Original Article

Red cell phenotyping of blood from donors at the National blood center of Malaysia

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Abstract:

Background: Human blood groups are polymorphic and inherited integral structures of the red cell membrane. More than 300 red cell antigens have been identified and further categorized into 30 major discrete systems. Their distribution varies in different communities and ethnic groups. **Aims:** This work was set to determine the prevalence of red cell phenotypes in donors from the major ethnic groups in Malaysia, namely, Malays, Chinese, and Indians. **Materials and Methods:** The work utilized the dextran acrylamide gel technique in which four types of gel cards were used to identify the blood groups of 594 subjects collected at the National Blood Transfusion Centre, Malaysia. **Results:** Blood group O and CDe/CDe (R1R1) were the most common in all ethnic groups. The cde/cde (rr) was more prevalent amongst Indians. The rare phenotypes found were cDE/cDE(R2R2) and cDE/CDE(R2Rz). With the Lewis system, the distribution of Le(a-b+) was similar among the ethnic groups. The rarest phenotype Fy(a-b-) was discovered in two donors. Jk(a-b-) was found in seven Malays and in two Indians. In the MNSs system, MN was common in Malays and Chinese, while the MM was more common among Indians. The rare SS was found in 19 donors. Malay and Chinese subjects had high P1 Negative blood but Indians showed high P1 positive blood. Within the Kell System, the very rare KK type was found in six subjects. **Conclusions:** The results obtained serve as an established database for the distribution of red cell phenotypes based on the blood group systems of donors from the major ethnic groups in Malaysia.

Key words:

Blood donors, distribution, ethnic groups, red cell phenotypes

Introduction

Human blood groups are unique surface membrane structures of red blood cells (RBCs), characterized by inherited polymorphisms. Since the discovery of the ABO system early in the twentieth century, they have been used as genetic markers of human polymorphism. Many blood group antigens and their genes have been identified, and their physiological roles uncovered,[1] and later they were found to be important determinants in transfusion medicine.[2] A total of 308 red cell antigens have been identified and classified into systems, collections, low-frequency antigens, and high-frequency antigens. Of these 308 antigens, 270 have been categorized into 30 major discrete systems.[3-5] In addition, well-known differences in the distribution of the blood group antigens among people of different races have been documented, such as those differences between Chinese and Caucasians in Taiwan,[6] as well as the differences in the distribution of blood groups in different ethnic and geographical areas.[7] Various studies have been performed to compare the red cell phenotype frequencies among the ethnic groups and populations, especially the phenotypes that are important in blood transfusion and in transplantation. Many blood group antibodies may cause hemolytic transfusion reactions.[2] The ABO blood group and D status of blood donors and recipients are always taken into account when RBCs are transfused.[8] Other RBC antigens are usually not considered unless the recipient had previously undergone alloimmunization. This points out to the need to phenotyping RBC units to one or several antigenic systems, since only ABO and Rh (D) are usually typed. The supply of phenotyped RBCs for patients with several RBC antibodies presents a difficult task to hospital blood banks and regional blood centers,[9] since the Malaysian human population is composed of a number of ethnicities, namely Malays (54%), Chinese (25.1%), Indians (7.5%), and other ethnic origins (13.1%).[10]

Hence, this work was carried out at the National Blood Center, Malaysia, to determine the prevalence of red cell phenotypes in donors from the major ethnic groups in Malaysia. The study was based on studying the prevalence and differential expression of the ABO, Rhesus, Lewis, Duffy, Kidd, MNSs, P, and Kell, antigens.

Materials and Methods

This study was approved by the Research and Ethics

Committee, Advanced Medical And Dental Institute, Universiti Sains Malaysia.

Sample size and inclusion criteria

The sample size was calculated as devised previously.[11] The inclusion criteria used the national guidelines for blood donation in Malaysia, which, generally, considered age, medical history, and infections. The information required was taken from the donors' information sheet.

Data collection

A total number of 594 donors were included in this study, consisting of 200 Malays, 274 Chinese, and 120 Indians. Of those, 150 donors were voluntary donors who attended the National Blood Centre (NBC) or during mobile blood donation sessions between November and December 2006. The remaining 444 donors were randomly selected from the data of donors at the NBC. Peripheral blood samples were collected in an ethylenediamenetetraacetic acid (EDTA) tube for ABO and Rh grouping as a routine test for blood donation. The test was performed using the Olympus PK7200 automated machine. A barcode number was given to each patient after the ABO and Rh regrouping tests were performed and the results of the ABO and Rh grouping of these subjects were then recorded in a datasheet.

Laboratory procedures

The tests utilized the dextran acrylamide gel technique.[12-14] In this technique, the gel is placed in microtubes containing anti-immunoglobulin G to detect accurately and reproducibly the presence of red cells sensitized with alloantibodies. Four types of gel cards were used (Diamed Ag, Switzerland). These cards were as explained below. First was the ID-Card RhD with the phenotypes anti-C, anti-c, anti-E, and anti-e. The second ID-Card Antigen Profile I was for anti-P1, anti-Le^a, anti-Le^b, anti-Lu^a, and anti-Lu^b. The third ID-Card Antigen Profile II was for the phenotypes anti-k, anti-Kp^a, anti-Kp^b, anti-Jk^a, and anti-Jk^b, whereas the fourth ID-Card Antigen profile III was with the ID-sera specific for anti-M, anti-N, anti-S, anti-s, anti Fy^a, anti-Fy^b.

Preparation of blood samples

For all ID-Cards except for ID-Card Antigen Profile III, a 5% red cell suspension was prepared and mixed gently, in a suspension tube using 0.5 ml of ID-Diluent 1 (Diamed Ag, Switzerland) and 25 µl of packed cells. The red cell suspension was incubated for 10 minutes at room temperature. After incubation, the cell suspension would be used within 15 minutes. As for ID-Card Antigen Profile III, a 0.8% red cell suspension was prepared in a clean tube using 1.0 ml of ID-Diluent 2 (modified LISS) (Diamed Ag, Switzerland) and 10 µl of packed cells and mixed gently. The cell suspension would be used immediately.

Test procedure

The test was performed as instructed by the manufacturer. Briefly, after labeling the cards, an aliquot of the RBC suspension was pipetted into the microtube, and centrifuged for 10 minutes. The ID-test sera (Diamed Ag, Switzerland) were then added and incubated in the ID-Incubator for 15 minutes at 37°C. This was followed by centrifugation for 10 minutes. The result reactions were interpreted and recorded in the worksheet. All the rare blood group results were duplicated. The reactions were graded from 0 to ++++. The microtube control must show a negative reaction. A positive reaction of the control would render the tests invalid, and the tests would be repeated.

Statistical analyses

The Statistical Package for Social Sciences was used (SPSS version 12.0 software package for Macintosh, SPSS Inc., Chicago, IL, USA). The prevalence of blood phenotypes was described using descriptive statistics. The 95% CI (exact binomial CI) was also obtained for each of the prevalences. The results were expressed in percentages, and the differences in prevalence between the studied ethnic groups were assessed using Chi-square test or Fisher's Exact Test if the Chi-square tests assumptions were not satisfied.

Results

A comparison of the distribution of the red cell phenotypes amongst the ethnic groups in Malaysia has been performed. It was found that blood group O was the highest among the Malays and the Chinese (36.7%), whereas in Indian donors, blood group O and blood group B were of equal frequencies. The frequencies were 34.5% in Malays, 38.3% in Chinese, and 36.7% in Indians. Blood group AB was of the lowest prevalence in Malays (7.5%), in Chinese (10.9%), and in Indian (6.7%).

It was also found that the Rh Type, Lewis, Ss, and P blood group systems had significantly different distributions among the Malays, the Chinese, and the Indian donors [Tables 1 and 2]. The RhD-positive subjects exceeded 97.5%. When analyzed according to race, the distribution was 99.5% in Malays, 98.5% in Chinese, and 91.7% in Indians. It was also found that the CDe/CDe (R1R1) genotype was most frequent in Malays (61.5%), then in the Chinese (53.6%), and then in Indians (50%). However, the RhD-Negative genotype cde/cde (rr) was relatively more frequently expressed in Indian donors. The cDE/cDE (R2R2) genotype was relatively more prevalent in Chinese (9.1%) as compared with Malays and Indians (1.0% and 0.8%, respectively). The cDE/CDE (R2Rz) was found in two Malay donors. The distribution of genotypes was influenced by ethnicity as the incidence of Rh genes differed [Table 3].

The study of the Lewis system showed that the expression of the Le (a-b+) exceeded 50% in all the study groups, with 68.6% in the Chinese, 58.3% in the Indians, and 57.5% in the Malays. The expression of the Le (a+b+) phenotype showed a lower expression, especially among the Indians: 12% in the Chinese, 7% in the Malays, and 0.8% in the Indians. The differences in the distribution of these phenotypes were statistically significant (P value <0.001) [Tables 1 and 2].

In the Duffy system, the Fy (a+b-) has been found to be most common phenotype in blood donors in all ethnic groups: 74% in Malays, 85.4% in the Chinese, and 40.8% in Indians. The Fy (a-b-) phenotype was found only in two donors, one Malay, and one Chinese. However, the Duffy system showed significant differences in expression in the three study ethnic groups (P value <0.001).

Of the Kidd phenotypes, the Jk (a+b+) was the commonest in all ethnic groups: 43.0% in Malays, 50.7% in the Chinese, and 43.3% in Indians. However, nine donors had the Jk (a-b-) phenotype, of whom seven were Malays and two were Indians. The distribution had no statistical significance (P value >0.001) [Tables 1 and 2].

Table 1: Distribution of the red cell phenotypes among 200 Malay, 274 Chinese, and 120 Indian blood donors at NBC

Blood Group System	Malay		Chinese		Indian	
	n	% (95% CI)	No	% (95% CI)	No	% (95% CI)
ABO System						
A	61	30.5 (24.2, 37.3)	75	27.4 (22.2, 33.1)	24	20.0 (13.3, 28.3)
B	55	27.5 (21.4, 34.2)	64	23.4 (18.5, 28.8)	44	36.7 (28.1, 45.9)
AB	15	7.5 (4.3, 12.1)	30	10.9 (7.5, 15.3)	8	6.7 (2.9, 12.7)
O	69	34.5 (27.9, 41.6)	105	38.3 (32.5, 44.4)	44	36.7 (28.1, 45.9)
Rh System						
Rh Positive	199	99.5 (97.2, 99.9)	270	98.5 (96.3, 99.6)	110	91.7 (85.2, 95.9)
Rh Negative	1	0.5 (0, 2.8)	4	1.5 (0.3, 3.7)	10	8.3 (4.1, 14.8)
Rh Type						
CDe/CDe (R1R1)	123	61.5 (54.4, 68.3)	147	53.6 (47.6, 59.7)	60	50.0 (40.7, 59.3)
*cDE/cDE (R2R2)	2	1.0 (0.1, 3.6)	25	9.1 (6.0, 13.2)	1	0.8 (0, 4.6)
CDe/cDE (R1R2)	30	15.0 (10.4, 20.7)	68	24.8 (19.2, 30.4)	15	12.5 (7.2, 19.8)
CDe/cde (R1r)	30	15.0 (10.4, 20.7)	18	6.6 (3.9, 10.2)	28	23.3 (16.1, 32.0)
*cde/cde (rr)	1	0.5 (0, 2.8)	2	0.7 (0, 2.6)	9	7.5 (3.5, 13.8)
cDE/cde (R2r)	5	2.5 (0.8, 5.7)	8	2.9 (1.3, 5.7)	6	5.0 (1.9, 10.6)
CDe/CDE (R1Rz)	7	3.5 (1.4, 7.1)	6	2.2 (0.8, 4.7)	1	0.8 (0, 4.6)
*cDE/CDE (R2Rz)	2	1.0 (0.1, 3.6)	0	0 (0, 1.3)	0	0 (0, 3.0)
Lewis System						
Le(a+b+)	14	7.0 (3.9, 11.5)	33	12.0 (8.4, 16.5)	1	0.8 (0, 4.6)
Le(a-b-)	44	22.0 (16.5, 28.4)	34	12.4 (8.7, 16.9)	29	24.2 (16.8, 32.9)
Le(a+b-)	27	13.5 (9.1, 19.0)	19	6.9 (4.2, 10.6)	20	16.7 (10.5, 24.6)
Le(a-b+)	115	57.5 (50.3, 64.4)	188	68.6 (62.8, 74.1)	70	58.3 (49.0, 67.3)
Duffy System						
Fy(a+b+)	46	23.0 (17.4, 29.5)	35	12.8 (9.1, 17.3)	54	45.0 (36.0, 54.3)
*Fy(a-b-)	1	0.5 (0, 2.8)	1	0.4 (0, 2.0)	0	0 (0, 3.0)
Fy(a+b-)	148	74.0 (67.3, 79.9)	234	85.4 (80.7, 89.3)	49	40.8 (32.0, 50.2)
Fy(a-b+)	5	2.5 (0.8, 5.7)	4	1.5 (0.3, 3.7)	17	14.2 (8.5, 21.7)
Kidd System						
Jk(a+b+)	86	43.0 (36.0, 50.2)	139	50.7 (44.6, 56.8)	52	43.3 (34.3, 52.7)
*Jk(a-b-)	7	3.5 (1.4, 7.1)	0	0 (0, 1.31)	2	1.7 (0.2, 5.9)
Jk(a+b-)	72	36.0 (29.4, 43.1)	67	24.5 (19.5, 30.0)	42	35.0 (26.5, 44.2)
Jk(a-b+)	35	17.5(12.5, 23.5)	68	24.8 (19.8, 30.4)	24	20.0 (13.3, 28.3)
MNSs System						
MM	75	37.5 (30.8, 44.7)	94	34.3 (28.7, 40.3)	53	44.2 (35.1, 53.5)
MN	88	44.0 (37.0, 51.2)	118	43.1 (37.1, 49.2)	45	37.5 (28.8, 46.8)
NN	37	18.5 (13.4, 24.6)	62	22.6 (17.8. 28.0)	22	18.3 (11.9, 26.4)
*SS	3	1.5 (0.3, 4.3)	2	0.7 (0, 2.6)	14	11.7 (6.5, 18.8)
Ss	31	15.5 (10.8, 21.3)	20	7.3 (4.5, 11.0)	50	41.7 (32.7, 51.0)
ss	166	83.0 (77.1, 87.9)	252	92.0 (88.1, 94.9)	56	46.7 (37.5, 56.0)
Kell System						
*KK	1	0.5 (0, 2.8)	3	1.1 (0.2, 3.2)	2	1.7 (0.2, 5.9)
Kk	1	0.5 (0, 2.8)	1	0.4 (0, 2.0)	1	0.8 (0, 4.6)
kk	198	99.0 (96.4, 99.9)	270	98.5 (96.3, 99.6)	117	97.5 (92.9, 99.5)
P System						
P1 Positive	80	40.0 (33.2,47.1)	85	31.0 (25.6, 36.9)	82	68.3 (59.2, 76.5)
PI Negative	120	60.0 (52.9, 66.8)	189	69.0 (63.1, 74.4)	38	31.7 (23.5, 40.8)

*: Rare blood group

In the MNSs system, M+N+ was common in the Malay donors (44.0%) and in the Chinese donors (43.1%). In the Indian donors, however, M+M+ was the most frequent at the rate of 44.2%. Nineteen donors had the S+S+ phenotype which was more frequent among the Indian donors (11.7%) and considerably lower in the Malay (1.5%) and the Chinese (0.7%) donors. The donor MN phenotype showed no significant difference between ethnic groups (*P* value >0.001) but the Ss phenotype was with significant differences (*P* value <0.001).

The P1-phenotype was prevalent in 40% of the Malays, in 31% of the Chinese, and in 68.3% of the Indians. These differences were significant (*P* value <0.001).

In the Kell system, the majority of the blood donors were kk positive: 99.0% in Malays (99.0%), 98.5% in the Chinese, and 97.5% in the Indians. Only six KK-positive donors were found (three Chinese, two Indians, and one Malay). The differences among the groups were not significant (*P* value >0.001).

Discussion

The blood group systems of 594 subjects from three ethnic groups, Malays, Chinese, and Indians were studied using the gel card method. This method was chosen because of its simplicity and efficacy and its practicality in population studies.[15,16] There are notable racial differences in the frequency of several blood group antigens.

The four phenotypes: A, B, O, and AB are present in all human

Table 2: Comparison of the prevalence of the red cell phenotypes among donors of the different ethnic groups at the NBC as analyzed by Chi-square test or Fisher's Exact Test of Chi-square

Blood Group	n	Malay	Chinese	Indian	x^2 stat (df)	*P* value
ABO System						
A	160	61	75	24	11.3529	0.078
B	163	55	64	44	(6)	
AB	53	15	30	8		
O	218	69	105	44		
Rh System						
Rh Positive	579	199	270	110	21.042 (2)	0.000
Rh Negative	15	1	4	10		
Rh Type						
CDe/CDe (R1R1)	330	123	147	60	82.042(14)	0.000[a]
*cDE/cDE (R2R2)	28	2	25	1		
CDe/cDE (R1R2)	113	30	68	15		
CDe/cde (R1r)	76	30	18	28		
*cde/cde (rr)	12	1	2	9		
cDE/cde (R2r)	19	5	8	6		
CDe/CDE (R1Rz)	14	7	6	1		
*cDE/CDE (R2Rz)	2	2	0	0		
Lewis System						
Le(a+b+)	48	14	33	1	33.892 (6)	0.000[a]
Le(a-b-)	107	44	34	29		
Le(a+b-)	66	27	19	20		
Le(a-b+)	373	115	188	70		
Duffy System						
Fy(a+b+)	135	46	35	54	94.855 (6)	0.000[a]
*Fy(a-b-)	2	1	1	0		
Fy(a+b-)	431	148	234	49		
Fy(a-b+)	26	5	4	17		
Kidd System						
Jk(a+b+)	277	86	139	52	20.303 (6)	0.002[a]
*Jk(a-b-)	9	7	0	2		
Jk(a+b-)	181	72	67	42		
Jk(a-b+)	127	35	68	24		
MNSs System						
MM	222	75	94	53	4.274 (4)	0.370
MN	251	88	118	45		
NN	121	37	62	22		
*SS	19	3	2	14	114.148	0.000
Ss	101	31	20	50	(4)	
ss	474	166	252	56		
Kell System						
*KK	6	1	3	2	1.427 (4)	0.727[a]
Kk	3	1	1	1		
kk	585	198	270	117		
P System						
P1 Positive	247	80	85	82	48.137 (2)	0.000
PI Negative	347	120	189	38		

[a]Fisher's Exact Test

populations, but their frequencies differ substantially throughout the world.[2] In this study, blood group O was the highest of all blood groups in all Malays and Chinese, whereas blood group O and blood group B were of equal frequencies among Indians. Indians in India and Thailand were found to have high blood group O in their populations with blood group B being the second commonest blood group after O.[17] Blood group A was the second commonest blood group amongst Malays and Chinese followed by group B. The least common group in all ethnic groups was the AB group. In a previous study of Asian populations, a similar trend of high frequency of group O 43% followed by groups A (27%) and B (25%) were reported.[17] Similarly, Thai donors also indicated highest occurrence with Group O (40.5%) and lowest with group AB (8.5%) [Table 4].[7,16,18]

With the Rh system, it has been concluded that more than 97.5% of donors in this study were Rh positive, with the CDe/CDe(R1R1) being of highest expression. When compared with previous works on Thai and Chinese donors, the CDe/CDe (R1R1) has also been reported to be of the highest occurrence.[2,16] RhD Negative with genotype cde/cde(rr) was very low in Malay and Chinese subjects but was relatively high in Indian subjects at 7.5%. The cde/cde (rr) varies in its prevalence among different ethnic groups. It was reported to be expressed in 35% of Caucasians, 26% of Blacks, and only 3% among Asians.[16-19] The cDE/cDE(R2R2) was more prevalent in the Chinese donors than in other ethnic groups, with a distribution similar to that of the Chinese population in Hong Kong.[2] Moreover, the cDE/CDE (R2Rz), which is considered to be a rare phenotype[18] was found in 2 Malays donors [Table 5].[4,7,18-20]

The findings with the Lewis system are comparable with those in the Japanese donors[18,20] and the Chinese donors.[2] As the Le(a+b+) is rare in European and African populations due to a fucosyltransferase encoded by a variant secretor allele that competes less efficiently with the Le fucosyltransferase,[20] it is relatively common in persons of Asian origin, as for example, Taiwanese and Japanese, with incidence ranging from 10% to 40%.[5,19] In the current study, and although it is slightly lower, it is still comparable with the previous findings in Asian groups. However, the prevalence is very low among Indians (0.8%). The

Table 3: Distribution of the Rh system genotypes expressed as percentages

Rh genotype	NBC Blood Donors		
	Malay (%)	Chinese (%)	Indian (%)
CDe/CDe (R1R1)	61.5	53.6	50.0
cDE/cDE (R2R2)	1.0	9.1	0.8
CDe/cDE (R1R2)	15.0	24.8	12.5
CDe/cde (R1r)	15.0	6.7	23.4
cde/cde (rr)	0.5	0.7	7.5
cDE/cde (R2r)	2.5	2.9	5.0
CDe/CDE	3.5	2.2	0.8
cDE/CDE	1.0	0	0

Table 4: Phenotypes and frequencies (%) in the ABO system[7,16,18]

Blood Group	Other Populations					Malaysians (NBC Blood Donors)		
	Caucasians	Blacks	Asians	Mexicans	Thais	Malays	Chinese	Indians
A	41	27	27	28	20.5	30.5	27.4	20.0
B	10	20	25	13	30.5	27.5	23.4	36.7
AB	4	4	5	4	8.5	7.5	10.9	6.6
O	45	49	43	55	40.5	34.5	38.3	36.7

Table 5: Genotypes and frequencies (%) in the Rh System[4,7,18-20]

Rh Genotype	Other Populations					Malaysians (NBC Blood Donors)		
	Caucasians	Blacks	Asians	Native ˜Americans	Thais	Malays	Chinese	Indians
CDe/CDe (R1R1)	42	17	70	44	51.5	61.5	53.6	50.0
cDE/cDE (R2R2)	2	1	21	34		1.0	9.1	0.8
CDe/cDE (R1R2)	13	4	5	4		15.0	24.8	12.5
CDe/cde (R1r)	15	7	-	6		15.0	6.7	23.4
cde/cde (rr)	35	26	3	6	low	0.5	0.7	7.5
cDE/cde (R2r)	12	16	-	-		2.5	2.9	5.0
CDe/CDE (R1Rz)	<0.2%	<0.2%	-	-		3.5	2.2	0.8
cDE/CDE (R2Rz)	0	0	1	6		1.0	0	0

Table 6: Phenotypes and frequencies (%) in the Lewis System[4,18,20]

Phenotype	Other Populations			Malaysians (NBC Blood Donors)		
	Caucasians	Blacks	Japanese	Malays	Chinese	Indians
Le(a+b-)	22	23	0.2	13.5	6.9	16.7
Le(a-b+)	72	55	73	57.5	68.6	58.3
Le(a+b+)	Rare	Rare	16.8	7	12	0.8
Le(a-b-)	6	22-30	10	22	12.5	24.2

Table 7: Phenotypes and frequencies (%) in the Duffy System[7,18,21,23]

Phenotype	Other Populations					Malaysian (NBC Blood Donors)		
	Caucasians	Blacks	Chinese	Japanese	Thai	Malays	Chinese	Indians
Fy(a+b-)	17	9	90.8	81.5	69	74	85.4	40.8
Fy(a-b+)	34	22	0.3	0.9	3	2.5	1.5	14.2
Fy(a+b+)	49	1	8.9	17.6	28	23	12.8	45
Fy(a-b-)	Very Rare	68	0	0	0	0.5	0.4	0

Table 8: Phenotypes and frequencies (%) in the Kidd System[4,16,18,23,24]

Phenotype	Other Populations			Malaysians (NBC Blood Donors)		
	Caucasians	Blacks	Asians	Malays	Chinese	Indians
Jk(a+b-)	26.3	51.1	23.2	36	24.5	35
Jk(a-b+)	23.4	8.1	26.8	17.5	24.8	20
Jk(a+b+)	50.3	40.8	49.1	43	50.7	43.3
Jk(a-b-)	Rare	Rare	0.9 (Polynesians)	3.5	0	1.7

incidence of Le(a-b-) is rather comparable with that in Thai donors (23.5%). The Chinese tended to have a lower incidence of Le(a-b-) yet with a similar occurrence of Le(a+b+) at 12% [Table 6].[4,8,20]

As with the Duffy system, it has been previously reported that the Fy^a is very common among Asian populations with occurrences of about 90.8%, 81.5%, and 69% in Chinese, Japanese, and Thai subjects, respectively.[16] Similar findings have been obtained in this study, the Fy(a+b-) was common among Malays and Chinese, whereas among Indians, the Fy(a+b+) was more common. At the same time, Indians showed a higher Fy(a-b+) expression than Malays and Chinese. Fy(a-b-): by all means, this is considered to be a rare phenotype in Chinese, Japanese, and Thai subjects.[18] In Thai donors, no Fy(a-b-) was found. In the current study, only two donors, one Malay and one Chinese, had this phenotype. Fy(a-b-) has been reported with higher frequencies in countries where there is a high incidence of Plasmodium vivax Malaria.[21] P. vivax is currently the dominant malaria species in Malaysia [Table 7].[7,18,21-23]

The Jk(a+b+) was the commonest Kidd phenotype in all ethnic groups. Similar findings have been reported in Asian and Thai populations.[16] Moreover, the Jk(a-b-), commonly known as antigen Jk3, has been rarely found, with no differences from previous reports rendering it a rare phenotype.[16] This study also showed low prevalence of Jk(a-b-) which was discovered in Malays (3.5%) and Indians (1.7%). However, the Jk(a-b-) was only found, though rarely in Polynesians[18] and in the Japanese [Table 8].[4,16,18,23,24]

In the MNS system, the MN phenotype was common in Malays and Chinese, whereas Indians had higher MM expression. Comparably, MMss are more common than MNSs among Thais.[16] The SS was considered rare among Taiwanese.[5] Nevertheless, 19 donors with SS marked a relatively high incidence among Indian donors only, since Malays and Chinese had a much lower expression, in which the ss type was more common. Of the Miltenberger group of the MNS, 15 of 156 donors (9.6%) were Mia+, all of whom were Chinese [Table 9].[7,18]

With the P system, Malays and Chinese subjects in this study showed high P1 Negative while Indians were more P1 Positive. This is comparable with the prevalence among Cambodian and Vietnamese subjects where P1 Negative was 80%.[16,24] However, a lower expression of P1 negative has been found among Thais.[15] This is not surprising as Asians have been reported to have higher prevalence of P1 Negative. The strength of expression of P1 antigen in adults varies individually and ethnically, since they appear to be genetically controlled or represent homozygous vs heterozygous inheritance of the P1 gene [Table 10].[16,18-21]

Table 9: Phenotypes and frequencies (%) in the MNSs System[7,18]

Phenotype	Other Populations		Malaysians (NBC Blood Donors)		
	Caucasians	Blacks	Malays	Chinese	Indians
MM	28	26	37.5	34.3	44.2
MN	50	44	44	43.1	37.5
NN	22	30	18.5	22.6	18.3
SS	11	3	1.5	0.7	11.7
Ss	44	28	15.5	7.3	41.7
ss	45	69	83	92	46.7

Table 11: Phenotypes and frequencies (%) in the Kell System[18,21]

Phenotype	Other Populations		Malaysians (NBC Blood Donors)		
	Caucasians	Blacks	Malays	Chinese	Indians
KK	0.2	Rare	0.5	1.1	1.7
Kk	8.8	2	0.5	0.4	0.8
kk	91	98	99	98.5	97.5

In the Kell system, the k antigen is antithetical to K and is of high frequency in all populations.[2,15] K has a frequency of about 9% in Northern Europeans, about 1.5% in people of African origin, and is rare in East Asia. The findings in this study are not in conflict with all the previous reports, since the majority of the blood donors at NBC were kk positive. The KK phenotype is very rare with frequencies of 0.2% in Caucasians and 0.1% amongst the Blacks.[16] In the current study, only six donors were KK positive, three Chinese, two Indians, and one Malay. No KK phenotype was detected in the Thai donors' study [Table 11].[18,21]

The major implications that can be drawn from this work are that blood groups do contribute to the make-up of ethnicity. Hence, these blood groups must be closely related with evolution, and it probably reflects the extent of closeness of different human races to each other. Moreover, practical implications are ever on the rise, especially with the escalating demand for blood and blood products, and with the advancements in transfusion medicine and science, and with the growing trend of getting the people of the world closer together. In addition, knowledge of the red cell antigen phenotype frequencies in a population with different ethnic origins can help in creating a donor data bank and database for the distribution of blood groups for preparing native cell panels, and providing proper antigen compatible blood for patients with multiple alloantibodies and may also reduce the reported RBC antigens alloimmunization along with their possible complications.[25] Furthermore, blood banks may also maintain a rare blood type file from amongst their regular voluntary donors and it may be practical to develop cryopreservation facilities for rare donor units.

In conclusion, a unique distribution pattern of some blood groups among the Malaysian population has been observed.

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Table 10: Phenotypes and frequencies (%) in the P System[16,18-21]

Phenotype	Other Populations			Malaysians (NBC Blood Donors)		
	Caucasians	Blacks	Thais	Malays	Chinese	Indians
P1 Positive	79	94	20	40	31	68.3
P1 Negative	21	6	80	60	69	31.7

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