

ABO and Rh (D) blood groups distribution in Pakistan: a systematic review

Abstract

The ABO blood group system was the first discovered human blood type in 1901 by Land Steiner. The ABO and Rh system is a clinically significant blood group system and extensively recognized in medical and anthropological studies, among 29 human blood group systems. The study aims to determine the frequency distribution of ABO and Rhesus (Rh) blood group system in all-region and provinces of Pakistan. According to this study, the sequence distribution of the ABO blood groups in the Pakistani population is B with frequency (33.37%), followed by O (33.14%), then A (33.99%), and AB (9.74%). The phenotypic frequency observed was 0.2399, 0.3337, 0.0974, and 0.3314 for blood groups A, B, AB, and O, respectively. While for Rh (D) positive and negative, it was 0.9063 and 0.0937, respectively. The study concluded that blood group B is most prevalent, while group AB is the least prevalent. Rh-positive is commonest while Rh-negative is the rarest blood group in Pakistan.

Keywords: ABO, ABO blood group system, RhD

Volume 8 Issue 6 - 2020

Ghani Ur Rehman

Yunnan Key Laboratory of Primate Biomedical Research, Institute of Primate Translational Medicine, Kunming University of Science and Technology, China

Correspondence: Ghani Ur Rehman, Yunnan Key Laboratory of Primate Biomedical Research, Institute of Primate Translational Medicine, Kunming University of Science and Technology, Kunming, Yunnan, China, Tel +8613211697224, Email ghanigeetics@gmail.com

Received: December 15, 2020 | **Published:** December 30, 2020

Introduction

The blood group system of ABO was first discovered mechanism in human blood type in 1901 by Land Steiner. Later, Landsteiner and Wiener found Rhesus (Rh) blood types in 1939. The ABO system classifies blood into A, B, AB, and O. The blood group system for Rhesus (Rh) was established in 1941, with Rh-positive and Rh-negative streams on the surface of the red blood cells (RBCs) dependent on the frequency and absence of inherited antigenic substances such as proteins, carbs, glycoproteins and Glycolipids. The ABO and Rh system is a clinically significant blood group-system among 29 human blood group systems, despite the discovery of numerous other markers such as microsatellites or groups. These are extensively recognized in medical and anthropological literature. For safe blood transfusion and organ transplantation, ABO and Rh blood group systems are critical. Moreover, both systems are well known in population genetic research, population migration processes, investigation of decision-making forensic cases, and disputed paternity matters.¹⁻¹⁰

Besides, blood groups are thought to be associated with different disorders such as salivary gland tumors, carcinoma, stomach carcinoma, thyroid disorders, small cell lung cancer, and cardiovascular disease.¹¹⁻¹⁴ The types of blood groups are hereditary. ABO blood groups are regulated by a single gene having three alleles found on chromosome 9. Rh blood group system inheritance is dependent on the existence of either R or r alleles. All human species have the same blood grouping system, with significant variations between frequencies' different incidence. The prevalence and frequency distribution of these blood groups among various cultures and races need to be understood. The occurrence of ABO and Rh blood groups among the Pakistani population indicates a marked variance,

suggesting racial variations, ethnic as well as genetic differences of the Pakistani community.¹⁵⁻²⁴

The distribution of blood types across various ethnic groups and races varies worldwide. It may vary in different populations and from one region to another in the same country. The world population is split into several ethnic groups. It is considerable to which these groups vary in terms of solely hereditary characteristics. Blood groups may be used as an easy and effective technique for this purpose. The relative prevalence of blood groups O, A, B, and AB in Western Europe is 46%, 42%, 9%, and 3%, respectively. The distribution of blood groups O, A, B, and AB in the United States is 45%, 41%, 10%, and 4%, respectively. Eastern Europe shows a higher blood group B percentage. Pure American Indians belong to group O, almost exclusively. Blood group B frequency in Central Asia is the highest. In Britain, Rh-negative is most frequent (17%), followed by Caucasoid (15%) less common in American Blacks (5%), in African Blacks the ratio is (0%) and very rare in Asians (1%).²⁵⁻²⁷

Pakistan, officially the Islamic Republic of Pakistan, located in South Asia, is the world's fifth-most populous country with a population exceeding 220 million. It has the world's second-largest Muslim population. Pakistani community comprises 97% Muslims while small non-muslims religious groups like Christians, Hindus, Sikhs, Qadianis, Parsis, and others 3%. Pakistan is an ethnically diverse population; among them, the largest ethnic group is Punjabi 44.15%, followed by Pakhtun or Pashtun 15.42%, Sindhi 14.1%, a transitional ethnic group between Punjabi and Sindhi making 10.53%, the Muhajir 7.51%, Balochi 3.57%, and the other groups of northern areas make up roughly 4.66% of the total population. Previous research studies on the distribution of ABO blood groups studied only small regions or with few sample sizes. However, as to our knowledge, no

study is made to analyze the distribution of ABO blood group system in all the areas of Pakistan. Therefore, this systematic analysis is the first attempt to examine the frequency distribution of Blood groups over 21 years span between 1999 to 2020. We attempted to quantify the frequency distribution and allelic frequency of ABO and Rh(D) blood groups in Pakistan from reported studies.

Material and methods

The literature search and research strategy was developed for the assessment of the ABO system distribution in Pakistan.

An online search for literature

Various search engines were used for this systematic review; this includes Google Scholar, PubMed, Science Direct, SciHub, Medscape, Web of Sciences, etc. The term and keywords searched to obtain the desired literature were Blood Group, Prevalence/Distribution/Frequency of the ABO blood group, Rhesus blood group system, and various Pakistan regions. The publication year for the literature search was restricted from January 1999 to September 2020. We expected

the lack of apparent accuracy of the information, so no form of publication was prohibited. Conditions for the inclusion of studies are that 1) Article must be written and published in the English language 2) studied population must be Pakistani. 3) the published paper must be between 2001 to 2018. 4) calculation of frequency distribution of ABO and rhesus blood group should be the core primary findings of the study. 5) research article, review papers letter to the editor, and abstracts relevant to the distribution of ABO should be included.^{28–35}

Assessment of article and classification

We divided the state of Pakistan into six regions, which include four provinces of Khyber Pakhtunkhwa, Punjab, Sindh, Balochistan, and two autonomous territories of Azad Jammu and Kashmir and Gilgit Baltistan. Details are given in Table 1. For the analysis of national statistics, the number of individuals from various areas of the same blood groups was analyzed. The number of individuals from different regions with the same blood groups was added to explore the national data with the percentage frequency distribution of ABO blood group system in Pakistan.

Table 1 Six regions of Pakistan with number of districts and populations

S.No.	Region	No of Area/District	Population (million)
1	Gilgit (Administrative Territory)	10	2
2	Azad Kashmir (Administrative Territory)	10	4.45
3	Khyber Pakhtunkhwa	35	35.53
4	Punjab	36	110
5	Sindh	30	47.89
6	Balochistan	33	12.34

Allele frequency

For the allelic frequency estimation, Hardy Weinberg quantitative genetics equilibrium was used. The overall likelihood ratio was also estimated by this approach, supposing that the ABO system is represented by a single gene having three alleles named as A, B, and O; both A and B are autosomal-dominant over O, and both A and B are codominant. The expected phenotypic frequency was estimated based on the blood allelic frequency results. We conducted the Chi-square test to determine the genotype frequencies the independence goodness of fit for gene.^{36–41}

Results

Search outcomes

We found the research studies from all the country regions in our literature review; from all this search, 37 studies have been valid for

inclusion in our research. Of the 37 eligible research studies published from all the regions, 34 were full manuscript, and 3 were abstracts.

Outcomes of the studies

Of all these 37 studies from all the six regions of Pakistan (Table 1), to assess the distribution and allelic frequency of each blood type total of 161893 individuals were used. The maximum number of studies from the most populated province/region of Pakistan Punjab has been published out of the total chosen studies, covering most of the population and the least number of studies published from Balochistan province (Table 2). Our investigation found that the overall frequency of Pakistan A, B, AB, and O blood groups was 23.99%, 33.37%, 33.14%, and 9.74%, respectively. The most common blood type in the Pakistani population is B with frequency (33.37%), followed by O (33.14%), then A (23.99%), and AB (9.74%). Among the total population, 90.63% were Rh (D) positive, while the rest of (9.37%) were Rh (D) negative, Figure 1.^{42–55}

Table 2 Observed frequencies of ABO and Rh (D) Blood groups from six regions of Pakistan

Region	Area	A	B	AB	O	Comments	Rh+ve	Rh-ve	Total	Reference
Gilgit	Gilgit	24.2	40	10	25.8	B>O>A>AB	89.8	10.2	150	(Islam & Robert, 2010)
	Skardu	30.62	26.8	15.98	26.6	A>B=O>AB	94.83	5.17	1045	(Alam, 2005)
Azad Kashmir	Kashmir	25.93	32.59	17.26	24.2	B>A>O>AB	83.6	16.4	2300	(Chishti, Waheed, Ansari, Wazir, & Hussain, 2012)
	Poonch	21.4	36.6	7	35	B>O>A>AB	89.5	10.5	3328	(M. Khan, Khaliq, Bakhsh, Akhtar, & Amin ud Din, 2009)
	Mirpur	26.38	32.5	9.47	31.65	B>O>A>AB	91.04	8.96	2937	(M Khalid, Qureshi, & Sciences, 2006)
Khyber Pakhtunkhwa	Karak	21.86	32.09	9.76	24.65	B>O>A>AB	88.37	11.63	645	(Abbas' et al., 2020)
	Hazara	24	32	11	33	O>B>A>AB	85.8	14.2	2300	(Ullah & Ahmad, 2015)
	Swabi	27.6	34.4	8.8	32.2	B>O>A>AB	94.3	5.7	2500	(Ullah & Ahmad, 2015)
	Peshawar	28	34	7	31	B>O>A>AB	91.87	8.13	429	(Parveen, Rehman, Hassan, Hassan, & Rehman, 2016)
	Bannu	31.03	36.23	7.67	25.07	B>A>O>AB	89.37	10.63	2581	(M. S. Khan et al., 2004)
	Swat	27.92	32.28	10.57	29.1	B>O>A>AB	90.13	9.87	22897	(Khattak et al., 2008)
	Bajaur Agency	29.42	30	10.5	30.08	O>B>A>AB	91.43	8.57	1200	(A. u. Rehman et al., 2014)
	Nowshehra	27.12	32.04	11.04	29.8	B>O>A>AB	92.88	7.12	4510	(Babar, Hassan, Ullah, & Khan, 1999)
	Dir Lower	31.94	27.99	27.99	28.66	A>O>B>AB	92.45	7.55	13758	(Ullah & Ahmad, 2015)
	Mardan	24.75	27.97	19.36	27.93	B>O>A>AB	94.3	5.7	2893	(MUHAMMAD Khalid, Aslam, Siyar, & Ahmed, 2013)
Punjab	Faisalabad	23.8	38	10	28.2	B>O>A>AB	89.1	10.9	200	(Hammed, Hussain, Ahmed, Rabbi, & Qureshi, 2002)
	Lahore	20.38	40.45	8.09	31.08	B>O>A>AB	89.48	10.52	618	(Kanwal, Qureshi, Aslam, & Masood, 2016)
	Liaquatpur	20.88	35.54	2.02	44.56	O>B>A>AB	90.35	9.65	1389	(A. REHMAN et al., 2005)
	Mandi Bahauddin	15.83	28.32	4.48	55.22	O>B>A>AB	91.4	8.6	2524	(Anees, Jawad, & Hashmi, 2007)
	Multan	26.57	34.15	9.61	29.67	B>O>A>AB	90.72	9.28	937	(F. U. Rehman et al., 2015)
	Multan	21.39	37.81	6.97	33.83	B>O>A>AB	92	8	900	(Ullah & Ahmad, 2015)
	Gujrat	17.4	22.29	4.35	55.96	O>B>A>AB	79.58	20.42	2647	(Anees & Mirza, 2005)
	Bahawalpur	21	36	6	37	O>B>A>AB	95	5	29659	(Ullah & Ahmad, 2015)
	Punjab	22.6	32.4	8.6	30.5	B>O>A>AB	93.9	6.1	5000	(Rahman & Lodhi, 2004)
	Rawalpindi/Islamabad	25.53	33.33	10.04	31.1	B>O>A>AB	92.45	7.55	2518	(M. S. Khan et al., 2006)
	Sahiwal	22	36.9	9.9	31.3	B>O>A>AB	87.1	12.9	20010	(M. I. Khan et al., 2009)
	Gujranwala	22.91	35.36	9.32	32.41	B>O>A>AB	92.03	7.97	4754	(Ilyas et al., 2013)
	Multan	21.92	36.95	7.33	33.8	B>O>A>AB	92.17	7.83	3000	(Alam, 2005)
	Lahore	19.03	38.36	10.62	31.99	B>O>A>AB	93.99	6.01	2900	(Siddiqui, Chaudhry, Nigar, & Butt, 2011)
	Rawalpindi/Islamabad	24.2	34.3	10.1	31.3	B>O>A>AB	91	9	4642	(Shakir, Khan, & Ghani, 2012)
	Wah Cantt	18	24	5	53	O>B>A>AB	73.9	26.1	4462	(Iqbal, 2009)
Lahore	24.2	37.8	9.1	28.8	B>O>A>AB	93	7	3000	(UMER et al., 2014)	
Islamabad	24.64	34.72	9.28	31.36	B>O>A>AB	92	8	625	(Jabin et al., 2018)	
Lahore	20.12	37.45	10.57	32.11	B>O>A>AB	92.97	7.03	514	(Butt, Malik, Khalid, Aziz, & Humayun, 2016)	

Table Continued...

Region	Area	A	B	AB	O	Comments	Rh+ve	Rh-ve	Total	Reference
Sindh	Karachi	24.1	33.1	7.2	35.6	O>B>A>AB	91.1	8.9	3521	(Ahmed, Memon, & Iqbal, 2019)
	Sindh	25.83	28.17	8.3	37.78	O>B>A>AB	95.76	4.24	3000	(Ullah & Ahmad, 2015)
Balochistan	Balochistan	23.2	31.7	10.1	35	O>B>A>AB	94.75	5.25	1600	(Hussain, Sheikh, Haider, Rashied, & Malik, 2001)
Total	Observed Frequency	23.99	33.37	9.74	33.14	B>O>A>AB	90.63	9.37	161893	

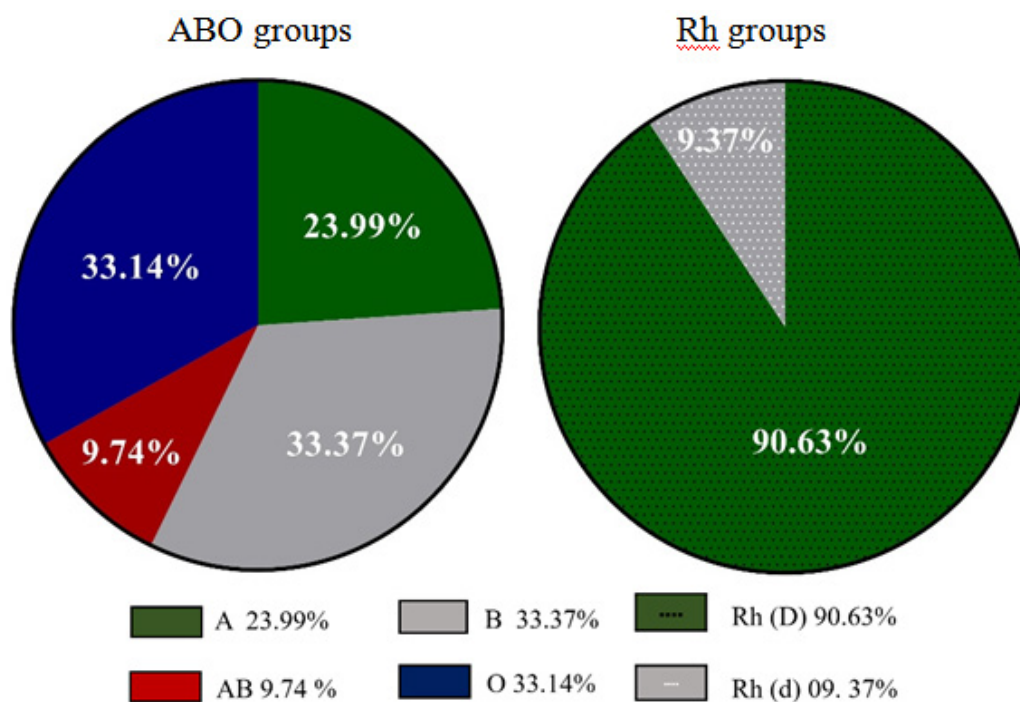


Figure 1 Pie charts summarize ABO and Rh (D) distribution in Pakistan. A total of 161893 samples. The national average of blood group: 90.63% for Rh (D) (green color) and 9.37% for Rh (d) (Gray color). Involving 23.99% for A (Green color), 33.37% for B (gray color), 9.74% for AB (Red color) and 33.14% for O (blue color).

Allelic frequency distribution of blood groups ABO and Rh (D) in Pakistan

According to the quadratic equation and Hardy Weinberg law of equilibrium calculated results, the frequencies for IA(p), IB(q), and i(r)

were 0.2435, 0.1809, and 0.5756 according to those data. Similarly, the Rh (D) positive and Rh (d) negative allelic frequencies for ID(v) and Id(u) were 0.6939 and 0.3061, respectively. Refer to Tables 3&4.

Table 3 Expected frequencies of ABO and Rh (D) system

Phenotype	Observed frequency	Genotype	Expected frequency
A	0.2399	AA AO/OA	$p^2+2pr = 0.3396$
B	0.3337	BB BO/OB	$q^2+2qr = 0.2409$
O	0.3314	OO	$r^2 = 0.3314$
AB	0.0974	AB	$2pq = 0.0881$
D	0.9063	DD/Dd	$V^2=0.4814, v^2+2uv=0.9063, 2uv=0.4248$
d	0.0937	dd	$U^2= 0.0937$

Table 4 Table comparison of observed and expected frequencies of ABO and Rh (D) blood group system

Existing Allelic Frequency					Existing Genotype Frequency of ABO and Rh System						Expected Genotype Frequency of ABO and Rh System						
$I_A=p$	$I_B=q$	$i=r$	$I_D=v$	$I_d=u$	O	A	B	AB	Rh+	Rh-	O	A	B	AB	Rh+	Rh-	
					0.3314	0.2399	0.3337	0.0974	0.9063	0.0937	r^2	p^2+2pr	q^2+2qr	$2pq$	v^2+2uv	U^2	
0.2435	0.1809	0.5756	0.6939	0.3061							0.3314	0.3396	0.2409	0.0881	0.9063	0.0937	
Total = 1		Total = 1		Total = 1		Total = 1		Total = 1		Total = 1		Total = 1		Total = 1		Total = 1	

Allelic frequency of O

r^2 = Phenotypic frequency of O Observed frequency of O = 0.3314

$$r = \sqrt{r^2}$$

$$r = \sqrt{0.3314}$$

$$r = 0.5756$$

Allele frequency of A

Observed frequency of A = 0.2399

$$A = AA + AO$$

$$= P^2 + 2pr$$

$$= P^2 + 2p(0.5756)$$

$$= P^2 + 1.152p = 0.3399$$

$$= P^2 + 1.152p - 0.3399 = 0$$

According to quadratic equation $(x = -b \pm \sqrt{b^2 - 4ac})/2a$
 $a = 1$

$$b = 1.152$$

$$p = 0.2435$$

$$c = -0.3399$$

Allelic frequency of B

According to Hardy Weinberg equation Observed frequency of B = 0.3337

$$P + q + r = 1$$

$$0.2435 + q + 0.5756 = 1$$

$$q = 0.1809$$

Allele frequency of d

U^2 = Frequency of d Phenotype Observed frequency of d = 0.0937

$$U^2 = 0.0937$$

$$U = \sqrt{0.0937}$$

$$U = 0.3061$$

Allele frequency of D Observed frequency of D = 0.9063

V = frequency of D phenotype

$$U + V = 1$$

$$V = 1 - 0.3061$$

$$V = 0.6939$$

According to the Chi-square test for ABO and Rh (D), the goodness of fit was statistically not significant ($p \geq 0.5$) (Table 3).

ABO and Rh (D) groups distribution with their allelic frequencies on a regional basis in Pakistan

Our study divided the state of Pakistan into six regions, including four provinces of Khyber Pakhtunkhwa, Sindh, Punjab, Balochistan, and two autonomous territories of Gilgit Baltistan and Azad Kashmir; details of the regions and its population are given in Table 1. According to our calculated data, blood group B is more prevalent in Punjab (34.41%), followed by Gilgit (33.40%), then Kashmir (32.50%), and Khyber Pakhtunkhwa (31.65%). In comparison, the O blood group is most common in Sindh (36.68%) and Balochistan regions (35%), as described in Figure 2. Individuals with Rh-positive blood groups were dominant in Balochistan (94.75%) compare to the rest of the regions, Figure 2.

This review also calculated the gene frequency for the ABO and Rh (D) genes using the Hardy Weinberg equilibrium. According to that the allelic frequency of O = i(r), A = IA (p), B = IB(q), D = ID(v) and d = Id(u) were 0.5756, 0.2435, 0.1809, 0.3061 and 0.6939 respectively details are given in Table 3. According to our studies the observed phenotypic frequency of A, B, AB, O and Rh (D) positive and negative blood groups were 0.2399, 0.3337, 0.0974, 0.3314, 0.9063 and 0.0937 whereas expected phenotypic frequency were 0.3396, 0.2409, 0.0881, 0.3314, 0.9063 and 0.0937 respectively. Refer to Table 4. Chi-square test shows the two values of observed and expected frequencies of ABO and Rh blood system were not statistically significant ($p \geq 0.05$) Table 4.⁵⁶⁻⁶¹

Discussion

Pakistan is a country with a 220 million population, according to the 2017 consensus of the Government of Pakistan. It is a residence for many ethnic and religious communities. No significant data is available in the Pakistani population concerning the distribution of blood groupings of ABO and Rh (D) and their allelic frequencies so far. Still, there are several regional studies available that analyze the distribution in their specific regions. A multicentric analysis by (Ullah & Ahmad) presented most of the ABO and Rh (D) blood groups. However, the analysis was not focused on the frequency and distribution necessary to reflect all populations' overall image. We analyzed six regions of Pakistan, including four provinces and two autonomous territories of the state, which include 0.15 million of the population in our review. We tried to include the reported studies from January 1999 to September 2020 to cover all the population of Pakistan.

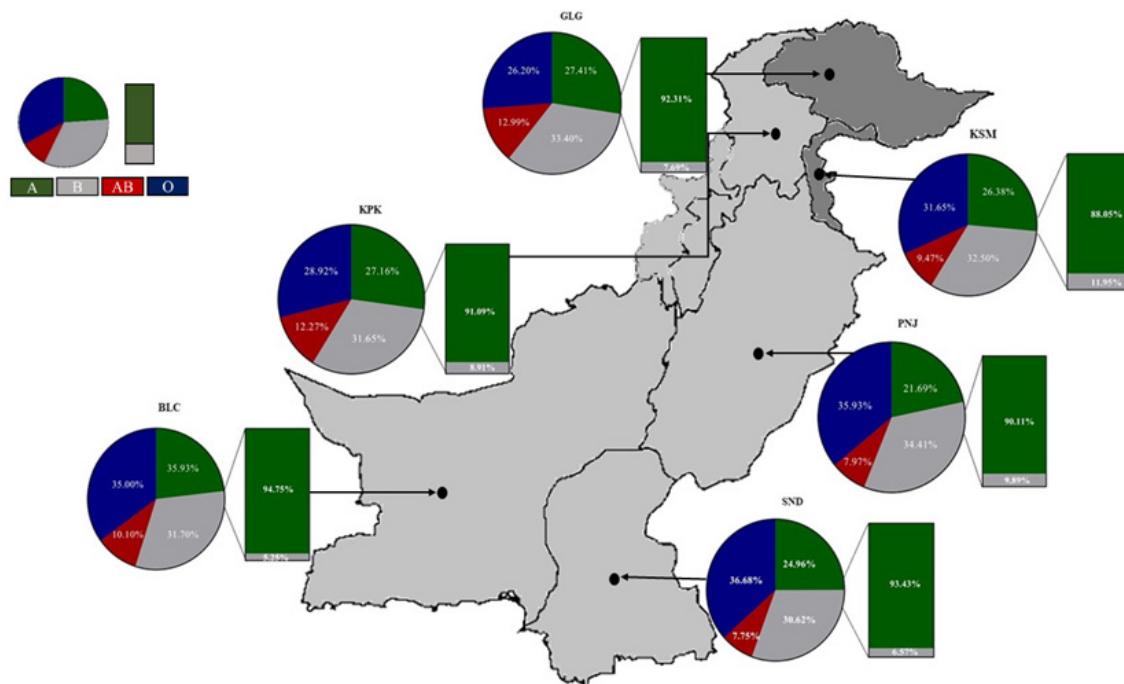


Figure 2 Map showing the frequency (%) of ABO and Rhesus blood groups in different regions/provinces of Pakistan. Pie charts represent per state average proportions of ABO; and bars show the proportion of Rh (D) groups. GLG = Gilgit; KSM = Kashmir; KPK = Khyber Pakhtunkhwa; PNJ = Punjab; SND = Sindh; BLC = Balochistan.

Blood group distribution is different regionally, ethnically, and from one population to another. According to our study, the sequence of the distributions of blood groups in the Pakistani population is B with frequency (33.37%) followed by O (33.14%) then A (23.99%), and AB (9.74%) is the least frequent blood group in the overall population of Pakistan. Our analyzed data is in line with a study published by Afzal, Hussain, & Siddiqi. This was also in agreement with a paper reported by Nanu & Thapliyal, 1997 in neighboring India. The results are also consistent with the study in which B is the most prevalent blood group in Africans and European populations. In contrast, blood group O and A is commoner in Australians.⁶²⁻⁶⁵ Other research conducted in various populations around the world indicate that blood group O is more predominant in Saudi Arabia (52%) (Bashwari, Al-Mulhim, Ahmad, & Ahmed, 2001), US (46%) (Frances, 2002), and in the Iranian population (41.16).

In addition, our research showed that gender or position had no significant impact on the occurrence of ABO blood groups in line with a previous study conducted in Nigeria. According to the Rh blood group findings, Rh+ was the highest in our study population (90.63%) than (9.37%) Rh-group. Our Rh-blood group population, however, is higher than those globally registered in Tanzania (3.2%) and 1.0% in China. 16% of the sample population with the Rh-blood group was higher than our studies, and 8% of the Rh-blood group in the Fezzan area were confirmed by Al Bayda city's local results in eastern Libya. Several studies have concluded that Rh+ is a dominant antigen compared to Rh.^{66,67}

In this review, we found that blood group B is most prevalent in Punjab (34.41%), Gilgit (33.40%), Kashmir (32.50%), and Khyber Pakhtunkhwa (31.65%) province. However, in Sindh and Balochistan, blood group O is prevalent, with 36.68% and in Balochistan 35%, respectively. The environmental influence and natural selection in the various areas of Pakistan will interpret this unequal blood distribution. Our study found that the B blood group is the most prevalent in

Pakistan's population as the findings comply with another study. Vibrio cholera's deadly cholera infection is considered to become more prevalent in Pakistan's regions. This can be justified by Row et al. by their hypothesis of region-specific selection burden. Therefore, it may be concluded that there is a tremendous geographical and environmental influence on blood groups. Similar findings by Dewan, 2015 have been reported in Bangladesh, which has identified more B blood group tendency in coastal areas to cholera prevention.

Limitations of the study

We tried our best to determine the frequency distribution of blood group systems and their frequencies in the Pakistani population in our systematic study, but still, our study poses some limitations, which are as follows; 1) in this review, all of the representative populations are not covered entirely because some of the regions did not publish more number of studies during our inclusion period (1999 to 2020) and only a paper or two was published which studied a limited number of individuals. 2) we tried to include many published studies, but all the published articles were not full manuscripts; some of them were abstracts used in our review. 3) the chances of overlapping the populations also exist because there were multiple studies published from the same region. 4) we include only D antigen in the Rh blood group system, whereas D antigen frequency can be influenced by other antigen systems such as C, c, e, and E.

Conclusion

All humankind shares specific blood groups which cannot be changed throughout their life. The blood group system is variable in different ethnic groups, races, and other geographical locations. We attempted to evaluate and measure the ABO blood group system's frequency and distribution in our current research analysis nationwide. Our study in Pakistan's population presented that blood group B is most prevalent, and AB is least prevalent, and more than 90 percent

of the population is Rh-positive. Our findings indicate that the allelic frequency of blood groups in Pakistan is allegedly distributed. The research we discoursed in the paper indicates that this unequal blood distribution along with genetic influence can be viewed in various regions of Pakistan as an environmental effect and natural selection. We believe that the knowledge of the frequency distribution of ABO system in the entire nation and especially in the country's specific areas, is essential for blood bank information, safe transfusion of blood, population migration, and disease trend concerning blood groups. The future national studies are planned with more sample size and other blood group systems to provide insight into the relationship of blood group antigens in relation with diseases within Pakistani populations and to lead to safe transfusion facilities in the countries.

Acknowledgments

None.

Conflicts of interest

The authors declare that they have no conflict of interest.

References

1. Abbas A, Abbas B, Aziz S, et al. Prevalence of ABO and Rh Blood Group In District Karak (Female). *Bulletin of Environment, Pharmacology and Life Sciences*. 2020;9(2):31–34.
2. Abbas AA. Frequency of ABO and Rh D Blood Groups among Sudanese Blood Donors Attending Central Blood Bank in Wad Medani, Gezira State, Sudan. 2017.
3. Afzal M, Hussain F, Siddiqi R. A survey of blood groups. *J Pak Med Assoc*. 1977;27(11):426–428.
4. Ahmed M, Memon A, Iqbal K. Distribution pattern of ABO and Rhesus blood groups among different ethnic population of Karachi. *J Pak Med Assoc*. 2019;69(10):1474–1478.
5. Akhigbe R, Ige S, Afolabi A, et al. Prevalence of haemoglobin variants, ABO and rhesus blood groups in Ladoke Akintola University of Technology, Ogbomoso, Nigeria. *Trends in Medical Research*. 2009;4(2):24–29.
6. Alam M. ABO and Rhesus blood groups in potential blood donors at Skardu (Northern Areas). *Pakistan Journal of Pathology*. 2005;16(3):94–97.
7. Amin-ud-Din M, Fazeli N, Rafiq MA, et al. Serological study among the municipal employees of Tehran, Iran. Distribution of ABO and Rh blood groups. *Haema*. 2004;7(4):502–504.
8. Anees M, Jawad A, Hashmi IJPAS. Distribution of ABO and Rh blood group alleles in Mandi Bahauddin district of Punjab, Pakistan. *Proc Pakistan Acad Sci*. 2007;44(4):289–294.
9. Anees M, Mirza MSJP. Distribution of ABO and Rh blood group alleles in Gujrat region of Punjab, Pakistan. *Proc Pakistan Acad Sci*. 2005;42(4):233–238.
10. Armstrong B, Hardwick J, Raman L, et al. Introduction to blood transfusion technology. *ISBT*. 2008;3(2):254–283.
11. Babar M, Hassan HS, Ullah H, et al. ABO and Rhesus blood group distribution in District Nowshera. *JPMI*. 1999;13(2).
12. Bashwari L, Al-Mulhim AA, Ahmad MS, et al. Frequency of ABO blood groups in the Eastern region of Saudi Arabia. *Saudi Med J*. 2001;22(11):1008–1012.
13. Begum D, Amin M, Khatun F, et al. Distribution of ABO and Rh blood Groups Among Tribal Population of Sylhet, Bangladesh. *Journal of Dhaka Medical College*. 2011;20(1):44–50.
14. Butt DS, Malik S, Khalid MZ, et al. Gender distribution of ABO and Rhesus blood groups among medical students of a public medical school in Lahore, Pakistan. *JPSZPMC*. 2016;30(2):77a.
15. Cerny T, Fey M, Oppliger R, et al. Prevalence of the rhesus-negative phenotype in caucasian patients with small-cell lung cancer (SCLC). *IJC*. 1992;52(3):504–506.
16. Chishti HM, Waheed U, Ansari MA, et al. ABO and Rhesus (D) blood group phenotypes in Mirpur, Azad Jammu Kashmir, Pakistan, 2008. *JPHBS*. 2012;1(2):43–46.
17. Dabholkar A. Elements of Bio Metrical Genetics (revised And Enlarged Edition): Concept publishing company. 1999.
18. Dewan GJE. 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. *JMHG*. 2015;16(2):141–147.
19. Frances T. Blood groups (ABO GROUPS). Common laboratory and diagnostic tests. In: Philadelphia: Lippincott. 2002.
20. Garratty G, Dzik W, Issitt P, et al. Terminology for blood group antigens and genes—historical origins and guidelines in the new millennium. *Transfusion*. 2000;40(4):477–489.
21. Guo N, Wang J, Ness P, et al. Demographics of apheresis platelet donors in five blood centers in China. *Transfusion*. 2012;52(3):560–566.
22. Gupta S, Gupta MJSC. Business Statistics. 2009.
23. Guyton A, Hall J. Blood groups; transfusion; tissue and organ transplantation. 2000.
24. Amjad Hameed, Wajahat Hussain, Janbaz Ahmed, et al. Prevalence of Phenotypes and Genes of ABO and Rhesus (Rh) Blood Groups in Faisalabad, Pakistan. *Pakistan Journal of Biological Sciences*. 2002;5:722–724.
25. Haruechaiyasak C, Damrongrat C. Article recommendation based on a topic model for wikipedia selection for schools. Paper presented at the International Conference on Asian Digital Libraries. 2008.
26. Hassan FM. Frequency of ABO, subgroup ABO and Rh (D) blood groups in major sudanese ethnic groups. *Pakistan Journal of Medical Research*. 2010;49(1):21–24.
27. Hemalatha N, Bhagya VJ. Frequency and distribution of blood groups among medical students in davanagere. *JPHMR*. 2015;3(1):1–4.
28. Hosoi E. Biological and clinical aspects of ABO blood group system. *JMI*. 2008;55(3–4):174–182.
29. Hussain A, Sheikh SA, Haider M, et al. Frequency Distribution of ABO and Rhesus Blood Groups in Population of Balochistan”, Pak. 2001;51(1):22–26.
30. Ilyas M, Iftikhar M, Rasheed. Frequency of ABO and Rh blood groups in Gujranwala (Punjab), Pakistan. 2013;59(1):107–114.
31. Iqbal Muhammad, Alauddin Niazi, Mohammad Tahir. Frequency of ABO and Rh blood groups in Healthy Donors. *Journal of Rawalpindi Medical College*. 2009;13(2):92–94.
32. Islam F, Robert HJP. Frequency of ABO and Rhesus blood groups in the population of Gilgit area of Pakistan. *JOP*. 2010;21(3):87–91.
33. Jabin F, Waheed U, Ahmed S, et al. Red blood cell phenotyping of blood donors in Islamabad, Pakistan. *GJTM*. 2018;3(1):26–29.
34. Jahanpour O, Pyuza JJ, Ntiyakunze EO, et al. ABO and Rhesus blood group distribution and frequency among blood donors at Kilimanjaro Christian Medical Center, Moshi, Tanzania. *BMC Res Notes*. 2017;10(1):738.
35. Kanungo S, Sah B, Lopez A, et al. Cholera in India: an analysis of reports, 1997-2006. *Bull World Health Organ*. 2010;88(3):185–191.

36. Kanwal S, Qureshi HJ, Aslam MS, et al. Frequency of ABO and Rh blood groups in students of Akhtar Saeed Medical and Dental College, Lahore. *Pak J Physiol.* 2016;12(1):29–30.
37. Khalid M, Aslam N, Siyar M, et al. Distribution of ABO and Rh D blood groups among blood donors in district Mardan Pakistan. *JJSMCS.* 2013;3:318–322.
38. Khalid M, Qureshi M. Frequencies of blood group antigens and corresponding alleles in the population of Mirpur, Azad Jammu Kashmir, Pakistan. 2007;16(3–4):96–98.
39. Khan M, Khaliq I, Bakhsh A, et al. Distribution of ABO and Rh D blood groups in the population of Poonch District, Azad Jammu and Kashmir. *East Mediterr Health J.* 2009;15(3):717–721.
40. Khan MI, Micheal S, Akhtar F, et al. Association of ABO blood groups with glaucoma in the Pakistani population. *Can J Ophthalmol.* 2009;44(5):582–586.
41. Khan MS, Farooq N, Qamar N, et al. Trend of blood groups and Rh factor in the twin cities of Rawalpindi and Islamabad. *J Pak Med Assoc.* 2006;56(7):299–302.
42. Khan MS, Subhan F, Tahir F, et al. Prevalence of blood groups and Rh factor in Bannu region NWFP (Pakistan). 2004;43(1):8–10.
43. Khattak ID, Khan TM, Khan P, et al. Frequency of ABO and Rhesus blood groups in District Swat, Pakistan. *J Ayub Med Coll Abbottabad.* 2008;20(4):127–129.
44. Kondam A, Chandrashekar M, Suresh M, et al. A study of incidence of hypertension in ABO and rhesus blood group system. *JJBB.* 2012;3(1):1426–1429.
45. Mahmood MA, Khawar S, Anjum AH, et al. Prevalence of hepatitis B, C and HIV infection in blood donors of Multan region. 2004;10(4).
46. Marzban M, Kamali M, Hosseinbasi T. Blood groups of the people of Ahwaz, Iran. *Anthropologischer Anzeiger.* 1988;46(1):83–89.
47. Mollison PJA, Analgesia. Blood transfusions in clinical medicine. 1954;34(5):59–60.
48. Mollison P. The genetic basis of the Rh blood group system. 1994;34(6):539–541.
49. Mondal B, Maiti S, Biswas BK, et al. Prevalence of hemoglobinopathy, ABO and rhesus blood groups in rural areas of West Bengal, India. *J Res Med Sci.* 2012;17(8):772–776.
50. Nanu A, Thapliyal R. Blood group gene frequency in a selected north Indian population. *Indian J Med Res.* 1997;106:242–246.
51. Nwauche C, O A Ejele. ABO and rhesus antigens in a cosmopolitan Nigeria population. *Niger J Med.* 2004;13(3):263–266.
52. Parveen N, Rehman J, Hassan SH, et al. Different blood groups. 2016;23(08):1001–1004.
53. Pennap G, Envoth E, Igbawua I. Frequency distribution of hemoglobin variants, ABO and rhesus blood groups among students of African descent. 2011;33–40.
54. Pinkston JA, Cole P. ABO blood groups and salivary gland tumors (Alabama, United States). *Cancer Causes Control.* 1996;7(6):572–574.
55. Rahman M, Lodhi Y. Frequency of ABO and Rhesus blood groups in blood donors in Punjab. 2004;20(4):315–318.
56. Rehman A, Saeed MA, Khan MA, et al. ABO & Rhesus Blood Groups. 2005;12(04):368–371.
57. Rehman A, Wahab Z, Khattak M. ABO and Rh (D) blood groups polymorphism in four tehsils of Bajaur Agency (Federally Administered Tribal Areas), Pakistan. 2014;18(1):259–261.
58. Rehman FU, Siddiqui MM, Nazir I, et al. Study of ABO and Rh-D Blood Groups among the Common people of Multan City Corporation area of Pakistan. *JPHE.* 2015;9(3):892–896.
59. Rowe JA, Opi DH, Williams T. Blood groups and malaria: fresh insights into pathogenesis and identification of targets for intervention. *Curr Opin Hematol.* 2009;16(6):480–487.
60. Saad KJJ. Distribution of ABO blood groups and resus factor (RH) in Albiyda/Libya. *Journal of Medical and Dental Science Research.* 2016;3(9):28–31.
61. Salih K, Abdrhman OM, Irhuma AA, et al. Anthropological studies among Libyans of Fazzan Province: ABO and Rh systems. 2005;4(1):64–69.
62. Shaheen S, Nouroz F, Mujtaba G, et al. A study of seroprevalence of ABO blood groups in Lahore. 2014;3(2):1–4.
63. Shakir CM, Khan SA, Ghani E. Frequency of ABO and Rh (D) blood groups among blood donors in Rawalpindi/Islamabad area. *JPAFMJ.* 2012;62(2):304–306.
64. Siddiqui Z, Chaudhry M, Nigar M, et al. A study of association between ABO and Rh blood groups, sex, age and angina pectoris. 2011;23(2):113–116.
65. Sidhu S, Sidhu LJCA. ABO blood-group frequencies among the Sansis of Punjab. 1980;4(1):55–57.
66. Ullah S, Ahmad TJWASJ. Distribution of ABO and Rh (D) blood groups in the population of District Dir Lower, Khyber Pakhtunkhwa Pakistan. *World Applied Sciences Journal.* 2015;33(1):123–135.
67. Umer KM, Bashir MW, Rehman R, et al. Frequency of ABO and Rh (D) blood groups among blood donors in Lahore, Pakistan. *International Journal of Advanced Biological and Biomedical Research.* 2014;2(3):597–600.