E. L., & Fuchs, C. S. (2009). ABO blood group and the risk of pancreatic cancer. *Journal of the National Cancer Institute*, *101*(6), 424–431. https://doi.org/10.1093/jnci/djp020.