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. Materials and Methods: The rarest 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. 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-documented 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.[3] The ABO blood group and D status of blood donors and recipients are always taken into account when RBCs are transfused.[6] Other RBC antigens are usually not considered unless the recipient had previously undergone alloimmunization. This points out 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 ethylenediaacetetraacetic 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 antihumanoglobulin 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-Lea, anti-Leb, anti-Lu(a+), and anti-Lu(a-). The third ID-Card Antigen Profile II was for the phenotypes anti-k, anti-Kp(a+), anti-Jk(a+), and anti-Jk(a-), 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+), and anti-Fy(a-).

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 (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 the 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].
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. 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 (%) | x² stat | P value |
|-------------|---|-----------|-------------|------------|---------|---------|
| 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 Positive | 579 | 199| 270| 110| 21.042 | 0.000 |
| Rh Negative | 15  | 1  | 4  | 10 |         |         |

Rh Type

| Rh Type | n | Malay (%) | Chinese (%) | Indian (%) | x² stat | P value |
|---------|---|-----------|-------------|------------|---------|---------|
| CDe/CDe (R1R1) | 330 | 123 | 147 | 60 | 82.042(14) | 0.000 |
| *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 (R1R2)  | 14  | 7 | 6 | 1  |         |         |
| *cDe/CDE (R2R2) | 2   | 2 | 0 | 0  |         |         |

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 | 0.0 |

Table 4: Phenotypes and frequencies (%) in the ABO system

| Blood Group | Caucasians (%) | Blacks (%) | Asians (%) | Mexicans (%) | Thais (%) | Malaysians (NBC Blood Donors) |
|-------------|----------------|------------|------------|--------------|-----------|--------------------------------|
| 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 |
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].

As with the Duffy system, it has been previously reported that the Fy* is very common among Asian populations with occurrences of about 90.8%, 81.5%, and 69% in Chinese, Japanese, and Thai subjects, respectively. 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. 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. P. vivax is currently the dominant malaria species in Malaysia [Table 7].

The Jk(a-b+) was the commonest Kidd phenotype in all ethnic groups. Similar findings have been reported in Asian and Thai populations. 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. 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 and in the Japanese [Table 8].

In the MNS system, the MN phenotype was common in Malays and Chinese, whereas Indians had higher MM expression. Comparably, MM has more common than MNSs among Thais. The SS was considered rare among Taiwanese. 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].

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%. However, a lower expression of P1 negative has been found among Thais. 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].

| Rh Genotype | Other Populations | Malaysians (NBC Blood Donors) |
|-------------|-------------------|--------------------------------|
| 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 (R1) | 15 | 7 | 6 | | | 15.0 | 6.7 | 23.4 |
| cde/cde (R2r) | 35 | 26 | 3 | 6 | low | 0.5 | 0.7 | 7.5 |
| CDE/CDE (R1R2z) | 12 | 16 | - | - | | 2.5 | 2.9 | 5.0 |
| CDE/CDE (R2R2) | <0.2% | <0.2% | - | - | | 3.5 | 2.2 | 0.8 |
| Other Populations | 0 | 0 | 1 | 6 | | 1.0 | 0 | 0 |

| Phenotype | Other Populations | Malaysians (NBC Blood Donors) |
|-----------|-------------------|--------------------------------|
| 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 |

| Phenotype | Other Populations | Malaysians (NBC Blood Donors) |
|-----------|-------------------|--------------------------------|
| 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 | 0.5 | 0.4 | 0 |

| Phenotype | Other Populations | Malaysians (NBC Blood Donors) |
|-----------|-------------------|--------------------------------|
| 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 |

Table 5: Genotypes and frequencies (%) in the Rh System

| Phenotype | Other Populations | Malaysians (NBC Blood Donors) |
|-----------|-------------------|--------------------------------|
| 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 (R1) | 15 | 7 | 6 | | | 15.0 | 6.7 | 23.4 |
| cde/cde (R2r) | 35 | 26 | 3 | 6 | low | 0.5 | 0.7 | 7.5 |
| CDE/CDE (R1R2z) | 12 | 16 | - | - | | 2.5 | 2.9 | 5.0 |
| CDE/CDE (R2R2) | <0.2% | <0.2% | - | - | | 3.5 | 2.2 | 0.8 |
| Other Populations | 0 | 0 | 1 | 6 | | 1.0 | 0 | 0 |

Table 6: Phenotypes and frequencies (%) in the Lewis System

| Phenotype | Other Populations | Malaysians (NBC Blood Donors) |
|-----------|-------------------|--------------------------------|
| 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

| Phenotype | Other Populations | Malaysians (NBC Blood Donors) |
|-----------|-------------------|--------------------------------|
| 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 | 0.5 | 0.4 | 0 |

Table 8: Phenotypes and frequencies (%) in the Kidd System

| Phenotype | Other Populations | Malaysians (NBC Blood Donors) |
|-----------|-------------------|--------------------------------|
| 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 |
In the Kell system, the k antigen is antithetical to K and is of high frequency in all populations.\cite{18,21} 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.\cite{18} 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 \cite{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.\cite{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.

**Acknowledgements**

Thanks are due to Dr. Afifah Hassan and to the staff of the Immunohematology unit, National Blood Centre, Kuala Lumpur for allowing the use of the laboratory equipment, and to the staff of the Donor Recruitment Unit, National Blood Centre, Kuala Lumpur for providing donors data.

### Table 9: Phenotypes and frequencies (%) in the MNSs System\cite{7,18}

| Phenotype | Other Populations | Malaysians (NBC Blood Donors) |
|-----------|------------------|--------------------------------|
|           | Caucasians | Blacks | Malay | Chinese | Indians |
| MM        | 28        | 26     | 37.5  | 34.3    | 44.2    |
| MN        | 50        | 44     | 44.3  | 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\cite{18,21}

| Phenotype | Other Populations | Malaysians (NBC Blood Donors) |
|-----------|------------------|--------------------------------|
|           | Caucasians | Blacks | Malay | 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    |

### References

1. Storry JR. Human Blood Groups: Inheritance and importance in transfusion medicine. J Infus Nurs 2003;26:367-72.
2. Daniels G, Bromilow I. Essential guide to blood groups. UK: Blackwell Publishing Ltd; 2007.
3. Thakral B, Saluja K, Sharma RR, Marwaha N. Phenotype frequencies of blood group systems (Rh, Kell, Kidd, Duffy, MNS, P, Lewis, and Lutheran) in north Indian blood donors. Transfus Apher Sci 2010;43:17-22.
4. Daniels G. Terminology for red cell antigens-1999 update. Immunohematol 1999;15:95-9.
5. Daniels GL, Fletcher A, Garratty G, Henry S, Jargensen J, Judd WJ, et al. Blood group terminology 2004: From the International Society of Blood Transfusion committee on terminology for red cell surface antigen. Vox Sang 2004;87:304-16.
6. Yung CH, Chow MP, Hu HY, Mou LL, Lyou JY. Blood group phenotyping and their application in Taiwan. Zhonghua Yi Xue Za Zhi (Taipei) 1989;43:345-54.
7. Harmening DM. Modern blood banking and transfusion practices. Philadelphia, PA: F.A. Davis Company; 1999.
8. Diedrich B, Anderson J, Sallander S, Shanwell A. K, Fy(a) and jk(a) phenotyping of donor RBCs on microplate. Transfusion 2001;41:1263-7.
9. Llopis F, Carbonell-Uberos F, Montero MC, Bonanad S, Planelles MD, Plasencia I, et al. A new method for phenotyping red blood cells using microplates. Vox Sang 1999;77:143-8.
10. Data Cancer Statistics, Data and Figures, Peninsular Malaysia, 2006, National Cancer Registry, Ministry of Health, Malaysia.
11. Dupont W, Plummer W. PS power and sample size program, available for free on the Internet. Controlled Clin Trials 1997;18:274.
12. Lapiere Y, Rigal D, Adam J, Jost D, Meyer F, Greber S, et al. The gel test: A new way to detect red cell antigen-antibody reactions. Transfusion 1990;30:109-13.
13. John CC, Nancy R. Evaluation and implementation of the gel test for Indirect Antiglobulin Testing in a community hospital laboratory. Arch Pathol Lab Med 1999;123:693-7.
14. Lid J, Noques N, Montero R, Hurtado M, Bieqa A, Parra R. Comparison of three microtube column agglutination system for antibody screening: DG Gel, Diamed-ID and Ortho Biovue. Transfusion Med 2006;16:131-6.
15. Chan A, Wong HF, Chui CH, Wong L, Cheng G. The impact of a gel system on routine work in a general hospital blood bank. Immunohaemotol 1996;32:30-2.
16. Nathaling O, Kuvanont S, Punyapisididd P, Tasaniyanon C, Sripalasai T. A preliminary study of the distribution of blood group systems in Thai blood donors determined by the gel test. Southeast Asian J Trop Med Public Health 2001;32:204-7.
17. Javed AL, Maseer AM, Nisar AB, Khan GQ, Showkat AK. The BO and RH Blood groups in Kashmiri Population. Indian J Pract Doctor 2006;3:200-6.
18. Reid ME, Lomas-Francis C. The Blood Group Antigen facts book. 2nd ed. New York: Elsevier Academic Press; 2004.
19. Chandanayingyong D, Bejcharandra S, Metaseta P, Pongsatapon S. Further study of Rh, Kell, Duffy, P, MN, Lewis and Gerbich blood groups on the Thais. Southeast Asian J Trop Med Public Health 1979;10:209-11.

Asian Journal of Transfusion Science - Vol 6, Issue 1, January - June 2012
20. Brecher ME, editor. AABB Technical Manual, fifteenth edition, Bethesda, MD: 2005.
21. Ryan JR, Stoute JA, Amon J, Dunton RF, Mtalib R, Koros J, et al. Evidence for transmission of Plasmodium vivax among a Duffy antigen negative population in Western Kenya. Am J Trop Med Hyg 2006;75:575-81.
22. Tham Ah Seng. Malaria and other vector-borne diseases control in Malaysia: historical development and chronological events. Ministry of Health, Vector-Borne Disease Control, Putrajaya, Malaysia: 2006.
23. Okubo Y, Yamaguchi H, Nagao N, Tomita T, Seno T, Tanaka M. Heterogeneticity of the phenotype Jk(a-b-) found in Japanese.

Cite this article as: Musa RH, Ahmed SA, Hashim H, Ayob Y, Asidin NH, Choo PY, et al. Red cell phenotyping of blood from donors at the National blood center of Malaysia. Asian J Transfus Sci 2012;6:3-9.

Source of Support: Nil, Conflict of Interest: None declared.

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