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POLYMORPHISM OF BLOOD SYSTEMS ABO AND RH (D) IN A BLOOD DONORS POPULATION OF THE KORHOGO NATIONAL BLOOD TRANSFUSION CENTRE

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ABSTRACT: A study was carried out on 632 consenting donors at the National Blood Transfusion Centre (CNTS) of the Regional Hospital of Korhogo Northern in Côte d'Ivoire to contribute to a better supply of human blood to health facilities through knowledge of the genetic frequencies of the ABO and Rhesus systems. Individual donor interviews were used to collect socio-cultural data, and the Beth-Vincent blood test and the Simonin serum test were used to perform manual blood grouping. The research showed that there are more men (92.25 %) than women (7.57 %), with approximately 1 woman for every 12 men. The average age of the donors was 33 years. The Gour ethnic group was the most common (61.06 %), followed by the Mandé (26.36 %). The phenotypic frequencies [O], [B], [A], and [AB] of the ABO system were observed in proportions of 46.52 %, 28.80 %, 19.62 %, and 5.06 %, respectively. The Rh (D) factor was 92.72 % for [Rh (D) +] and 07.28 % for [Rh (D) -] respectively. Sociological factors had no effect on the distribution of blood groups. The O allele is the most common (0.682) in this population, followed by the B and A alleles, which have frequencies of 0.186 and 0.132, respectively. The Rh (D) + allele predominated, with a frequency of 0.74 compared to 0.26 for the Rh (d) allele. According to the Hardy-Weinberg law, these various genetic structures are in panmictic equilibrium.

KEYWORDS: ABO/Rh systems, genetic frequencies, blood donors, Korhogo.

1 INTRODUCTION

In science and pathology, the ABO system and the Rhesus Rh (D) factor are of critical importance, particularly in transfusion medicine, medical immunology, and human genetics [1]. The study of these systems revealed the existence of genetic variation in human populations at an early stage [2]. The ABO system and the Rhesus factor Rh (D) were used to establish blood compatibility between two people, as well as various other factors [3]. Almost every country in the world studies the genetic structure of the ABO and Rhesus Rh (D) blood systems in order to deal with big epidemics, natural disasters, and particular anemic infectious diseases. Genetic mutations, human reproductive patterns, natural selection, and migration are all linked to this distribution [1]. The ABO system and the Rhesus factor have uncertain phenotypic, allelic, and genotypic frequencies in Côte d'Ivoire. Outside of the hospital, the need for blood transfusions and blood products has risen over time. A study is being conducted at the National Blood Transfusion Centre (CNTS) in Korhogo in order to contribute to the understanding of the genetic structure of the ABO and Rhesus systems in populations from various geographical areas of Côte d'Ivoire in order to build a credible database.

The purpose of this study is to examine ABO and Rhesus system polymorphism in the Korhogo National Blood Transfusion Centre's blood donor population. There will be new statistics on phenotypic, allelic, and genotypic frequency. These data will be compared to those from other Côte d'Ivoire regions as well as the rest of the West African sub-region.

2 MATERIALS AND METHODS

2.1 STUDY SITE

The research study was conducted at the Korhogo Regional Hospital Centre's National Blood Transfusion Centre (CNTS) (CHR). Korhogo is the seat of the Poro region's departmental government (Figure 1). It is bordered on the north by the Bagoué area and on the south by the Tchologo region [4], and it has a tropical Sudanese climate. Poro has a population of 763,852 people and covers an area of 12,500 km^2 [4].

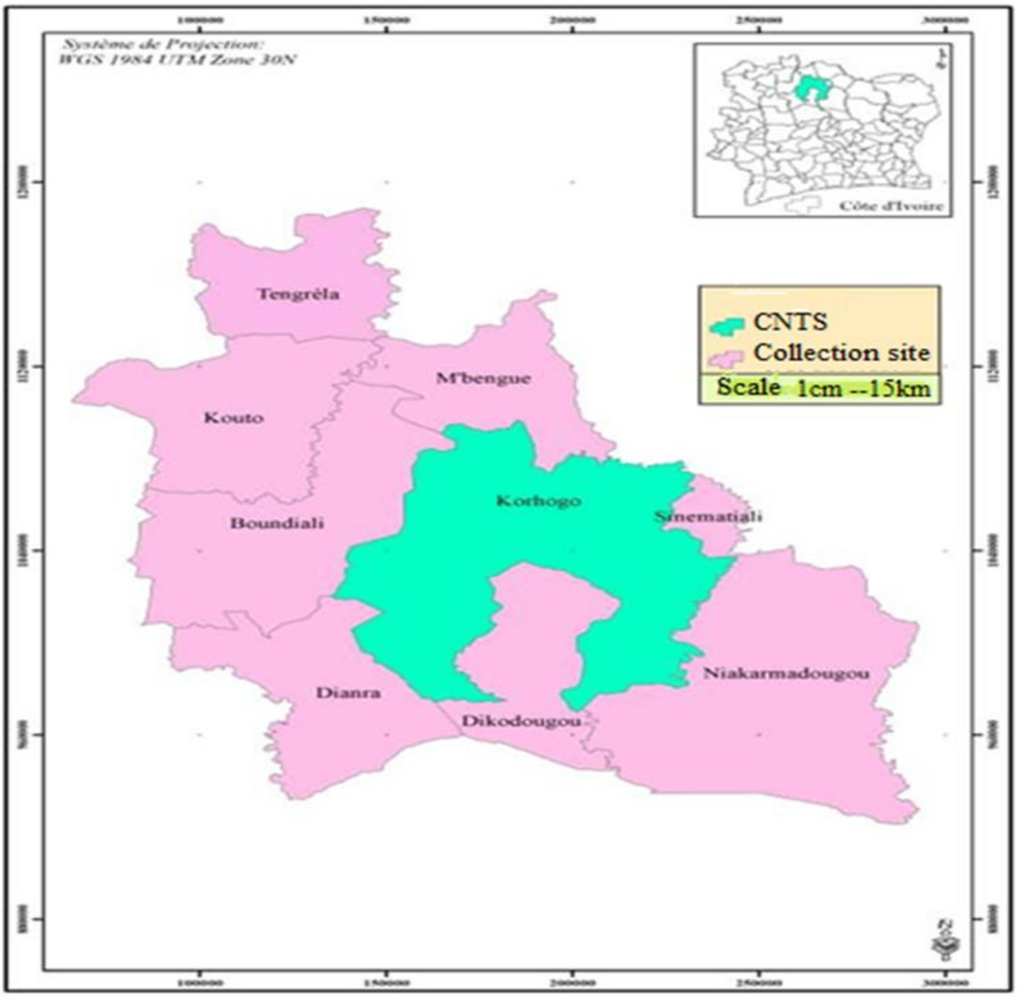

Fig. 1. Poro Region and its several departments (INS, 2014)

2.2 SELECTION OF DONORS AND BLOOD COLLECTION

Blood was obtained from 632 participants who agreed to an interview and were randomly selected from the CNTS blood donor database in Korhogo, municipality. A questionnaire was given to them to collect sociological data such as the donor's name, sex, age, religion, and ethnic group.

The puncture surface is sterilized after the tourniquet is applied to the forearm, and correct phlebotomy of a peripheral vein is performed. A 21G needle is used to collect around 5 ml of blood from dry or heparinized tubes.

2.3 BLOOD GROUPING FOR THE ABO SYSTEM AND RHESUS FACTOR

On the blood donors, two manual grouping approaches were used at the same time. The first was the Beth-Vincent or globular test, which used the Anti-A, Anti-B, and Anti-AB serum tests to search for antigens on the surface of red blood cells. The second was the Simonin (serum test), which uses A, B, and O test red cells to look for antibodies in plasma [5]. Any mismatch between the globular and serum tests prevented the donor's blood from being validated. The results were interpreted as follows: net agglutination indicates a positive reaction, whereas the absence of agglutination indicates a negative reaction (Figure 2).

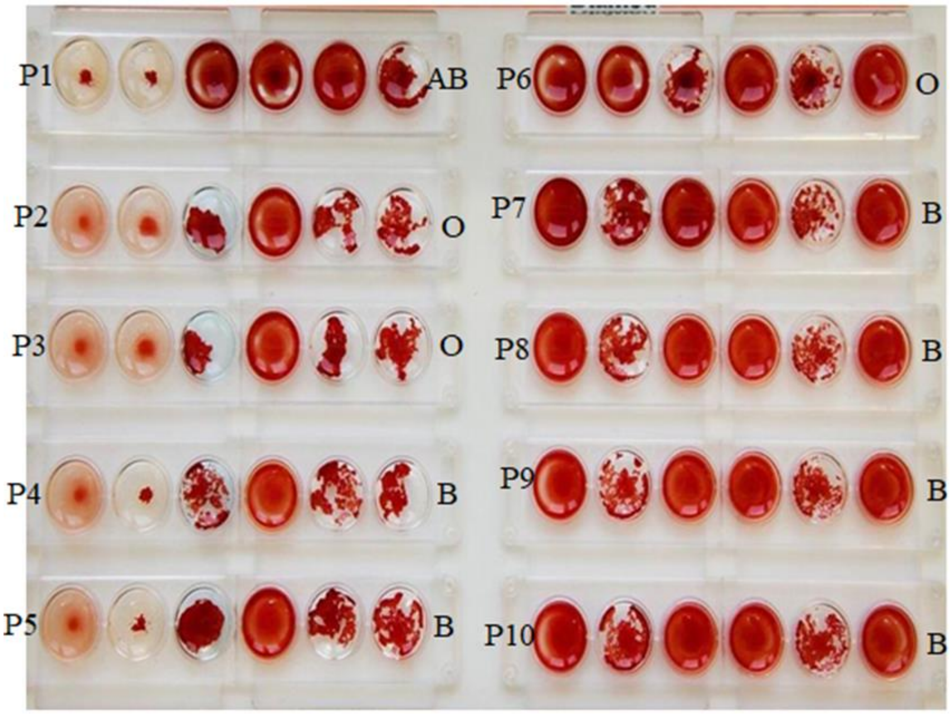

Fig. 2. Beth-Vincent and Simonin tests

The Anti-D test serum was used by Beth-Vincent to look for D antigen on the surface of red blood cells. Agglutination indicates that the D antigen is present on the subject's red blood cells, and the subject is labeled [Rh^+] (Figure 2). When there is no agglutination, the weak Rhesus is searched to confirm or refute the outcome. This test involves washing the subject's red cells with physiological water and testing them in a hemolysis tube with Anti-D test serum. The presence of agglutination in the tube indicates that the subject is [RhD^+], whereas the absence of agglutination indicates that the donor is [Rhd^-].

2.4 DATA COLLECTION

Individual interviews with the 632 blood donors collected socio-cultural information (gender, age, religion, and ethnic group). The ABO and Rhesus grouping results were used to compile data on blood groups [A], [B], or [O] and their Rhesus factor [RhD^+] or [Rhd^-].

2.5 DATA ANALYSIS

Basic statistical analysis (mean, standard deviation, frequency) was performed on socio-cultural and grouping data, followed by Chi-square tests. The phenotypic, allelic, and genotypic frequencies of ABO and Rhesus blood systems were determined using the Bernstein, Landsteiner-Weiner, and Hardy-Weinberg formulae [6, 7].

2.5.1 Allele Frequencies Of A, B, O, Rh+ And Rh-

The frequencies of the alleles A, B, and O were deduced using the Bernstein formulae listed below. Let [A], [B], and [O] be the different phenotypes, and p, q, and r be the respective frequencies of A, B, and O alleles.

In a panmictic population of infinite size, in the absence of mutation and selection, the genotype frequency will be the development of (p + q + r) 2, p, q, and r being the allele frequencies in equilibrium where p + q + r = 1.

A allele frequency $p'=1- ([O] + [B])^{1/2}$,

Allele frequency B $q'= 1- ([O] + [A])^{1/2}$,

Allele frequency O $r'= ([O])^{1/2}$.

The theoretical frequencies calculated from phenotypic data are the allele frequencies p', q', and r'. The deviation correction value D is defined as D = 1 - (p' + q' + r').

Following that, the allelic frequencies are adjusted using the following formulas:

p = (1 + D/2) p’

q = (1 + D/2) q’

r = (1 + D/2) (r’+ D/2)

If D = 0 then p = p'; q = q' and r = r'

The frequencies of Rh+ (D) and Rh- (d) alleles were calculated using the Landsteiner and Wiener formulas:

$s =1- (Rh)^{1/2}$; $t = (Rh)^{1/2}$

2.5.2 Genotypic Frequencies

Genotypic frequencies were estimated using the calculated allelic frequencies and adjusted with the Hardy-Weinberg formulae: $(p + q + r)^2 = p^2 + 2pq + q^2 + 2pr + 2qr + r^2 = 1$

AA = p^2; BB = q^2, OO = r^2, AB = 2pq; AO = 2pr; BO = 2qr.

2.5.3 Checking The Population At Panmictic Equilibrium

To ensure that the sample followed Hardy Weinberg's law, Pearson's Chi-square (2) tests ($P<0.05$) were performed between the observed and expected values.

Person Chi-square tests on the phenotypic variables were used to test two hypotheses (H0 and H1) to ensure the panmictic equilibrium of the sample used.

H0 = the Hardy-Weinberg population of blood donors at Korhogo's National Blood Transfusion Centre follows the Hardy-Weinberg law.

H1 = the blood donor population of Korhogo's National Blood Transfusion Centre does not adhere to the Hardy-Weinberg law.

3 Result

3.1 Distribution Of Socio-Cultural Data

Men outnumbered women in the donor population studied, accounting for 92.25 % vs 7.57 %. The majority of the donors (48.10 %) were between the ages of 18 and 30. They were followed by adults aged 31-50 years (46.04 %) and donors aged 51 and up (46.04 %) (Table 1). 71.82 % of these donors are Muslims. Akan, Gur, Mandé, and Krou made up 7.57 %, 61.06 %, 26.36 %, and 0.57 % of donors, respectively (Table 1).

Table 1. Distribution of CNTS donors in Korhogo according to sociological variables

Variables	Modality	Number observed	Percentage (%)	Test χ^2
Gender	Men	583	92.25	P = 0.0001
	Women	49	07.75	***
Ethnic group	Gour	404	63.92	
	Akan	50	07.91	P = 0.0001
	Mandé	173	27.37	***
	Krou	5	00.79	
Religion	Muslim	446	70.57	P = 0.0001
	Christiane	157	24.84	***
	Animist	29	04.59	
Age group	Adults	291	46.04	P = 0.0001
	Young	304	48.10	***
	Old	37	05.86	

**** The test is highly significant with P<0.001*

3.2 Phenotypic Distribution Of Blood Systems In Donors

3.2.1 ABO System And Rhesus Factor

The study sample included people of the ABO system's four (4) different phenotypic groups. Blood group [O] had the highest proportion of donors with 46.52 %, followed by blood groups [B], [A], and [AB] with 28.80 %, 19.62 %, and 5.06 %, respectively (Figure 3). This repair is unaffected by other variables such as ethnicity or gender (Table 2). The [O] phenotype appears to be more common in men (46.65 %) and women (44.90 percent), but this difference is not statistically significant (Table 2). The two phenotypes were represented in the donor population in unequal proportions, with the positive rhesus ([RhD$^+$]) accounting for 92.72 % and the negative rhesus ([Rhd$^-$] accounting for only 07.28 % (Figure 4).

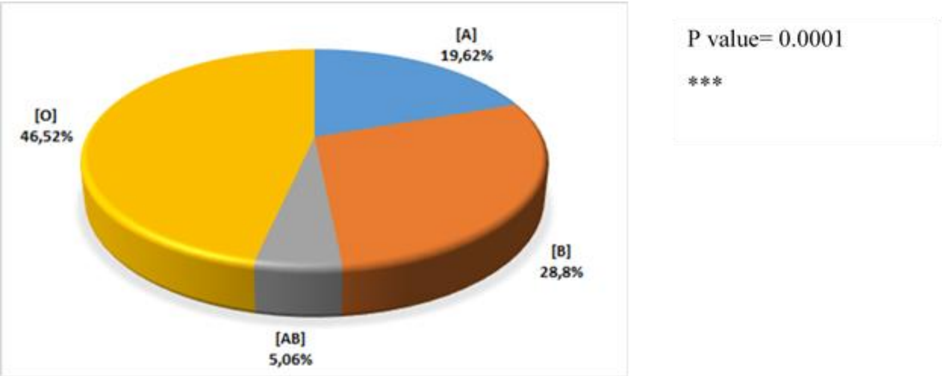

Fig. 3. Proportions of ABO blood groups in donor population

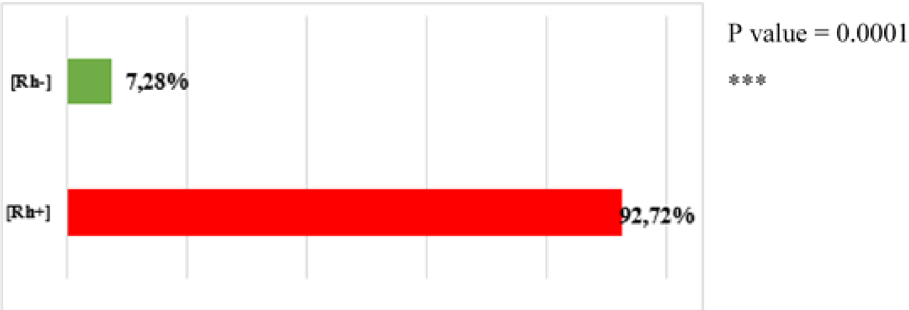

Fig. 4. Proportions of Rhesus Rh (D) factors in donor population

This distribution was unaffected by the donor's ethnicity, religion, or gender (Table 2). Nonetheless, men had a Rh-positive rate of 92.97 %, while women had a rate of 89.80 % (Table 2).

Pearson's chi-square test ($P<0.05$) revealed that no variables influenced the blood group distribution in the donor population (Table 3).

3.2.2 Relationship Between The ABO System And The Rhesus Factor

Rhesus (D) factor positivity is prevalent (92.68 %) in the Korhogo CNTS donor population. There were more rhesus-positive than rhesus-negative people regardless of donor group (Table 4), but this distribution was unchanged by blood groups according to the Pearson Chi-square test ($P<0.05$).

3.3 A, B, O, Rh+ And Rh- Allele Frequencies

Alleles A, B, and O were found in the sample at frequencies of 0.186, 0.132, and 0.682, respectively. In this donor population, the O allele was relatively common (68.2 %) (Table 5). The frequencies of the Rh+ and Rh- alleles were 0.73 and 0.27, respectively. This population had a high rate of the Rh+ allele (Table 5).

Table 2. Phenotypic distribution of the ABO system and the Rhesus factor of blood donors of the Korhogo CNTS

		Groupes ABO				**Facteur Rh**	
		A	**AB**	**B**	**O**	**Rh+**	**Rh-**
Gender	Men	19.73	5.15	28.47	46.65	92.97	07.03
	Women	18.37	4.08	32.65	44.90	89.80	10.20
Religion	Muslim	24.03	04.65	31.78	39.53	93.02	06.98
	Christiane	18.60	05.00	27.80	48.60	92.80	07.20
	Animist	00.00	33.33	66.67	00.00	66.67	33.33
Ethnic group	Gour	14.00	02.00	32.00	52.00	92.00	08.00
	Akan	19.80	05.45	27.47	47.28	92.72	07.28
	Mandé	40.00	00.00	40.00	20.00	100.0	00.00
	Krou	20.23	05.20	30.64	43.93	92.49	07.51
Age group	Adults	24.20	02.55	31.85	41.40	94.27	5.73
	Young	17.71	5.83	27.58	48.88	92.38	07.62
	Old	24.14	06.90	31.03	37.93	89.66	10.34
	Total	**19.62**	**5.06**	**28.80**	**46.52**	**92.72**	**07.28**

Table 3. Effects of sociocultural variables on blood group distribution among blood donors of the Korhogo (P<0.05)

System	Variables	χ^2 test	P value	Significance
ABO	Religion	8.882	0.228	NS
	Age group	3.278	0.579	NS
	Ethnic	3.071	0.795	NS
	Gender	0.023	0.930	NS
Rh (D)	Religion	1.039	0.595	NS
	Age group	0.955	0.620	NS
	Ethnic	0.451	0.929	NS
	Gender	0.674	0.412	NS

NS = Non-Significant at 5%

Table 4. Distribution of Rhesus factor proportions according to ABO blood types

Groups	[Rhd$^-$]	[RhD$^+$]	Total	Chi-square test
[A]	5,65 %	94,35 %	100 %	
[AB]	3,12 %	96,88 %	100 %	P = 0,350
[B]	6,04 %	93,96 %	100 %	NS
[O]	9,18 %	90,82 %	100 %	
Total	7,28 %	92,72 %	100 %	

NS: Non-Significant at 5 %

Table 5. Allelic frequencies of the ABO system and Rhesus factor of blood donors

Alleles	Theoretical frequencies	Calculated frequencies
A	p=1- ([O] + [A]) ^{½}	0,186
B	q= 1- ([O] + [B]) ^{½}	0,132
O	r= ([O]) ^{½}	0,682
Total	**632**	**1**
Rh$^+$ (D)	s = 1 – (Rh$^-$) $^{1/2}$	0,74
Rh$^-$ (d)	t = (Rh$^-$) $^{1/2}$	0,26
Total	**632**	**1**

3.4 ABO AND RH (D) BLOOD SYSTEM GENOTYPIC FREQUENCIES

The allelic frequencies of each blood system were used to estimate the expected frequencies. lists the various genotypes and their frequencies. The OO genotype has a frequency of 0.465, which is 0.035, 0.254, 0.017, 0.180, and 0.049 higher than the AA, AO, BB, BO, and AB genotypes.

For the Rhesus factor, the genotypes Rh+Rh+, Rh+Rh-, and Rh-Rh- are reflected by frequencies of 0.533, 0.073, and 0.394, respectively. The number of donors of these various genotypes was also estimated (Table 6).

Table 6. Genotype frequency distributions of the ABO system of blood donors

Genotypes	Theoretical frequencies	Calculated frequencies	Calculated numbers
		ABO system	
AA	p²	0.035	22
AO	2pr	0.254	160
BB	q²	0.017	11
BO	2qr	0.180	114
OO	r²	0.465	295
AB	2pq	0.049	31
Total	**1**	**1**	**632**
		Rhesus factor	
Rh$^+$Rh$^+$	s^2	0.533	337
Rh$^+$Rh$^-$	t^2	0.073	46
Rh$^-$Rh$^-$	2st	0.394	249
Total	**1**	**1**	**632**

p, q, r, s and t represent respectively the allelic frequencies of A, B, O, Rh + and Rh-

3.5 PANMIXIA

Both blood systems accepted the hypothesis that this population follows Hardy-law. Weinberg's (Table 7).

Table 7. Distribution of blood donors ABO phenotypic numbers

Phenotypes	Theoretical numbers	Calculated numbers	Observed numbers	Chi-square calculated
ABO system				
[A]	(P^2+2pr)	182	182	0.000
[B]	(q^2+2qr)	125	125	0.000
[AB]	(2pq)	31	31	0.000
[O]	(r^2)	294	294	0.000
Total	**1**	**632**	**632**	**0.000**
Rhesus factor				
[Rh+]	s^2 + 2st	582	586	0.043
[Rh-]	t^2	50	46	0.320
Total	**1**	**632**	**632**	**0.363**

*ABO system α = 0.05 df_1 = 6-3 = 3 **χ^2** cal_1 = 0.000 **χ^2** $read_1$ = 7.82*
*Rhesus Factor α = 0.05 df_2 = 3-2 = 1 **χ^2** cal_2 = 0.363 **χ^2** $read_2$ = 3.84*
***χ^2 cal < χ^2 read** then H0 is accepted and H1 rejected.*

4 DISCUSSION

Men outmatched women in this Korhogo blood donor population. This result is due to the characteristics repair of the Ivorian population, which shows a predominance of men, according to the 2014 general census [4]. Furthermore, the highly active maternity situation of women aged 31 to 50 could explain this result. To begin, a population dominated by young people can explain the high frequency (48.10 %) of young people. In fact, according to the most recent general census in Côte d'Ivoire [4], young people under the age of 35 account for 77.30 % of the Ivorian population. The tendency of adults (31 to 60 years old) to donate blood in order to save lives and benefit from a health check-up provided by the CNTS justifies their interest in giving blood. Donors over the age of 60 have a low frequency because they are a smaller proportion of the population and rarely exceed 3 % [4]. These people have health issues as well, and the age limit for donating blood is 65 years [8]. A study on blood donors by age group in Guinea, which shares a border with Côte d'Ivoire, revealed similar results. The same order of predominance of the age groups 18-30, 31-50, and over 50 was observed, with frequencies of 45.5 %, 42 %, and 12.5 % respectively [9]. According to religion, the repair of blood donors revealed that the Muslim religion is dominant in this area, with a rate of 70.57 %. This rate is due to the study area (Poro Region in northern Côte d'Ivoire), where the majority of the population practices Islam [10]. The Christian religion has a presence of 23.79 %, which is justified by the presence of some halogen peoples in this region as well as the interest of some natives in practicing this religion. With a frequency of 4.39 percent, animists are few in number. In fact, this is one of the ancestors of the population studied's first and earliest religions [10]. It is declining because the presence of new religions established in the study area is having a significant impact on it. This was also observed by the Atef Omas Foundation [11]. Gour is the most commonly represented ethnic group regardless of blood group (61.06 %). Indeed, Sénoufo and its various subgroups comprise the large Gour ethnic group (Lobi, Camara, Nafara, Djamala). Furthermore, Korhogo is the capital of the Sénoufo (indigenous) Gour region. Dulat *et al.* [12] discovered a high presence of Senufo in this Poro region in a similar study in Côte d'Ivoire.

The phenotypic distribution of ABO among donors in this population was 46.52 %; 28.80 %; 19.62 %; and 5.06 % for groups O, B, A, and AB, respectively. According to the chi-square test results, this distribution resembles the normal distribution of a natural population in Hardy-Weinberg equilibrium. Korhogo blood donors would come from a non-inbred population. Group O has the highest representation (64.51 %), while group AB has the lowest (5.15 %). Many other studies have found this order of predominance, such as Alla [13] in Côte d'Ivoire, who found 49 % group O, 24 % group B, 22 % group A, and 5 % group AB. The phenotypic distribution of blood donors from groups O, B, A, and AB in Abidjan revealed a similarity with frequencies of 50.97 %, 23.18 %, 21.73 percent, and 4.12 %, respectively [14]. Oumou [15] observed the same thing in Mali, with frequencies of 45.70 % group O, 24.50 % group B, 24 % group A, and 5.80 % group AB. Similar studies in most West African countries reveal the same distributions. In Guinea, for example, blood groups O, B, A, and AB are distributed at 48.88 %, 23.86 %, 22.54 %, and 4.72 %, respectively [9]. In Burkina Faso, the distribution was 51 percent group O, 23 % group B, 19 % group A, and 7 % group AB [16]. According to Anifowoshe et al. [17], these proportions are similar to those found in Nigeria (52.93 %; 22.77 %; 20.64 %; and 3.66 %).

The distribution of ABO system antigens in Côte d'Ivoire differs from that of European countries. In France, for example, group A is the most common, accounting for 45 % of the population, followed by group O (43 %), group B (9 %), and group AB ([18], [13]). Mainfray [19] discovered a 44 % predominance of group A in Brittany, followed by 42 % of group O, 10 % of B, and 4 % of AB. In Switzerland, the A phenotype is the most prominent (47.12 %) in a Swiss military population, followed by groups O, B, and AB, which have proportions of 39.5 %, 9.1 %, and 4.1 %, respectively [20]. The human population of different regions of the globe, as well as different migratory flows, would influence this repair, which varies from continent to continent. The phenotypic distribution at the Rhesus factor level reveals that the majority of this population is D antigen or Rhesus positive (Rh^+). Other similar studies have yielded similar results of 92.95 % Rh (D^+) and 7.05 % Rh negative ([14], [16], [1], [19]). The results of this study differ from those of Oukaci [21], who discovered more people (30.36 %) with negative rhesus in the population of the Algerian Wilaya of Bejaa. Korhogo's population is more likely to avoid haematological anti-D accidents than the Wilaya of Bejaa's population. The genotypic and phenotypic frequencies of the ABO systems and Rhesus factors do not differ significantly by sex, region of origin, or ethnic group. They are similar to the various studies conducted by Loua *et al.* [9] in Guinea, where sociological variables had no effect on the genetic distribution of the ABO system.

At the 5% significance level, the frequencies of the A, B, and O alleles in the Korhogo blood donor population were 0.13, 0.19, and 0.68, respectively. The results of the study of this study are consistent with previous research conducted at the Abidjan Blood Transfusion Centre (Côte d'Ivoire) by Ouédraogo *et al.* [14] and confirm the predominance of the O allele, followed by the B allele and the A allele, with proportions of 0.71, 0.15, and 0.14, respectively. In contrast to this finding and that of Ouédraogo et al. [14], Tahria [22] found that the A, B, and O alleles had frequencies of 0.24, 0.13, and 0.63 in Algeria. According to Tlamçani [23], the allele frequencies for O, A, and B were 0.71, 0.18, and 0.11, respectively, in Western Morocco. These findings indicate that the O allele is more common in African human populations than in Europe, where allele A is more common. The expected genotypes were AA, AO, BB, BO, OO, and AB, with frequencies of 0.02, 0.18, 0.05, 0.23, 0.47, and 0.04 respectively. These frequencies are similar to those obtained by Ouédraogo *et al.* [14] in Abidjan. Tahria's [23] observations, however, differed from those in Korhogo. The variation in the frequencies of the A, B, and O alleles in each country is what distinguishes them.

5 CONCLUSION

The genetic frequencies (phenotypic, allelic, and genotypic) of donors in the Poro region have been determined through the study of ABO and Rh (D) blood system polymorphism. Although there are minor differences, the distribution of these gene frequencies is similar to that found in other regions of Côte d'Ivoire.

These findings will aid in the strengthening of regional blood system databases in order to improve the supply of blood and blood products. These two systems' genetic structure is similar to that of West African countries, allowing for integrated management of sub-regional blood structures.

This distribution differs from that of Caucasian populations in Europe, indicating a structuring in relation to different geographical regions of the world.

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INTERESTS CONFLICT

Because all of the authors contributed equally to the design, execution, completion of work, and framing of the manuscript, there is no conflict of interest to be declared.

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