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Original article

Distribution and Allele Frequencies of ABO and Rh Blood Types in Al-Jabal Al-Akhdar, Libya

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Abstract
This study investigates the distribution and allele frequencies of the ABO and Rh blood systems in the Al-Jabal Al-Akhdar region of Libya. A total of 3,363 individuals from ten towns in the region were included. ABO blood types and Rh factor were recorded from families, and ABO genotypes were inferred by pedigree analysis. Chi-square goodness-of-fit tests were used to compare the proportions of observed ABO phenotypes and Rh antigens across towns. Overall, blood type A had the highest frequency at 33.37%, followed by O at 29.63%, B at 27.92%, and AB at 9.09%. Regarding Rh status, 88.91% of individuals were Rh-positive, and 11.09% were Rh-negative. Allele frequencies for the ABO system in the overall population were estimated as p = 0.280, q = 0.242, and r = 0.478. The allele frequencies of the Rh system were p = 0.766 and q = 0.234. Significant differences across towns were observed for blood types A, AB, and O (p-value = 0.025, 0.000, and 0.001, respectively). However, no significant differences were found for blood types B, Rh-positive, and Rh-negative (p-value = 0.301, 0.990, and 0.093, respectively) across towns. These findings provide useful data for population genetics and transfusion medicine in the region. Further work is needed to examine genetic diversity and population structure in other blood group systems.
Keywords. ABO Blood Types, Allele Frequencies, Rh Factors, Pedigree Analysis.

Introduction

Blood is one of the most vital fluids in the human body, facilitating the circulation of nutrients, oxygen, hormones, and enzymes. Although there is a singular type of blood that performs these functions in humans, various blood type systems exist. One prominent system is the ABO blood type system, comprising three carbohydrate antigens: A, B, and O, where the O gene produces an inactive enzyme, the A and B genes code for the enzymes A and B glycosyltransferases (GTs), respectively [1]. The Rh system, particularly the D antigen, is a major determinant of alloimmunization risk in transfusion and pregnancy and is therefore critical for safe blood banking and perinatal care. In fact, blood type antigens play a crucial role not only in blood transfusions and organ transplantation but also in genetic research, anthropology, and tracing human ancestry. Furthermore, human blood types are inherited genetically and display varying levels of polymorphism. The distribution of blood types shows significant differences across various populations [2]. ABO blood type distribution varies across different geographic regions and ethnic populations [3].

Population data on ABO and Rh allele and phenotype frequencies provide essential information for transfusion services, genetic and forensic studies, and public health planning. Geographic and ethnic variation in these frequencies reflects historical migrations, genetic drift, selection, and admixture, making blood-group distributions useful for reconstructing population history as well as for addressing local clinical needs. Despite global surveys, many regions remain under-characterized, and localized studies can identify unique frequency patterns relevant to regional healthcare systems. Al-Jabal Al-Akhdar in northeastern Libya is a region with distinct demographic, historical, and environmental features. Its population has been shaped by indigenous Berber groups, Arab migrations, Ottoman and European influences, and its position along Mediterranean trade routes. These complex ancestral contributions may be reflected in the genetic structure of blood-group loci. However, comprehensive data on ABO and Rh distributions in Al-Jabal Al-Akhdar remain limited.

The prevalence of ABO and Rh shows significant variation across different regions of the world and among various ethnic groups [4]. Many studies have shown that among the ABO blood types, type O is the most prevalent, followed by types A, B, and AB [5]. Extensive research has explored the distribution of ABO and Rh blood types across global populations, revealing marked regional differences that reflect genetic and ethnic diversity. A large multiethnic study in the United States reported blood type O as the most prevalent (46%), with varying frequencies observed among White non-Hispanic, Hispanic, Black non-Hispanic, Asian, and Native American groups [6]. Conversely, type B exhibited substantial regional variation, reaching 39.84% in Northern India [7]. However, in a study of 12,215 healthy Jordanian blood donors, blood type A was the most common phenotype (36.62%) [8]. Likewise, a study in Egypt found blood type A to be more common [9]. In the case of AB, most researchers have reported that the AB blood type generally occurs at lower frequencies [6]. However, understanding the distribution of blood groups in a specific population is essential for the effective management of blood banks and for transfusion-related clinical practice. It also allows for the detection of any significant differences in phenotype distribution when compared to other populations [2]. Such comparisons can illuminate how factors like genetic background, geographical distribution, and ethnicity contribute to variations in blood type frequencies, further enhancing our understanding of human genetics and population health.

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This study aims to determine the distribution and allele frequencies of the ABO and Rh blood groups in the population of the Al-Jabal Al-Akhdar region of Libya. By establishing phenotypic frequencies and estimating allele proportions, the research will inform local transfusion practice, contribute to broader population-genetic knowledge of Libya, and provide baseline data for future comparative studies.

Methods

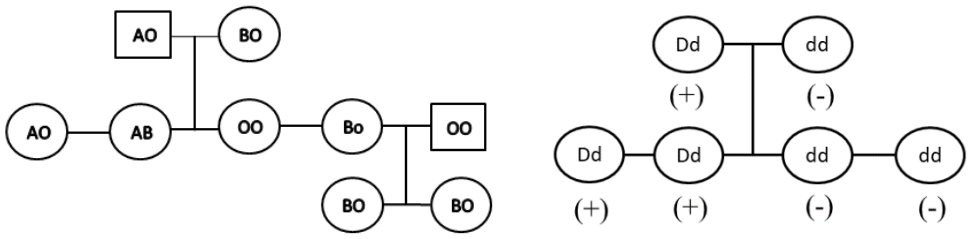
Study design and setting

ABO blood types and Rh factors were recorded for family members using a survey. Participants came from 405 families in ten towns in the Al-Jabal Al-Akhdar region, totaling 3,363 healthy individuals. Families were recruited by random sampling of towns to ensure geographic representation. Inclusion criteria: families with at least one parent and one child available for pedigree verification. Exclusion criteria: families with incomplete information.

The genotypes of the ABO blood types and the Rh factor were defined using the pedigree analysis (Fig. 1). The allelic frequencies of the ABO alleles and Rh factor were defined by the following equations:

ABO allelic frequencies: $p = (AA + ½\ AO + ½\ AB) / Total$, $q = (BB + ½\ BO + ½\ AB) / Total$, $r = (OO + ½\ AO + ½\ BO) / Total$.

Rh allelic frequencies: $D\ (p) = (DD + ½\ Dd) / Total$, $d\ (q) = (dd + ½\ Dd) / Total$.



(**a**) (**b**)

Figure 1. Family pedigree analysis: (a) blood types; (b) Rh factor.

Statistical analysis

Allele frequencies and phenotype proportions were calculated by town and for the overall sample. The Chi-square Goodness-of-Fit Test (One Variable) was used to compare the observed phenotype proportions for ABO blood groups and Rh factors across the various towns. Data were analyzed using Minitab version 20.3. A p-value < 0.05 was considered statistically significant.

Results

Overall, the data indicated a low prevalence of the AB blood type (9.09%) and small variances among the other blood types (A: 33.37%, B: 27.92%, O: 29.63%). Also, the results showed that Marwah has the highest percentage of the A blood type (56.67%), whereas Al-Faydia has the lowest percentage of the A blood type (25.35%). Qandula has the highest percentage of the B blood type (39.05%), whereas Al Bayada has the lowest percentage of the B blood type (18.42%). Derna has the highest percentage of the AB blood type (26.68%), whereas Al-Faydia has the lowest percentage of the AB blood type (1.41%). Also, Derna has the lowest percentage of the O blood type (9.27%), while Al-Bayda has the highest percentage of the O blood type (41.87) (see Table 1).

Table 1. Percentages of ABO blood types and Rh factor among different towns of Al-Jabal Al-Akhdar

Towns	A (%)	B (%)	AB (%)	O (%)	Rh+ (%)	Rh- (%)
Al-Bayda	29.47	23.66	5.01	41.87	85.89	14.11
Derna	34.19	29.87	26.68	9.27	87.70	12.30
Shahat	31.65	32.26	6.27	29.82	90.95	9.05
AL-Qubah	35.88	30.61	6.33	27.18	89.97	10.03
AL-Haniya	29.31	28.28	5.17	37.24	88.97	11.03
Omer-Al Mukhtar	37.61	27.35	4.27	30.77	86.32	13.68
Qandula	37.14	39.05	4.76	19.05	93.33	6.67
Al-Faydia	25.35	35.21	1.41	38.03	90.14	9.86
Marwah	56.67	25.56	4.44	13.33	76.67	23.33
Al_Bayada	41.45	18.42	5.92	34.21	88.16	11.84
Entire Population	33.37	27.92	9.09	29.63	88.91	11.09

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In general, the positive Rh was higher than the negative Rh (+ Rh: 88.91%, - Rh: 11.09%). Qandula has the highest percentage of the positive Rh (93.33%), whereas Marwah has the lowest percentage of the positive Rh (76.67). However, Qandula has the lowest percentage of the negative Rh (6.67%), whereas Marwah has the highest percentage of the negative Rh (23.33) (Table 1).
Allele frequencies of ABO blood types (designated as p, q, and r) across different locations or populations. In the entire population, the "r" frequency was the highest at 0.478, while p and q frequencies were 0.280 and 0.242, respectively. The "r" tends to be the most frequent across most populations (Table 2). Allele frequencies of the Rh factor related to D (p) and d (q). In the entire population, frequencies were D at 0.766 and b at 0.234. Across various towns, D values vary from 0.617 (Marwah) to 0.833 (Qandula), while b values range from 0.167 (Qandula) to 0.383 (Marwah) (see Table 2).

Table 2. Allele frequencies of ABO blood types and Rh factor among different towns of Al-Jabal Al-Akhdar

Towns	ABO blood type frequencies			Rh factor frequencies	
	p	q	r	D (p)	d (q)
Al-Bayda	0.162	0.342	0.496	0.742	0.258
Shahat	0.236	0.258	0.506	0.828	0.172
Derna	0.275	0.249	0.476	0.751	0.249
Omer Al-Mukhtar	0.321	0.17	0.509	0.697	0.303
Qandula	0.276	0.329	0.395	0.833	0.167
Marwah	0.411	0.233	0.356	0.617	0.383
Al-Faydia	0.19	0.225	0.585	0.789	0.211
Al-Bayada	0.161	0.342	0.497	0.78	0.22
Al-Haniya	0.229	0.233	0.538	0.743	0.257
Al-Qubah	0.3	0.253	0.447	0.786	0.214
Entire Population	0.280	0.242	0.478	0.766	0.234

Chi-Square Goodness-of-Fit Test was used to compare multiple proportions of the ABO blood types appearing in each town. The results showed significant differences for blood types A, AB, and O (p-value = 0.025, 0.000, and 0.001, respectively) across the towns (Al-Bayda, Derna, Shahat, Al-Qubah, Al-Haniya, Omer-Al Mukhtar, Qandula, Al-Faydia, Marwah, and Al-Bayada). However, there was no significant difference in the B blood type (p-value = 0.301) across the towns. The distribution of Rh+ and Rh− did not differ significantly between towns (p-value = 0.990 for Rh+; p-value = 0.093 for Rh−) (see Table 3).

Table 3. Chi-square test comparing blood type and Rh factor distributions among towns in Al-Jabal Al-Akhdar

Variable	DF	x^2	P-Value
(A) Blood type	9	19.0598	0.025*
(B) Blood type	9	10.6474	0.301
(AB) Blood type	9	63.6244	0.000*
(O) Blood type	9	38.2748	0.001*
Rh positive	9	2.07164	0.990
Rh negative	9	14.9230	0.093

**Significant difference ($p < 0.05$).*

In the case of the Rh factor, chi-square contributions indicated that Marwah had the largest influence on the overall test statistics. Specifically, Marwah contributed 1.4133 to the chi-square for Rh+ (it had the lowest Rh+ proportion, 76.67%) and 10.1804 to the chi-square for Rh− (it had the highest Rh− proportion, 23.33%) (Fig. 2).
Marwah and Al-Bayada towns had the largest difference between the observed and expected A blood type. Therefore, these towns make the most contribution to the chi-square statistic, 12.083 and 0.8674, respectively (Fig. 3). In the case of B blood type, Qandula and Al_Bayada had the most contribution to the chi-square statistic, 3.46093 and 3.87599, respectively. However, Derna made the most contribution to the chi-square statistic, 54.9786. Thus, it had the largest difference between the observed and expected AB blood type. Also, Derna had the largest difference between the observed and expected O blood type. It makes the most contribution to the chi-square statistic, at 12.5976, with the lowest observed proportion of O blood type at 9.27 (Fig. 3).

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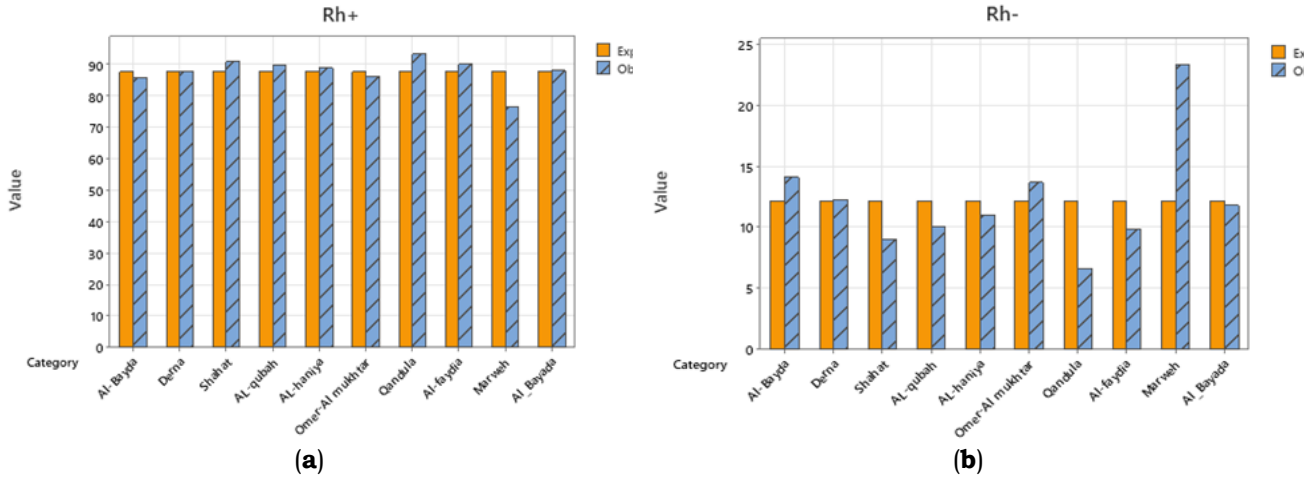
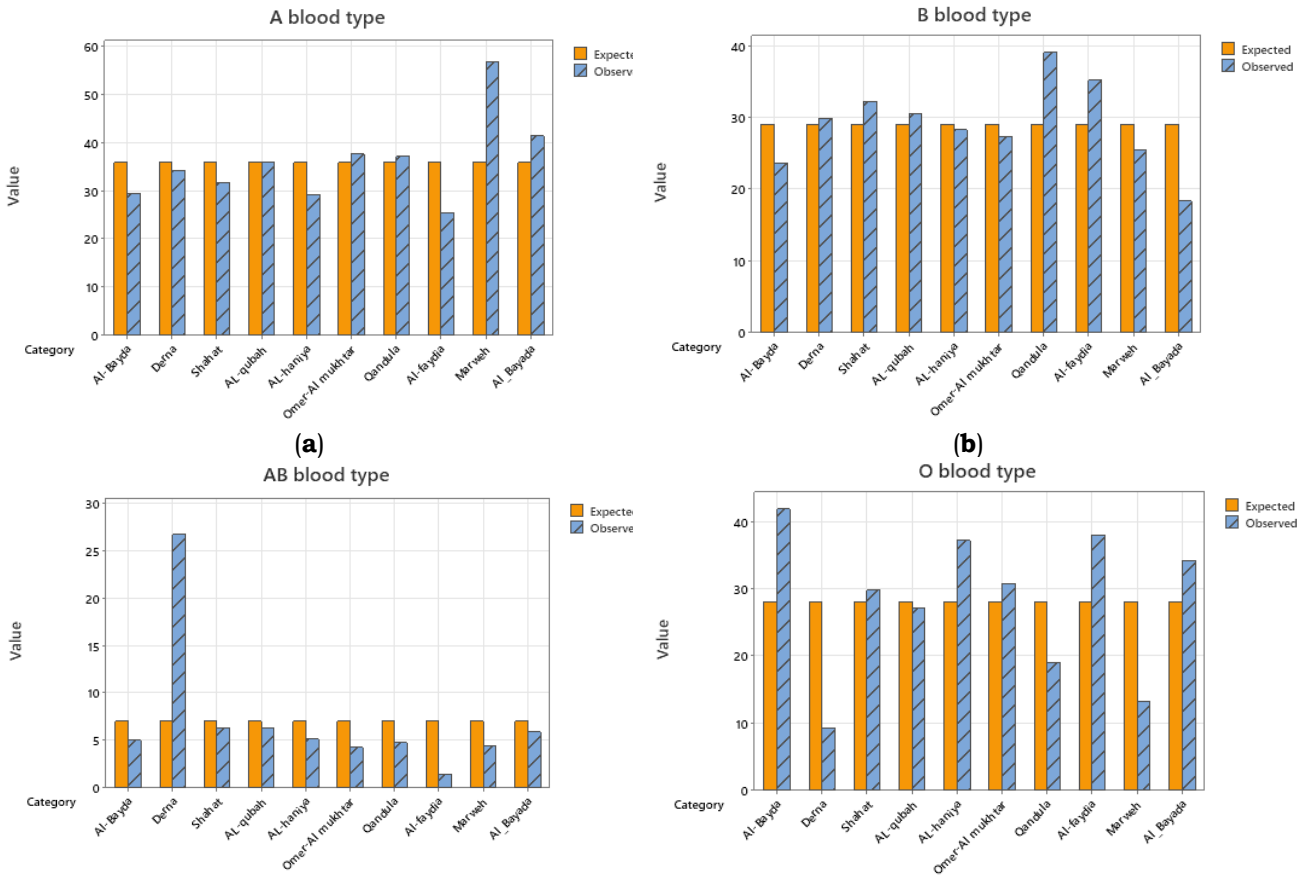


(**a**) (**b**)

Figure 2. Observed and expected value of Rh factor among towns of Al-Jabal Al-Akhdar: (a) Rh positive; (b) Rh negative



(**a**) (**b**)

(**c**) (**d**)

Figure 3. Observed and expected value of ABO blood types, Rh factor among towns of Al-Jabal Al-Akhdar: (a) Blood type A; (b) Blood type B; (c) Blood type AB; (d) Blood type O

Discussion

In a recent study, percentages of ABO blood types and Rh factor across various towns in Al-Jabal Al-Akhdar revealed notable variations. The AB blood type was particularly rare, while the A, B, and O types showed moderate prevalence. The prevalence of blood type O in this study is consistent with findings from other studies in Jordan [9]. The entire population of Al-Jabal Al-Akhdar indicated a low prevalence of the AB blood type (9.09%) and small variances among the other blood types (A: 33.37%, B: 27.92%, O: 29.63%). Other studies have reported the AB blood type to be relatively common, with a prevalence of 10% in Bangladesh and 10.58% in Pakistan [10, 11], while it was least common (2.5%) among Hispanics and North American Indians in the United States [6]. In a study in Ajdabiya, Libya, the AB blood type frequency was relatively high (15.22%) [12]. However, our study found higher percentages of blood type A in the towns. Other Libyan studies have reported a high prevalence of blood type O [12- 16]. This variation may be due to demographic differences and the specific population sample in this study. The 11.09% Rh-negative rate observed in this study aligns with rates documented for other Mediterranean groups [9]. Across towns within the Al-Jabal

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Al-Akhdar population, the 'r' allele typically shows the highest frequency. This agrees with other studies conducted in Libya [12]; however, this high r frequency has also been reported elsewhere [5, 17-19]. In contrast, the p and q alleles showed some variation between towns, indicating geographic variability in blood- type frequencies that may reflect underlying genetic diversity or demographic factors.

Conclusion

This study provides valuable data on the distribution and allele frequencies of the ABO and Rh blood type systems in the Al-Jabal Al-Akhdar region of Libya. It revealed notable variations in the distribution of blood types A, AB, and O across the towns of Al-Jabal Al-Akhdar. Allele frequencies also varied by location, reflecting genetic diversity and demographic factors. For instance, Al-Faydia exhibited the highest r-frequency, whereas Marwah recorded the lowest. Notably, the two towns are geographically distant from each other. These findings have significant implications for blood-bank administration, transfusion medicine, and regional population-genetics research. Further investigations are recommended to examine the genetic diversity and population structure of additional blood-group systems.

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Conflicts of Interest

The authors report no competing interests.

References

1. Ferguson-Smith MA, Aitken DA, Turleau C, De Grouchy J. Localisation of the human ABO:Np-1:AK-1 linkage group by regional assignment of AK-1 to 9q34. Hum Genet. 1976 Jan 26;34(1):35-43. doi: 10.1007/BF00284432.
2. Sun Y, Wang L, Niu J, Ma T, Xing L, Song A, et al. Distribution characteristics of ABO blood groups in China. Heliyon. 2022 Sep 1;8(9):e10568. doi: 10.1016/j.heliyon.2022.e10568.
3. Su M, Lu SM, Tian DP, Zhao H, Li DR, Zheng ZC. Relationship between ABO blood groups and carcinoma of esophagus and cardia in Chaoshan inhabitants of China. World J Gastroenterol. 2001 Oct;7(5):657-61. doi: 10.3748/wjg.v7.i5.657.
4. Barot T, Patel D, Shah R. Distribution of ABO and Rhesus (Rh) blood groups among voluntary blood donors in Central Gujarat, India. Int J Contemp Med Res. 2020 Jul;7(7):G1-G3. Available from: http://dx.doi.org/10.21276/ijcmr.2020.7.7.34
5. Abubakeer A, Mansour N. The Association Between ABO and Rhesus Blood Groups and Diabetes Mellitus in Libya: A Systematic Review of National Evidence. Razi Medical Journal. 2025 Sep 15:267-71.
6. Garratty G, Glynn SA, McEntire R. ABO and Rh(D) phenotype frequencies of different racial/ethnic groups in the United States. Transfusion. 2004 May;44(5):703-6. doi: 10.1111/j.1537-2995.2004.03338.x.
7. Chandra T, Gupta A. Frequency of ABO and rhesus blood groups in blood donors. Asian J Transfus Sci. 2012 Jan;6(1):52-3. doi: 10.4103/0973-6247.95057.
8. Hassawi DS. Allele Frequency and Molecular Genotypes of ABO Blood Group System in a Jordanian Population. J Med Sci. 2007;7(1):51-8. doi: 10.3923/jms.2007.51.58.
9. Abdelmonem M, Fyala A, Boraik A, Shedid M, Mohamed AH, Abdel-Rhman M. Distribution of Blood Types and ABO Gene Frequencies in Egypt. Am J Clin Pathol. 2019 Oct;152(Suppl_1):S153. doi: 10.1093/ajcp/aqz131.006.
10. Dewan G. 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. Egypt J Med Hum Genet. 2015 Apr;16(2):141-7. doi: 10.1016/j.ejmhg.2015.01.002.
11. Khattak ID, Khan TM, Khan P, Shah SM, Khattak ST, Ali A. Frequency of ABO and Rhesus blood groups in District Swat, Pakistan. J Ayub Med Coll Abbottabad. 2008 Oct-Dec;20(4):127-9. Available from: https://pubmed.ncbi.nlm.nih.gov/19999224/
12. El-Moghrabi HA, Al-Drussi I, Ziuo FY, Omar FA, El-Brghty K. Prevalence, Gender Distribution, and Allelic Distribution of ABO and Rh-D Blood Groups in AL-Salim Laboratory for Medical Analysis, Ajdabiya, Libya. Int J Sci Res. 2019;8(12):2319-7064. doi: 10.21275/sr21205012929.
13. Ameigaal S, Ageel A. A cross sectional preliminary study on the prevalence of ABO and rhesus blood groups in Bani Waleed City, Libya. Libyan Int Med Univ J. 2019 Jul-Dec;4(2):56-61. doi: 10.4103/liuj.liuj_18_19.
14. Sakal ID, Emberesh RA, Alhamoudi AA, Habhab ST, Waddan MA. Prevalence and distribution of abo and rh (d) factor among blood donors in sabratha-libya. Saudi J Life Sci. 2019;4(9):283-6. doi: 10.36348/SJLS.2019.v04i09.001.
15. Asteal FA. Distribution of ABO and Rh-D blood groups in Aljufra, Libya. J Acad Res Appl Sci. 2021 Jan;17:49-53. doi: 10.65540/jar.v17i.299.
16. Alshwesh R, Elfituri Z, Omran E, Ramih E. ABO and Rhesus Blood Group Frequency among Donors and Admitted Patients at Zawia Medical Center, AzZawya City, Libya. AlQalam J Med Appl Sci. 2024 Feb 17;7(1):142-6. doi: 10.5281/zenodo.10726287.
17. Loua A, Lamah MR, Haba NY, Camara M. Fréquence des groupes sanguins ABO et rhésus D dans la population guinéenne [Frequency of ABO and rhesus D blood groups in the Guinean population]. Transfus Clin Biol. 2007 Nov;14(5):435-9. French. doi: 10.1016/j.tracli.2007.12.008.

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18. Anifowoshe AT, Owolodun OA, Akinseye KM, Iyiola OA, Oyeyemi BF. Gene frequencies of ABO and Rh blood groups in Nigeria: A review. Egypt J Med Hum Genet. 2017 Jul;18(3):205-10. doi: 10.1016/j.ejmhg.2016.10.004.
19. Jahanpour O, Pyuza JJ, Ntiyakunze EO, Mremi A, Shao ER. ABO and Rhesus blood group distribution and frequency among blood donors at Kilimanjaro Christian Medical Center, Moshi, Tanzania. BMC Res Notes. 2017 Dec 16;10(1):738. doi: 10.1186/s13104-017-3037-3.

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