Demography and blood donation trends in Saudi Arabia: A nationwide retrospective, cross-sectional study

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Background: Blood product supply and utilization are understudied in Saudi Arabia. This study evaluates the trends in Saudi blood banks readiness, donors’ demography, and blood product utilization and wastage.

Study design and methods: A retrospective, cross-sectional study of records obtained from the Ministry of Health (MOH) was initiated to report trends and statistics on annual whole blood donors and blood product utility from 2010 to 2020. Data collected in 2020 was further characterized for donors’ demographics, laboratory readiness, and staffing.

Results: The average number of annual blood donors over the last decade (2010–2020) was 325,847.3 ± 43,160. The forecasted blood donation and dispatch trends suggest a significant increase in blood demand ($R^2 = 0.7582$) over annual donation rates ($R^2 = 0.2356$). In 2020, 342,460 nationwide blood donations were registered in governmental donation centers and females constituted a mere 2.5%. Approximately 60% of whole blood donation was voluntary, 36% was compensatory, and 4% was part of driving license renewal. The highest blood donation rate per 1,000 inhabitants was observed in Taif (69.8) and Alqonfoda (45.0). Eastern directory and Madinah had the most successful donation campaigns attracting 53% and 50% of total annual donations, respectively. Notably, Tabouk, Ha’il, and Albaha had the highest blood product wastage medians.

Conclusion: Blood donation rates and impetus, staffing ratios, and laboratory readiness and wastage varied among the various directories. Laboratory managers and medical directors need to increase efforts to refine current guidelines in order to comply with the transformation plan of the health sector.
(4.5%) are the highest in comparison to neighboring Middle Eastern countries (Alsaeed et al., 2018).

The Kingdom’s blood transfusion services underwent several national initiatives which had the collective effect of reducing blood transfusion management. The Ministry of Health (MOH) takes the biggest share of blood transfusion services in the country via the regional Directorates of Laboratories and Blood Banks (DLBBs), and all governmental blood banks must report blood donations, screening for transfusion-transmissible infections, blood products utilization and wastage annually to the Center of Laboratories and Blood Transfusion Services.

For decades, MOH has been providing 62% of inpatients’ care free-of-charge through governmental health facilities (Al-Ahmad and Roland, 2005). The system was long known to be successful in controlling endemic disease, immunization, and maternal health issues; however, it has been recently challenged by the rapid population growth, escalating costs, and deteriorating quality (e.g., long waiting times) of governmental hospitals (NTP, 2020). In 2018, healthcare expenditure in Saudi Arabia was estimated to represent 6.36% of the gross domestic product (GDP) (World Bank, 2022). Blood donation screening, processing, and labor also exert a considerable economic burden and adds to the cost pressures which can be otherwise controlled. Thus, reaching a considerable balance between supply and demand while reducing wastage must be a priority. In this study, we characterize nationwide blood banks’ readiness, blood donors’ demography, donation impetus, and rates of utilization and wastage. Such knowledge is invaluable in the assessment of current strategies and to formulate priorities for future quality performance indicators.

2. Methods

2.1. Ethical approval

This retrospective, cross-sectional study was approved by the Ethical Committee of MOH (21–71 E) dated August 2021. Blood Transfusion Services data files were retrieved and analyzed for blood banks’ readiness, donors’ demographics, and donation and utilization patterns.

2.2. Statistics

Descriptive statistics of hospitals readiness, donors’ demographic characteristics, and blood usage rates were stratified against major Saudi cities based on population size. The performance indicator, wastage as a percentage of issues (WAPI), is a metric of different types of wastage (expiration, temperature control error, and miscellaneous) and solely accounts for issued products and not the size of blood bank’s inventory (Baig et al., 2020). WAPI was calculated as follows:

\[
\text{WAPI} (\%) = \frac{\text{wasted blood units per. unit time}}{\text{issued blood units per. unit time}} \times 100
\]

A linear regression equation was fitted to blood donation and dispatch trends over the years 2010–2020, slope values, R², and 10-year forecast were generated using the FORECAST.ETS. STAT function and Exponential Smoothing algorithm (ETS) and error metrics (MASE, SMAPE, MAE, RMSE) on Microsoft Excel version 16.95 (Microsoft Corporation, Redmond, WA, USA). The average rate of blood donation was displayed as the average number of donors ± standard deviation. In all cases, a P value < 0.05 was considered statistically significant and GraphPad Prism version 9.2.0 (GraphPad Software, Inc., San Diego, CA, USA) was used for analysis.

3. Results

3.1. Readiness of blood banks

Nationwide, there are 25 central blood banks, 103 secondary blood banks, and 107 blood transfusion centers that are distributed among the main cities (Table 1). Central blood banks perform blood collection, processing, and distribution. As central laboratories, central blood banks also carry out serological and nucleic acid screening tests for transfusion-transmitted infections (TTIs) on blood units collected within the same geographical region. Secondary blood banks perform all services provided by central blood banks, except for TTI screening, including blood transfusion. Transfusion centers are solely responsible for cross-matching and blood transfusion services. All blood banks are equipped with standard manual and automated blood processing and apheresis facilities with considerable variation in readiness among cities given their different demography (Tables 2 and 3). Blood banks are staffed with varying numbers of physicians (specialists and consultants), nurses, phlebotomists, and laboratory personnel (technicians and specialists). The presence of physicians is mandatory for the management of donation complications. The total number of blood bank personnel in 2018 was 2,469 which underwent a steep decline by 29.44% and reached 1,742 employees in 2020. Phlebotomists and general physicians were the most affected, decreasing in numbers by 56.3% and 47.3%, respectively (Fig. 1). To determine whether blood donation centers are sufficiently staffed, the exact number of employees per center and the output per full-time equivalent (FTE) must be available. Due to the unavailability of this information, the ratio of annual donors to operational and bench staff members (i.e., directly involved with donors’ preparation and blood products processing) was determined instead (Table 4). Donor to staff ratio varied widely among the different cities with Alqurayat (5.2) and Ha’il (2.4) demonstrating the highest donor to staff ratio, while Taif stood out as having the least (0.4). This method however does not take into consideration institution volume, daily donor numbers, or demographic variabilities; thus, productivity evaluation may have produced different results by alternative measures.

3.2. Demographic data

Trends of blood donations and dispatches from 2010 to 2020 are illustrated in Fig. 2A. The average number of blood donors did not fluctuate much in the past 10 years with an average of 325,847.3 ± 43,160 donors annually. However, the steady blood supply trend did not keep pace with the significant emerging increase in demand for blood products. Interestingly, blood donation rates were not significantly affected by the drastic reduction in phlebotomists or with COVID-19 pandemic (i.e. years 2019 and 2020) (Fig. 2B).

To evaluate donors’ retention and recruiting strategies, the 2020 cohort of donors was further characterized. The number of total blood donors in 2020 was 342,460, of which 82.5% were frequent donors while 17.5% were first-time donors (Table 5 and Table 6). Female donors constituted 2.51% of total donations. The distribution of donors’ blood groups was similar to what was reported previously in regional studies (Alsuhaibani et al., 2015; Bashwari et al., 2001).

The median blood donation rate among the twenty main cities is equivalent to 15 donations per 1000 people, which is equivalent to that of upper-middle-income countries (Table 5) (WHO, 2020). The highest blood donation rate per 1000 people was observed in Taif (69.8), Alqunfoda (43.0), and Alqurayat (28.0). Interestingly, provincial capitals and most populous cities of Riyadh (6.4), Mecca
(7.0), and Jeddah (9.6) recorded the least donated blood units in 2020. To encourage voluntary donation, government hospitals arranged 1,137 blood donation campaigns in 2020 (Table 5). Such campaigns expanded the total annual blood donation by 24%. Donation campaigns were most successful at increasing donation rates in the Eastern directory (53%) and Madinah (50%). The campaigns have also increased voluntary blood donation rates in Riyadh (21%) and Makkah (14%). Donation campaigns had little impact on the total blood donation rate in Alqurayat (2%), Jeddah (6%), and the Northern borders (6%) directories. In addition to blood donation campaigns, blood is also donated voluntarily (i.e., nonremunerated) and represented 59.98% of nationwide blood donations, or as a replacement donation by family and friends of someone who needs blood (36%), or during driver’s license renewal (4.02%) (Table 5). Voluntary donation exceeded 69% in nine directories namely, the Eastern directory, Qassim, Hail, Najran, Northern borders, Hafr Albatin, Taif, Alqurayat, and Alehsa. Thus, MOH has noted these directories as the first candidates for eliminating replacement donation in order to reach 100% voluntary non-remunerated blood donation and to comply with the Global Framework for Action established by WHO (WHO, 2010). Donations by non-Saudi citizens represented 27.19% of whole donations (Table 6).

3.3. Blood utilization and wastage

Whole blood units collected in 2020 were processed into different blood components with a total of 797,184 units being issued (Fig. 4). Packed red blood cells (pRBC) represented 41.6% of all issued blood components followed by fresh frozen plasma (FFP),
platelets, and cryoprecipitates (30.98%, 26.19%, 1.18%, respectively). Ideal blood inventory management requires a trade-off between shortage and wastage. WAPI was thus utilized to compare and rank wastage in blood products among the different cities, where the lower the percentage, the better the performance independently of the hospital type and size (Chapman and MacPherson, 2007; Stanger et al., 2012; Yazer et al., 2016). The median WAPI in all cities was 12 for pRBCs, 49 for platelets, 50.69 for plasma, and 24.38 for cryoprecipitate. PRBCs wastage was the highest in Alqurayat (WAPI = 42.75%), Tabouk (26.57%), and Hafr Albatin (25.78%) directories. The highest wastage in plasma was recorded in three directories: Alqonfoda (89.27%), Hafr Albatin (68.28%), and Jizan (61.46). Wastage percentage of platelets was relatively high considering its short half-life which ranged from 12% to 95% (Fig. 4). Conversely, wastage of blood products collected by apheresis was considerably low with 98% of collected RBC units were dispatched. Similarly, 78% of plasma units and 93.6% of collected platelets units were dispatched (Fig. 5). A total of 6,914 pre-processed whole blood units were discarded either due to heavy bag weight (14.70%), clot formation (24.87%), or quantity insufficiency (60.41%) (Fig. 6).

4. Discussion

Blood bank management in Saudi Arabia is underrepresented in the scientific literature. The current study reports blood banks’ readiness, donation patterns, and emerging challenges. Based on the retrieved Blood Transfusion Services annual reports, governmental blood banks are sufficiently equipped with standard equip-
### Table 4
Regional variations in blood donation rates and donor to staff ratio in 2020.

| Directory         | Population¹ | Annual blood donors | Total blood donation centers | Staff | donors/day | Donor:staff² |
|-------------------|-------------|---------------------|----------------------------|-------|------------|--------------|
| Riyadh            | 8,002,100   | 51,716              | 38                         | 101   | 192        | 1.9          |
| Makkah            | 4,074,045   | 31,391              | 10                         | 145   | 116        | 0.8          |
| Jeddah            | 3,456,259   | 33,467              | 9                          | 116   | 124        | 1            |
| Taif              | 175,000     | 12,223              | 15                         | 108   | 45         | 0.4          |
| Alquraufa         | 220,000     | 9,906               | 5                          | 7     | 36         | 0.2          |
| Madinah           | 2,080,436   | 29,835              | 18                         | 193   | 70         | 0.7          |
| Taif              | 1,387,996   | 19,412              | 16                         | 141   | 72         | 0.5          |
| Eastern           | 1,041,863   | 14,838              | 7                          | 63    | 55         | 0.8          |
| Half Albatin      | 390,282     | 6,336               | 6                          | 30    | 24         | 0.8          |
| Aseer             | 1,995,681   | 21,129              | 19                         | 53    | 78         | 1.4          |
| Beesha            | 204,491     | 5,409               | 5                          | 23    | 20         | 0.8          |
| Tabouk            | 890,922     | 12,236              | 9                          | 80    | 45         | 0.5          |
| Ha'il             | 684,619     | 9,041               | 13                         | 14    | 33         | 2.4          |
| Northern borders  | 359,235     | 5,701               | 8                          | 18    | 21         | 1.1          |
| Jizan             | 1,533,680   | 29,840              | 17                         | 129   | 110        | 0.8          |
| Najran            | 569,332     | 13,576              | 10                         | 87    | 50         | 0.5          |
| Jizan             | 466,384     | 7,316               | 8                          | 19    | 27         | 1.4          |
| Aljawf            | 349,959     | 5,717               | 7                          | 40    | 21         | 0.5          |
| Alqurayat         | 147,550     | 4,120               | 2                          | 11    | 15         | 1.5          |
| Total             | 31,742,308  | 342,460             | 237                        | 1,470 | 1,264      |              |

¹ Based on population statistics of 2020 (GAS, 2022).
² Healthcare professionals who are directly involved in donors’ preparation and blood products processing.

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**Fig. 2. Trends of whole blood donations (WB).**

**A)** Trends of WB donation ($R^2 = 0.2356$) and PRBCs dispatches ($R^2 = 0.7582$) during the years 2010 – 2020, and forecasted supply and demand (2021–2030) ($p < 0.0001$).

**B)** Average of annual donors during the COVID-19 pandemic (2019–2020) was not statistically significant (ns) from the years (2010–2018) ($p = 0.113$, 95% Confidence Interval: –11.71, 1.47).
ment and instrumentation to facilitate the process of blood collection, processing, and storage. The 2018 reduction in staff numbers was an act supporting the second strategic objective of the health sector’s National Transformation Plan (NTP) which entails increasing the efficient utilization of available resources. Interestingly, the average annual blood donation was not significantly affected by blood banks’ staff reduction or the COVID-19 pandemic. Because staff performance details were not available, we determined the daily donors to staff ratio to roughly estimate the efficacy of the blood donation process. Ratios varied considerably among the investigated cities which probably reflects demographic variability (Novis et al., 2022). For this data to be useful for decision makers, the actual staffing level must be compared with FTE in each center and must take into consideration the governorates’ population size to identify where shortages are most significant. In addition, staffing ratios and productivity must be investigated in future studies as labor costs represent 50% to 70% of direct laboratory expenditures (Valenstein et al., 2005).

Table 5
Donors’ distribution among Saudi directories.

| Directory     | Total donors (% female) | Voluntary donations (%) | Compensatory donation (%) | Driving license renewal donation (%) | Donation per 1000 people | Donation campaigns (% of voluntary donations) | Number of voluntary societies | Number of mobile donation units |
|---------------|-------------------------|-------------------------|---------------------------|-------------------------------------|--------------------------|-----------------------------------------------|-----------------------------|-------------------------------|
| Riyadh       | 51,716 (2.0%)           | 43%                     | 55.10%                    | 2.10%                               | 6.4                      | 173 (21%)                                     | 14                          | 6                             |
| Makkah        | 31,391 (3.9%)           | 34%                     | 64%                       | 2%                                  | 7                        | 26 (14%)                                      | 0                           | 2                             |
| Jeddah        | 33,467 (1.7%)           | 59.50%                  | 40.50%                    | 0%                                  | 9.6                      | 18 (6.5%)                                     | 3                           | 2                             |
| Taif          | 12,223 (4.8%)           | 75%                     | 15%                       | 10%                                 | 69.8                     | 21 (16%)                                      | 1                           | 1                             |
| Al-Qunfoda     | 9,906 (0.7%)            | 68%                     | 5%                        | 27%                                 | 45                      | 83 (28)                                       | 3                           | 1                             |
| Madinah       | 29,835 (1.1%)           | 47%                     | 52%                       | 1%                                  | 14.3                     | 47 (50%)                                      | 6                           | 2                             |
| Qassim        | 19,051 (7.9%)           | 70%                     | 30%                       | 0%                                  | 13.7                     | 163 (14%)                                     | 3                           | 1                             |
| Eastern       | 19,412 (1.8%)           | 94%                     | 6%                        | 0%                                  | 5.7                      | 98 (53%)                                      | 3                           | 1                             |
| Aseer         | 14,838 (2.1%)           | 69%                     | 31%                       | 0%                                  | 14.2                     | 24 (27%)                                      | 0                           | 1                             |
| Ha’il Al-Batim| 6,535 (0.5%)            | 89%                     | 10%                       | 1%                                  | 16.7                     | 18 (8%)                                       | 0                           | 1                             |
| Aseer         | 21,129 (2.0%)           | 57%                     | 41%                       | 1%                                  | 10.7                     | 24 (18%)                                      | 0                           | 2                             |
| Beesha        | 5,409 (2.1%)            | 68%                     | 24%                       | 8%                                  | 26.5                     | 9 (13%)                                       | 1                           | 1                             |
| Tabouk        | 12,236 (1.4%)           | 56%                     | 16%                       | 28%                                 | 13.7                     | 23 (16%)                                      | 9                           | 5                             |
| Ha’il Al-Batim| 9,041 (1.6%)            | 74%                     | 26%                       | 0%                                  | 13.2                     | 26 (13%)                                      | 0                           | 3                             |
| Northern Borders | 5,701 (0.7%)         | 73%                     | 26%                       | 15%                                 | 15.8                     | 14 (6%)                                       | 0                           | 2                             |
| Jizan         | 29,840 (1.5%)           | 56%                     | 36%                       | 8%                                  | 19.4                     | 178 (39%)                                     | 22                          | 3                             |
| Najran        | 13,576 (1.7%)           | 95%                     | 3%                        | 2%                                  | 23.8                     | 85 (19%)                                      | 5                           | 1                             |
| Al-Bahah      | 7,316 (3.5%)            | 67%                     | 25%                       | 8%                                  | 15.6                     | 62 (30%)                                      | 2                           | 1                             |
| Al-Jawf       | 5,717 (0.5%)            | 67%                     | 31%                       | 2%                                  | 16.3                     | 41 (22%)                                      | 2                           | 1                             |
| AL-Qurayyat   | 4,120 (0.6%)            | 79%                     | 21%                       | 0%                                  | 28                      | 4 (2%)                                        | 0                           | 1                             |
| Total         | 342,460 (2.5%)          | 59.98%                  | 36.00%                    | 4.02%                               | Median = 15              | 1,137 (24%)                                   | 74                          | 38                            |

* Of nationwide voluntary donations.

Table 6
Percentages of donors based on motivation.

| Gender | Citizenship | Voluntary | Compensatory | Driving license renewal | Total |
|--------|-------------|-----------|--------------|-------------------------|-------|
| Male   | Saudi       | 46.38%    | 22.55%       | 1.84%                   | 70.70%|
|        | Non-Saudi   | 11.70%    | 12.85%       | 2.15%                   | 26.70%|
|        | Total male donations | 58.08% | 35.41% | 3.99%       | 97.49%|
| Female | Saudi       | 1.60%     | 0.40%        | 0.03%                   | 2.03% |
|        | Non-Saudi   | 0.29%     | 0.19%        | 0.01%                   | 0.49% |
|        | Total female donations | 1.89% | 0.59% | 0.03%       | 2.51% |
| Total  | 59.98%      | 36.00%    | 4.02%        | 100%                    |       |

A consistent growing gap between whole blood supply and demand over the past decade was observed in this study. Such a gap needs to be addressed by policy makers to identify determinants of blood utilization and wastage to monitor and improve the efficiency and quality of blood transfusion practices. A well-managed blood bank should have a cost-efficient operational strategy for balancing supply with forecasted demand. The clinical demand for pRBCs was particularly severe where the number of transfused pRBCs accounted for 82.8% of all blood donations in 2020. Median WAPI values in Saudi governmental blood banks are higher than those reported by American and European countries (Yazer et al., 2016) and thus, urging the need to formulate strategies to minimize blood products wastage. Given that platelets have a short shelf-life of five days, wastage is generally expected to be higher than that of other blood components. To reduce blood wastage and enhance stock management, a number of low-cost policies can be implemented. These include improved communication between blood banks and providers (Levin et al., 2005).
2019; Mishra et al., 2021), staff continual education (Burk et al., 2021), improved transport Kron et al., 2021), and updating transfusion protocols (Bawazir and Dakkam, 2020; Gholami et al., 2021) which all have been proven to have a cumulative effect in reducing blood wastage.

It is estimated that in a high-income country such as Saudi Arabia, the median blood donation rate would be 31.5 per 1000 people (WHO, 2020). However, the median donation rate in 2020 was far below the recommended rate with only three cities meeting the recommended median (i.e., Taif, Alqonfoda, and Alqurayat). Surprisingly, the provincial capitals of Riyadh and Mecca recorded the least median donation rates.

Although blood banks in Saudi Arabia abide by the standards and regulations of MOH, they do not operate under a centralized management system. Such a fragmented system yielded several shortcomings and limitations to this study, most notably the lack of demographic details of blood donors (age, marital status, socioeconomic status, donation frequency, and impetus of frequent donors); hence, limiting our ability to characterize the donor’s cohort. In addition, the decentralized system resulted in the inadequate reporting of blood banks’ shortage or overload status and did not identify which departments (e.g., surgery, obstetrics/gynecology, pediatrics, and emergency)

| Blood Groups | Prop.1 | Issué2 | Sald.3 | Donor4 | Prepared | Issué5 | Sald.6 | Donor7 | Prepared | Issué5 | Sald.6 | Donor7 | Prepared | Issué5 | Sald.6 | Donor7 |
|-------------|-------|-------|-------|-------|---------|-------|-------|-------|---------|-------|-------|-------|---------|-------|-------|-------|
| RBCs        | 49.2% | 41.6% | 7.4%  | 16.4% | 4.9%    | 4.1%  | 6.6%  | 17.6% | 6.2%    | 2.1%  | 1.5%  | 13.4% | 3.3%    | 1.0%  | 1.0%  | 1.0%  |
| Platelets   | 2.0%  | 3.2%  | 0.4%  | 6.4%  | 10.0%   | 0.0%  | 0.0%  | 0.0%  | 0.0%    | 0.0%  | 0.0%  | 0.0%  | 0.0%    | 0.0%  | 0.0%  | 0.0%  |
| Plasma      | 1.9%  | 1.5%  | 0.1%  | 0.0%  | 0.0%    | 0.0%  | 0.0%  | 0.0%  | 0.0%    | 0.0%  | 0.0%  | 0.0%  | 0.0%    | 0.0%  | 0.0%  | 0.0%  |

Stocked units.
1Dispatched units.
2Horizontal data bars are normalized to the highest value.

Fig. 3. Frequencies of nationwide blood groups.

Fig. 4. Numbers of issued blood products and wastage of issue in 2020.

Fig. 5. Number of nationwide prepared and dispatched apheresis units in 2020.
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