BMJ Open

Frequency and distribution of ABO and Rh blood group systems among blood donors at the Northern Zone Blood Transfusion Center in Kilimanjaro, Tanzania: a retrospective cross-sectional study

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To cite: Vuhahula EAM, Yahaya J, Morgan ED, *et al*. Frequency and distribution of ABO and Rh blood group systems among blood donors at the Northern Zone Blood Transfusion Center in Kilimanjaro, Tanzania: a retrospective cross-sectional study. *BMJ Open* 2023;**13**:e068984. doi:10.1136/bmjopen-2022-068984

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2022-068984).

Received 08 October 2022
Accepted 02 February 2023

Check for updates

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ABSTRACT

Objectives ABO and Rh blood group systems are the major factors affecting the blood transfusion safety. The frequency and distribution of these blood group systems vary worldwide. We aimed to determine the frequency and distribution of ABO and Rh blood group systems among first-time blood donors at the Northern Zone Blood Transfusion Center in Kilimanjaro, Tanzania.

Design Cross-sectional descriptive population-based study.

Setting Data on ABO and Rh blood group systems were obtained and analysed from the Northern Zone Blood Transfusion Center among first-time blood donors.

Participants There were 65 535 first-time blood donors aged 15–55 years who donated at the Northern Zone Blood Transfusion Center from January 2017 to December 2019.

Outcome measures The percentage of ABO and Rh blood group systems among different categories of blood donors was calculated.

Results Retrospective data from Blood Establishment Computer System of 65 535 first-time blood donors were analysed in the present study. The mean age of the blood donors was 30.6±11.2 years (range: 15–55 years). The vast majority of the blood donors 84.2% (n=55 210) were men. Also, the majority 69.6% (n=45 595) were aged ≥35 years. Blood group O was the most common blood group which was found in over half 52.4% (n=34 333) of the blood donors and majority 95.3% (n=62 461) of the donors were Rh positive. Moreover, the majority 78.3% (n=51 336) were voluntary donors and the remaining 21.7% (n=14 199) were replacement donors.

Conclusion Majority of the donors had blood group O and also the vast majority of the donors were Rh positive. Considering the large size of our study population, this has provided a more comprehensive information regarding the frequency and patterns of ABO and Rh blood group systems in Tanzania. The observed association of blood group A with one of the regions from which donors were coming from, is intriguing and further studies may confirm possible related genetic evolution.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ To our knowledge, this is the largest population-based study of ABO and Rh blood group systems on frequency and distribution in different regions of the general Tanzanian population.
⇒ This study exclusively included first-time blood donors which is important for sustainability of the willingness to donate blood among individuals in the country.
⇒ The major limitation of this study is that we did not further investigate the subtypes of the ABO blood groups such as A1, A2, A3, Aw, Ax and Ael.
⇒ The fact that data were collected from a single zonal centre in the country, this affected the generalisability of our findings.

INTRODUCTION

The ABO blood group system is used to characterise the ABO blood groups by the presence of A, B or AB antigens.[1] The blood groups are identified depending on the expression of specific carbohydrate sugars on the surface of red blood cells such as N-acetylgalactosamine and D-galactose for A and B antigen, respectively.[2] These sugars are structured on the H antigen in which blood group O is formed when the H antigen remains unchanged.[2] The Rh blood group system is the most polymorphic of the human blood groups and it comprises not less than 45 independent antigens which are more of clinical significance in transfusion medicine.[3] The phenotypes of Rh blood group system are encoded by two distinct genes which carry C or c together with either E or e antigens, and the D antigen have been elucidated.[4] The distribution of Rh positive and Rh negative groups vary between

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countries globally, where, for example, in Britain and USA the frequency of Rh negative group is relatively higher than other regions.[5]

There is limited data regarding assessment of the frequency and distribution of the ABO and Rh blood group systems in the practice of transfusion medicine in Tanzania. Additionally, there is a shortage of blood from the blood banks in Tanzania. The need for knowledge of frequency and distribution of the ABO and Rh blood group systems is mandatory for effective management of blood bank centres at all levels in Tanzania. Therefore, investigating the frequency and distribution of the different blood groups among blood donors in the country is of paramount importance for quick and safe blood transfusion practices.[6] Knowing the frequency of these two important blood group systems in a Tanzanian population is important for blood banks and transfusion centres to address blood safety and product usage requirements.[7]

In this study, we aimed to assess the frequency and distribution of ABO and Rh blood groups from the Northern Zone Blood Transfusion Center (NZBTC) in Kilimanjaro, Tanzania, among first-time blood donors from 2017 to 2019.

MATERIALS AND METHODS

Study design

A retrospective cross-sectional and descriptive study was conducted so as to investigate the patterns of ABO and Rh blood groups among first-time blood donors.

Study setting and period

This study was carried out at NZBTC which is situated in Moshi municipality within Kilimanjaro region. The study included retrospective data from the Blood Establishment Computer System (BECS) of first-time blood donors from January 2017 to December 2019. The Moshi municipality is found in the Northern area of Tanzania, 462 km away from the economic capital city of Tanzania (Dar es Salaam) and 387 km to the national capital of Tanzania (Dodoma). The current total population of the zone is estimated as 184 292. NZBTC blood bank was established in 2004 through cooperative agreement of the USA and government of Tanzania by support of President's Emergency Plan for AIDS Relief funding. At present, the blood bank provides blood for all hospitals in the whole of Northern zone which encompasses Kilimanjaro, Tanga and Arusha regions. The blood bank also serves neighbouring regions such as Manyara.

Study population

A total of 65 535 first-time blood donors without deferral characteristics and with complete clinical data and information on ABO and Rh blood group systems were included in the study. Data regarding age, sex, place of residence and type of blood group systems were retrospectively extracted from the BECS.

Recruitment of the blood donors

All individuals visiting the blood bank centre for the intention of donating blood are first registered and then counselled by the trained donor counsellors. This is followed by assessment of the eligibility for blood donation using local guidelines.

Blood grouping procedure

ABO and Rh blood group systems were determined using tube method as per manufacturer's instructions.[8]

Data collection procedure

Extraction of the required data from the BECS at the blood bank centre was done by a data manager. The extracted data included age, sex, type of blood donor, frequency of blood donation, region of the donor and year of donation. The extracted data were then entered in Excel spreadsheet.

Statistical analysis

The collected data were exported from the Excel spreadsheet to the Statistical Package for Social Science (SPSS) programme V.21.0 (IBM SPSS pack, Chicago, USA) programme. This was followed by cleaning for errors which was done by running frequency and crosstabs. Age was summarised as mean±SD while categorical data (sex, type of blood donor and Rh status) were summarised in proportions. X^2 statistical test was used to determine the association between categorical variables. P value was considered to be significant when it was less than 0.05.

Patient and public involvement statement

This work did not include direct interaction with patients or the public in designing and conceptualisation of this work.

RESULTS

Selection process of the cases to be included in the present study

The process of recruiting the donors in the study is outlined in figure 1. A total of 69 663 blood donors were recorded at the blood bank for the period of 3 years (2017–2019). Of all donors, 5.3% (n=3711) were repeat donors and only 0.29% (n=203) donors were deferred. Among those who were not deferred, 0.31% (n=214) were excluded due to missing clinical data; making the retention rate for the study to be 99.7% (n=65 535).

Baseline characteristics of the donor study population

All donors' demographic and donation variables are shown in table 1. Over half of the donations 42.3% (n=27 692) were from the year 2018 and the least number of donations 25.9% (n=16 975) were in 2019. The mean age of the blood donors was 30.6±11.2 years (range: 15–65 years). The vast majority of the blood donors 84.2% (n=55 210) were men with a male to female ratio of 5.5:1. Majority of the blood donors in this study 78.3% (n=51 336) were voluntary donors. In this study, we defined replacement

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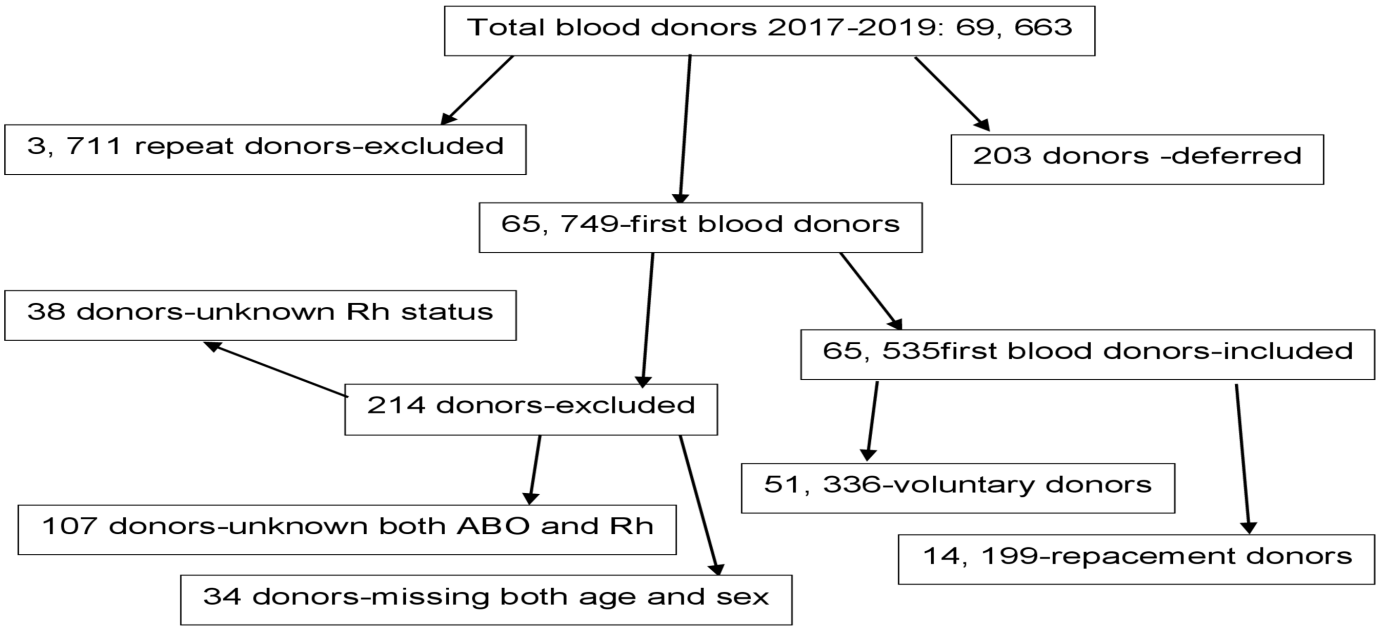


Figure 1 Flow chart indicating selection of the blood donors.

Table 1 Background information of the blood donors in the study (N=65 535)

Variable	Frequency (n)	Percentage (%)
Year of donation		
2017	20 868	31.8
2018	27 692	42.3
2019	16 975	25.9
Sex		
Male	55 210	84.2
Female	10 325	15.8
Type of blood donor		
Voluntary	51 336	78.3
Replacement	14 199	21.7
Type of ABO blood group		
A	16 015	24.4
B	12 542	19.1
AB	2648	4.0
O	34 333	52.4
Rh status		
Positive	62 461	95.3
Negative	3074	4.7
Region of residence		
Kilimanjaro	21 554	33.2
Tanga	17 734	27.3
Manyara	9315	14.3
Arusha	16 400	25.2
Others	532	0.8

donor as a situation when a friend or family member of the recipient donates blood to replace the stored blood used in transfusion, ensuring a consistent supply.[9]

The frequency and distribution of ABO blood groups have been found to show variation across different regions globally. For almost 3 years the frequency and distribution of the ABO blood groups for three compared regions (Africa, Asia and Europe) the percentage of the A, B, AB and O blood groups still follows the O>A>B>AB trend (table 2).

The distribution of donor blood types by their age groups is listed in table 3. The majority 86.7% (n=24 655) of the first-time blood donors were voluntary donors in all age groups. Almost one-third 29.5% (n=5059) of the replacement donors were in the age group of 26–35 years. The oldest age group (56–65 years) accounted for the least number of blood donors 2.8% (n=1840).

The frequency and distribution of the ABO and Rh blood groups among donors based on age, sex, type of donor, region of residence and year of donation is shown in table 4. The prevalence of men with blood group O was significantly higher than that of women (60% vs 8.5%) (p=0.002). There were more donors with blood group A from Manyara region than all other regions although the difference did not reach research statistical significance (p=0.621). We also observed that, the prevalence of elderly donors (56–65 years) with Rh negative antigen was significantly higher than that of all other age groups (p=0.013). There were no significant differences for ABO and Rh blood groups (p=0.419).

The overall prevalence of Rh negative antigens was 4.7% (n=3074) and 4.6% (n=741), 4.2% (n=524), 4.5% (n=118) and 4.9% (n=1691) for blood group A, B, AB and O, respectively. The variation in the distribution of Rh negative antigens across the blood groups was not

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Table 2 Publications from various regions of the world indicating frequency and distribution of ABO blood groups

Reference	Year	Region	Percentage of ABO blood groups			
			A	AB	B	O
[8]	2017	East Africa	26.0	3.0	19.0	52.0
[10]	2017	East Africa	24.0	5.3	20.9	49.3
[33]	2017	East Africa	24.25	5.5	18.75	51.75
[34]	2016	East Africa	25.0	4.25	20.39	50.36
[35]	2019	West Africa	22.54	5.60	28.56	43.30
[36]	2016	West Africa	22.77	3.66	20.64	52.93
[25]	2014	West Africa	25.07	4.45	21.86	48.62
[37]	2020	Horn of Africa	29.48	6.81	24.06	39.65
[38]	2020	North Africa	49.01	3.92	24.06	33.33
[39]	2018	Central Africa	18.4	3.1	20.1	58.3
[35]	2017	Central Africa	30.6	4.1	17.1	46.7
[40]	2020	North America	34.7	3.9	11.8	49.6
[41]	2021	North America	32.0	6.0	19.0	42.0
[42]	2018	North America	27.44	1.81	8.93	61.82
[43]	2020	Asia	40.2	10.4	19.5	29.9
[44]	2018	Asia	34.7	10.0	24.1	31.2
[45]	2017	Europe	40.2	5.1	13.0	40.0
Current study	2023	East Africa	24.4	19.1	19.1	52.4

statistically significant despite blood group O having a relatively higher prevalence of Rh negative antigens compared with other blood groups (table 5).

DISCUSSION

In Tanzania, there is scarce information regarding frequency and distribution of ABO and Rh blood groups among blood donors although of data which have been reported from studies with small sample size.[8 10] In this study, we aimed to assess the frequency and distribution or pattern of ABO and Rh blood group systems in a sample population of first-time blood donors. Our study included a larger sample size compared with other previous studies that were done in Tanzania. The majority of blood donors were voluntary donors and blood group O was most prevalent. These key findings may help in explaining the common patterns of blood groups among blood donors in Tanzania.

Table 3 Age distribution of the blood donors according to their type (N=65 535)

Age group (years)	Type of blood donor		
	Voluntary: n (%)	Replacement: n (%)	Total: n (%)
18–25	24 655 (86.7)	3766 (13.3)	28 421 (100)
26–35	12 115 (70.5)	5059 (29.5)	17 174 (100)
36–45	8319 (71.3)	3344 (28.7)	11 663 (100)
46–55	4768 (74.1)	1669 (25.9)	6437 (100)
56–65	1479 (80.4)	361 (19.6)	1840 (100)
Total	**51 336 (78.3)**	**14 199 (21.7)**	**65 535 (100)**

Majority of blood donors in the present study were men. This is similar to the finding to the studies which have been done in developed and developing countries.[8 10–12] Frequent failure of women to meet the required cut-off point of haemoglobin of 12 gm/dL for them to donate blood has been linked to low percentage among female blood donors has been found to be higher in developing countries compared with developed countries.[13] A number of contributing factors for them to have low haemoglobin include menstrual cycle, menorrhagia, prenatal iron deficiency anaemia and postnatal blood loss.[14 15] Additionally, one study in Europe reported that women are so prone to adverse reactions associated with blood donation particularly vasovagal events which also prevents them from being frequent blood donors.[16] Furthermore, traditionally, in most countries in Africa, women are considered generally that are physically unfit for them to donate blood unlike men.[17 18] Another study which was done in Brazil reported that religious beliefs has an influence in modifying the attitude of an individual towards blood donation and it was found to have negative impact among women.[19]

By far, young individuals (aged not more than 35 years) were the majority of blood donors in the present study who consisted of almost 70% of all blood donors in the study. This is consistent with many studies done in Africa.[8 20] Being physically fit, mobile and having good

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Table 4 Frequency and distribution of the ABO and Rh blood groups among donors based on age, sex, type of donor, region of residence and year of donation (N=65 535)

Variables	ABO blood groups: n (%)					Rh blood group status: n (%)		
	A	B	AB	O	Total	Rh+ve	Rh-ve	Total
Year of donation								
2017	5702 (27.3)	4201 (20.1)	544 (2.6)	10 421 (49.9)	20 868 (100)	19 986 (95.8)	882 (4.2)	20 868 (100)
2018	8924 (32.2)	5670 (20.5)	1140 (4.1)	11 958 (43.2)	27 692 (100)	26 176 (94.5)	1516 (5.5)	27 692 (100)
2019	1389 (8.2)	2671 (15.7)	964 (5.7)	11 951 (70.4)	16 975 (100)	16 299 (96.0)	676 (4.0)	16 975 (100)
Age (years)								
18–25	7085 (24.9)	5544 (19.5)	1192 (4.2)	14 600 (51.4)	28 421 (100)	27 208 (95.7)	1213 (4.3)	28 421 (100)
26–35	4172 (24.3)	3323 (19.3)	663 (3.9)	9013 (52.5)	17 174 (100)	16 265 (94.7)	909 (5.3)	17 174 (100)
36–45	2848 (24.4)	2113 (18.1)	409 (3.5)	6290 (53.9)	11 663 (100)	11 152 (95.6)	511 (4.4)	11 663 (100)
46–55	1472 (22.9)	1190 (18.5)	273 (4.2)	3460 (53.8)	6437 (100)	6181 (96.0)	256 (4.0)	6437 (100)
56–65	438 (23.8)	362 (19.7)	70 (3.8)	970 (52.7)	1840 (100)	1655 (89.9)	185 (10.1)	1840 (100)
Sex								
Male	11 703 (21.2)	8515 (15.4)	1543 (27.9)	33 449 (60.6)	55 210 (100)	52 898 (95.8)	2312 (4.2)	55 210 (100)
Female	4312 (41.8)	4027 (39.0)	1105 (10.7)	881 (8.5)	10 325 (100)	9563 (92.6)	762 (7.4)	10 325 (100)
Type of donor								
Voluntary	13 290 (25.9)	9566 (18.6)	2087 (4.1)	26 393 (51.4)	51 336 (100)	49 033 (95.5)	2303 (4.5)	51 336 (100)
Replacement	2725 (19.2)	2976 (21.0)	561 (4.0)	7937 (55.9)	14 199 (100)	13 428 (94.6)	771 (5.4)	14 199 (100)
Region of residence								
Kilimanjaro	5772 (26.8)	3062 (14.2)	740 (3.4)	11 980 (55.6)	21 554 (100)	20 684 (96.0)	870 (4.0)	21 554 (100)
Arusha	4090 (24.9)	3061 (18.7)	670 (4.1)	8579 (52.3)	16 400 (100)	15 694 (95.7)	706 (4.3)	16 400 (100)
Manyara	1597 (40.8)	2010 (21.6)	453 (4.9)	5255 (56.4)	9315 (100)	8743 (93.9)	572 (6.1)	9315 (100)
Tanga	4453 (25.1)	4281 (24.1)	690 (3.9)	8310 (46.9)	17 734 (100)	17 019 (96.0)	715 (4.0)	17 734 (100)
Others	103 (19.4)	128 (24.1)	95 (17.9)	203 (38.2)	532 (100)	321 (60.3)	211 (39.7)	532 (100)

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Table 5 Distribution of Rh antigens per ABO blood group among participants (N=65 535)

ABO blood groups	Rh status: n (%)		
	Rh+ve	Rh-ve	Total
A	15 274 (95.4)	741 (4.6)	16 015 (100)
B	12 018 (95.8)	524 (4.2)	12 542 (100)
AB	2530 (95.5)	118 (4.5)	2648 (100)
O	32 642 (95.1)	1691 (4.9)	34 333 (100)

awareness, all have been reported to motivate the youths to donate blood. On the other hand, the low rate of blood donation among old individuals has been pointed out that, elders are associated with chronic disease including ischaemic heart disease, diabetes mellitus, malignancy and hypertension.[21] However, the age profile for donors in our study is quite different from the one seen in donors from European countries in which there is a significant number of elderly donors compared with the donors in our study and other reported studies in other developing countries. This has once been explained due to increased demand of blood transfusion and low number of blood donors in most European countries which prompted an increase in the age limit for donors as a way of trying to meet the demand for blood.[22] Also, the observed difference in the life span between European countries and those in African countries, may explain the difference of the age profile of donors between the two compared regions.

Regarding association of the studied factors with ABO and Rh blood groups in the present study, we observed that, sex was significantly associated with ABO blood groups. This is similar to the observation of the studies which were done in Ghana[23] and Iran[24] but different from the study of Jahanpour *et al* in which there was no association between sex patterns of the ABO blood groups.[8] This association between sex and ABO blood groups could be by chance and not true association.

Concerning association of ABO blood groups and ethnic groups, a study which was done in Cameroon[25] and another one in Ghana[26] both reported association between ABO blood groups and ethnic groups. We also observed an increased prevalence of blood group A among donors from Manyara region as compared with other regions (Kilimanjaro, Arusha and Tanga) although the difference did not reach research statistical difference. This may perhaps explain different geographical and population distributions of the antigens determining the ABO blood groups.

In Tanzania and even in the East Africa region, for the past 3 years, blood group O has remained to be the most common ABO blood group followed by blood group A. This is similar even in other regions including Asia and Europe in spite of the slight high proportion of blood group A compared with blood group O that has been reported in some European and Asian countries.[27 28] Blood group AB has consistently remained with low proportion for the past 3 years and even beyond that period implying that, across different races and geographical regions globally, blood group AB has significantly low proportion. Some conditions have been reported to be linked with certain blood groups. For example, recently, it has been found that, a significant number of patients with COVID-19 disease caused by SARS-2-COVID have blood group A. This contributes to a shift in frequency of dominancy of blood group O as it was found elsewhere.[29 30] Individuals who are Rh negative produce anti-D if they are transfused with blood which is Rh positive.[31] The proportion of blood donors in the present study with Rh negative was 4.7% still low when compared with 2% which was reported in Tanzania from a study which had a sample size of 1845 blood donors which is quite insignificant when compared with 65 535 blood donors in the current study. Studies have shown that the incidence of Rh negative may stand up to 17% globally.[5 32]

The strengths of our study is that it included a large sample size compared with previous studies which were done in Tanzania on frequency and distribution of ABO and Rh blood group systems. Additionally, our study included only first-time donors which is important in assessing willingness of individuals to donate blood. However, we were not able to analyse other blood group systems such as A1, A2, A3, Aw, Ax and Ael due to financial constraints.

In conclusion, our findings have shown that blood group O and AB were the most common and least types of blood groups, respectively. Also, most of the donors were men with ages ranging from young age to middle adult age. Therefore, there is a need for increasing awareness among young individuals in the country, which may help in increasing the amount of blood collected from the blood transfusion centres available in Tanzania.

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Acknowledgements We thank all workers at the Northern Zone Blood Transfusion Center for being supportive.

Contributors EAMV, JY and AM: conceived, designed and wrote the first draft of the study, EM, EDM and EO: data curation, methodology and organisation of the study. All authors revised the manuscript critically and EAMV accepted to be the guarantor of the work.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Disclaimer The views endorsed in this paper are those of the authors and do not necessarily reflect the official policy or position of the Department of Pathology, Kilimanjaro Christian Medical University College in Tanzania.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

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Patient consent for publication Not applicable.

Ethics approval Ethical approval was obtained from the review by ethical committee of the Kilimanjaro Christian Medical University College (KCMUco) (approval number 2451). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data that were used in this study are available on reasonable request from the manager of the blood bank using email: northernzonebtc@org.tz

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REFERENCES

1 Li HY, Guo K. Blood group testing. *Front Med (Lausanne)* 2022;9:827619.
2 Agrawal A, Tiwari AK, Mehta N, *et al*. ABO and rh (D) group distribution and gene frequency; the first multicentric study in india. *Asian J Transfus Sci* 2014;8:121–5.
3 Flegel WA. The genetics of the rhesus blood group system. Blood Transfus 2007;5:50–7.
4 Floch A. Molecular genetics of the Rh blood group system: alleles and antibodies—a narrative review. Ann Blood 2021;6:29.
5 Golassa L, Tsegaye A, Erko B, *et al*. High rhesus (Rh(D)) negative frequency and ethnic-group based ABO blood group distribution in Ethiopia. BMC Res Notes 2017;10:1–5.
6 Legese B, Shiferaw M, Tamir W, *et al*. Association of ABO and rhesus blood types with transfusion-transmitted infections (ttis) among apparently healthy blood donors at bahir Dar blood bank, bahir Dar, North West, Ethiopia: a retrospective cross-sectional study. *J Blood Med* 2022;13:581–7.
7 Drammeh B, De A, Bock N, *et al*. Estimating tanzania's national met and unmet blood demand from a survey of a representative sample of hospitals. *Transfus Med Rev* 2018;32:36–42.
8 Jahanpour O, Pyuza JJ, Ntiyakunze EO, *et al*. ABO and rhesus blood group distribution and frequency among blood donors at kilimanjaro christian medical center, moshi, tanzania. *BMC Res Notes* 2017;10:738.
9 Perez P, Salmi LR, Folléa G, *et al*. Determinants of transfusion-associated bacterial contamination: results of the french BACTHEM case-control study. *Transfusion* 2001;41:862–72.
10 Nwangwu J, Roland I, Mbelwa D, *et al*. Prevalence of malaria infection and ABO human blood group in dar-es-salaam, Tanzania. Adv Infect Dis 2017;07:153–7.
11 Carver A, Chell K, Davison TE, *et al*. What motivates men to donate blood? A systematic review of the evidence. *Vox Sang* 2018;113:205–19.
12 Bani M, Giussani B. Gender differences in giving blood: a review of the literature. *Blood Transfus* 2010;8:278–87.
13 Mast AE. Low hemoglobin deferral in blood donors. *Transfus Med Rev* 2014;28:18–22.
14 Breymann C, Auerbach M. Iron deficiency in gynecology and obstetrics: clinical implications and management. *Hematology Am Soc Hematol Educ Program* 2017;2017:152–9.
15 Bongomin F, Olum R, Kyazze AP, *et al*. Anemia in Ugandan pregnant women: a cross-sectional, systematic review and meta-analysis study. *Trop Med Health* 2021;49:19.
16 Taheri Soodejani M, Haghdoost AA, Okhovati M, *et al*. Incidence of adverse reaction in blood donation: a systematic review. *Am J Blood Res* 2020;10:145–50.
17 Asamoah-Akuoko L, Hassall OW, Bates I, *et al*. Blood donors' perceptions, motivators and deterrents in sub-Saharan Africa-a scoping review of evidence. *Br J Haematol* 2017;177:864–77.
18 Prados Madrona D, Fernández Herrera MD, Prados Jiménez D, *et al*. Women as whole blood donors: offers, donations and deferrals in the province of Huelva, south-western Spain. Blood Transfus 2014;12 Suppl 1:s11-20.
19 Zucoloto ML, Bueno-Silva CC, Ribeiro-Pizzo LB, *et al*. Knowledge, attitude and practice of blood donation and the role of religious beliefs among health sciences undergraduate students. *Transfus Apher Sci* 2020;59:102822.
20 Checkley L, Motwani G, Wange IC, *et al*. Assessment of blood donation and transfusion in eastern uganda: a mixed-methods study. *Ann Glob Health* 2019;85:1–9.
21 Ascherio A, Rimm EB, Giovannucci E, *et al*. Blood donations and risk of coronary heart disease in men. *Circulation* 2001;103:52–7.
22 Müller-Steinhardt M, Müller-Kuller T, Weiß C, *et al*. Safety and frequency of whole blood donations from elderly donors. Vox Sang 2012;102:134–9.
23 Bostancı MT, Avcı MA, Aksoy Khurami F. Primary umbilical endometriosis: menstruating from the umbilicus. *TURKDERM* 2017;101–103:101–3.
24 Andalibi M, Dehnavi Z, Afshari A, *et al*. Prevalence of ABO and Rh blood groups and their association with demographic and anthropometric factors in an Iranian population: mashad study. *East Mediterr Health J* 2020;26:916–22.
25 Ndoula ST, Noubiap JJN, Nansseu JRN, *et al*. Phenotypic and allelic distribution of the ABO and rhesus (D) blood groups in the Cameroonian population. *Int J Immunogenet* 2014;41:206–10.
26 N Doku G, K Agbozo W, A Annor R, *et al*. Frequencies and ethnic distribution of ABO and RhD blood groups in the volta region of Ghana, towards effective blood bank services. *Afr H Sci* 2022;22:641–7.
27 Jelinek HF, Mousa M, Alkaabi N, *et al*. Allelic variants within the ABO blood group phenotype confer protection against critical COVID-19 Hospital presentation. *Front Med* 2022;8:1–13.
28 Pokolo HT, Mushabati F, Daka V, *et al*. n.d. Distribution of the ABO and rhesus blood groups in a population of namibian blood donors-implications of blood transfusion. ;3.
29 Nasiri M, Khodadadi J, Hajrezaei Z, *et al*. The probable association between blood groups and prognosis of covid-19. *Ijph* 2021;50:825–30.
30 Göker H, Aladağ-karakulak E, Demïroğlu H, *et al*. The effects of blood group types on the risk of COVID-19 infection and its clinical outcome. *Turk J Med Sci* 2020;50:679–83.
31 Maya ET, Buntugu KA, Pobee F, *et al*. Rhesus negative woman transfused with rhesus positive blood: subsequent normal pregnancy without anti D production. *Ghana Med J* 2015;49:60.
32 Ayenew Z, Gizaw AT, Workneh D, *et al*. Outcome of non-traumatic surgical acute abdomen in nekemte referral hospital Southwest Ethiopia: a retrospective cross-sectional study. *Surgery* 2017;07:1–5.
33 Waiganjo R. The heterogeneity and prevalence of ABO and rh D antigens in the voluntary blood donors of kenya. *Int J Sci Res* 2017;6:1784–8.
34 Apecu RO, Mulogo EM, Bagenda F, *et al*. Abo and rhesus (D) blood group distribution among blood donors in rural south western uganda: a retrospective study. *BMC Res Notes* 2016;9:513.
35 Sawadogo S, Nebie K, Millogo T, *et al*. Distribution of ABO and RhD blood group antigens in blood donors in Burkina Faso. *Int J Immunogenet* 2019;46:1–6.
36 Anifowoshe AT, Owolodun OA, Akinseye KM, *et al*. Gene frequencies of ABO and Rh blood groups in Nigeria: a review. *Egyptian Journal of Medical Human Genetics* 2017;18:205–10.
37 Tiruneh A, Yetneberk T, Gelaw M, *et al*. Frequency of ABO and Rh blood group distribution at Debre Tabor blood bank, Amhara region, north-central Ethiopia. A six-year retrospective survey. *J Blood Med* 2020;11:357–61.
38 Yalaoui S*et al*. DOSSIER COVID: ARTICLE ORIGINAL groupes sanguins ABO et risque d ' atteinte par le COVID-19 ABO blood groups and risk of COVID-19. 2020;98:888–91.
39 Chung DS, Shen F, Lee S, *et al*. A retrospective study of directed blood donations in the kasungu district of Malawi. *OJBD* 2018;08:74–82.
40 Hoiland RL, Fergusson NA, Mitra AR, *et al*. The association of ABO blood group with indices of disease severity and multiorgan dysfunction in COVID-19. *Blood Adv* 2020;4:4981–9.
41 Bloch EM, Patel EU, Marshall C, *et al*. Abo blood group and SARS-cov-2 antibody response in a convalescent donor population. *Vox Sang* 2021;116:766–73.
42 Canizalez-Román A, Campos-Romero A, Castro-Sánchez JA, *et al*. Blood groups distribution and gene diversity of the ABO and Rh (D) loci in the Mexican population. *Biomed Res Int* 2018;2018:1925619.
43 Isik S, Cevik S, Turhan AH, *et al*. Abo and Rh blood groups and risk of myelomeningocele. *Turk Neurosurg* 2020;30:449–53.
44 Yu H, Xu N, Li Z-K, *et al*. Association of ABO blood groups and risk of gastric cancer. *Scand J Surg* 2020;109:309–13.
45 Chandler T, Hiller J, Peine S, *et al*. Blood donation and donors: insights from a large German teaching hospital (2008-2017). *Vox Sang* 2020;115:27–35.

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