

An Evaluation of Blood Components Inventory Management During Hajj and Umrah Season at Makkah Hospitals

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Abstract

Objectives: The current study aims to utilize blood bank data collected from the Army forces hospital in Makkah to improve transfusion services at Makkah hospitals and evaluate the inventory system during the Hajj season.

Methods: Three years' results showed that blood centre production is not constant, with an average of 1800 units during Hajj season that includes Cryo (450), FFP (450), PLT (450), and PRBC (450) units. Moreover, data indicated that the average usage of units is 1119 during the same season (120 Cryo, 424 FFP, 207 PLT and 368 PRBC).

Results: This demonstrated that the inventory of blood units fluctuates during the year with an overproduction of Cryo (80%), FFP (67%), PLT (83%) and PRBC (57%) units in Hajj Season. It can be concluded that the manner and effectiveness with which the present issues in Makkah blood banking are having a major impact on the current system used to obtain the nation's blood supply and the safety, adequacy, and operational cost of that supply.

Conclusion: The current study recommends building a generic data warehouse with smart decision support systems that use artificial intelligence to maintain blood bank production and inventory system during the year, especially during Hajj and Umrah seasons.

Keywords: Blood banks, supply, equipment and supplies, blood units, Makkah

Introduction

The Islamic hajj gathering in Makkah, Saudi Arabia, is considered as one of the largest global gatherings. The number of pilgrims for both Hajj and Umrah can reach up to 10 million people annually from more than 180 countries around the globe. During Hajj in 2015, 2016, and 2017 more than 2 million pilgrims came to Makkah.¹ In Saudi Arabia and over the course of years, a modern surveillance system for Hajj has been developed and is continually improving with experiences and advances in the technology.^{1,2} This surveillance system is essential to minimize accidents and ensure proper infection control during Hajj and Umrah.

Additionally, Riyadh seasons, Formula 1 Saudi Arabia Grand Prix and other massive gathering events are increasing in Saudi Arabia with recent development and changes. Also, Saudi Arabia is threatened continuously by constant attacks to hit civilian areas, schools, and hospitals. Planning and organising emergency plans in such a situation are essential to address all possible needs.³⁻⁵ Such planning and organizational efforts require collecting and analysing data gathered from different authorities during such events.³⁻⁵

Major traumatic injuries during Hajj and umrah include stampedes, fire, traffic accidents and other injuries. For example, during the Hajj season in September 2015, 107 pilgrims died, and 394 were injured in the crane collapse accident at the building site of the Grand Mosque in Makkah.^{1,2} Also, in the same year, 769 pilgrims died, and 934 were injured in the stampede accident in Mina at the Jamarat Bridge.⁶ The casualty numbers in these accidents created strains on all the healthcare systems in Makkah region.^{1,6}

Of the main systems that could be affected during such incidents is the Blood Banking systems in different hospitals in the Makkah region. These Blood Banks need to work effortlessly to provide blood units and blood components to cover the need. Thus, careful planning and management of the Blood Banking systems in these situations are key to avoiding serious

effects and losses of lives.^{7,8} This planning should be built around the distribution of ABO and Rh blood groups of blood donors in the KSA.⁹

In Hajj, hospitals in the Makkah region have records of the blood unit requests, numbers of donations, and shortages during that time. Careful analysis of such data and reviewing of the finding to improve the plans and regulations during Hajj, Umrah and other events is critical. Thus, this study aimed to measure donor attendance and donation trends in Hajj and Umrah seasons and evaluate the blood components productions simultaneously. Furthermore, it measured the blood units' demand to assist in efficient ways of managing blood supply and demand during the Hajj and Umrah and similar future public or mass gathering emergencies.

Methods

Study Design

The current study is a retrospective study based on data collection from a laboratory information system using blood donor records and unit production during the period from 1436 to 1440 Hijri at Security Forces Hospital Program in Makkah.

Ethical Approval

The data were obtained from the blood bank unit of the hospital after optioning ethical approval from the internal review board at Security Forces Hospital Program in Makkah (0211-120818).

Data Collection Tools

Data for this study were obtained using an Excel template (Microsoft version 360) of donors' lab records at the Security Forces Hospital Program (SFH) in Makkah. All data during the period from 1436H to 1440 Hijri were included in the study, as there were no exclusion criteria. Subsequently, data cleaning was performed to organize the data and remove any duplication.

Statistics

Data was reviewed and analysed using the statistical package of social sciences (SPSS version 24); the descriptive statistics were presented in count and percentages. The Chi-square test was performed to compare the number of donors with other variables, and P -value > 0.05 were considered statistically significant.

Results

Overview of Blood Donation and Unit Production from 1436-1440H

A retrospective study was conducted on 5473 blood donors who donated blood at the Security Forces Hospital Program in Makkah from 1436H to 1440H. Details of blood donation and blood units' production were summarised in Table 1. The table demonstrated that blood donation frequency varies through the years and months. Only 11.4% (626) of the participant was in 1440H, which was the lowest year with recorded donations, and a large number of participants in 1437H, 27.8% (1523), followed by year 1439H were participant was 26.7% (1462). Data demonstrated that blood donation was lowest in Ramadan at 5% (272) compared to other months; also, Shawal was

Table 1. Characteristics of blood donation and production during the study period

Characteristic	<i>n</i>	%	
Frequency of blood donation during Arabic months	1. Muharram	423	7.7
	2. Safar	487	8.9
	3. Rabi Al-Awwal	431	7.9
	4. Rabi Al-Thani	599	10.9
	5. Jamada Al-Awwal	558	10.2
	6. Jamada Al-Thani	494	9.0
	7. Rajab	461	8.4
	8. Shaban	406	7.4
	9. Ramadan	272	5.0
	10. Shawwal	355	6.5
	11. Dhul Qadah	529	9.7
	12. Dhul Hijjah	458	8.4
Total	5473	100.0	
Frequency of blood donation during Hijry years	1436	856	15.6
	1437	1523	27.8
	1438	1006	18.4
	1439	1462	26.7
	1440	626	11.4
	Total	5473	100.0
Frequency of blood units produced	CRYO	5084	24.0
	FFP	5326	25.1
	PLT	5322	25.1
	PRBS	5473	25.8
	Total	21205	100

This table shows the demographic characteristics of blood donors who participated in the study. Number (*n*) and percentage (%).

6.5% (355), Dhul Qadah was 9.7% (529), and Dhul Hijjah was 8.4% (458). Results showed that a total of 21205 blood unit components were collected during the study period 1436–1440. The most collected blood unit was packed red cells (25.8%), followed by platelet (25.1%), fresh frozen plasma (25.1%), and then cryoprecipitate (24%), respectively.

The Monthly Report of Blood Donation Distribution Between 1436H to 1440H Showed Fluctuation in the Number of Donations Depending on the Month

Data for the five years were recorded from the month of Muharram to Dhul Hijjah. The monthly breakdown of blood units collected each year is shown in Figure 1. Data indicated that the frequency of blood donation trends varies throughout the years and months. In Muharram, the blood donation rate was low compared to other months, then it started to increase in the middle of the year and dropped again to a similar rate in Dhul Hijjah. There was a notable drop in the number of donors during Ramadan in all years, and it was the lowest compared to other months in the same year. In addition to the 12th month of Hajj, the donation rate also decreased compared to other months in all years. The year 1440H was the lowest compared to other years since donation numbers were zeroes from the 5th to 12th months, in addition to the year 1438H were zeros from month 8th to 12th. Results indicated that there were statistical differences in comparing rates of donation, a P -value of 0.0001.

Utilization of Blood Components Between 1436H to 1440H Showed that the Unit Production did not cover the needs

Blood units' production and usage data for the five years were recorded. The monthly breakdown of the percentage of blood units' utilization for each year is shown in Table 2. Data demonstrated that utilization of blood units differs according to year, month, and type of blood unit. Data indicated that during Ramadan, production of the blood units exceeded the usage for CRYO (52.9%), PRBC (52.2%), PLT (25.0%) and FFP (17.6%). A similar finding was observed during Hajj too, where the production increased for CRYO (81.1%), PLT (91.6%) and FFP (55.8%), with the expectation of PRBC, where the production decreased by (–29.5%). Furthermore, results indicated that Hajj and Umrah seasons impact the unit's utilisation where unit production does not cover the needs.

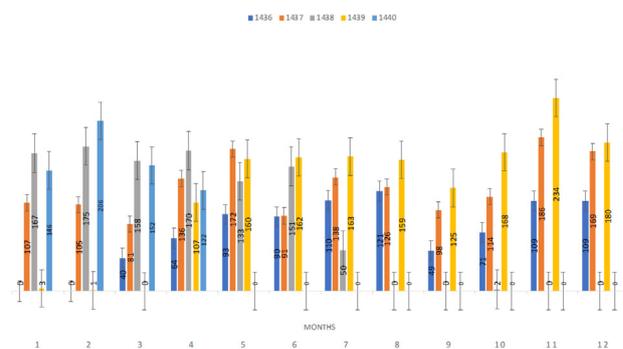


Fig. 1 Number of donors from 1436 to 1440. This Figure shows the distribution of blood donors among Hejry months. P -value was 0.0001.

Table 2. Percentage of the utilization of blood components at SFH-Makkah hospital

Year	Unit type	Month												Average	P-value
		1	2	3	4	5	6	7	8	9	10	11	12		
1437	CRYO	60.0	100.0	100.0	68.7	72.4	36.2	80.5	83.7	52.9	67.0	94.7	81.1	75	0.051
	FFP	-8.0	100.0	85.7	60.0	75.6	-58.5	58.5	67.4	17.6	46.2	88.6	55.8	49	
	PLT	14.0	90.1	56.0	19.1	7.3	9.6	-2.4	82.6	25.0	35.2	96.5	91.6	44	
	PRBC	56.0	53.1	65.9	29.6	53.7	28.7	-22.0	56.5	52.2	6.6	41.2	-29.5	33	
1438	PRBC	22.0	51.4	28.9	59.6	46.0	45.7	-14.1	59.0	52.3	41.3	51.7	30.3	40	0.049
	CRYO	57.8	100.0	91.2	95.7	83.3	75.0	87.1	94.3	83.0	85.6	100.0	74.2	86	
	FFP	40.4	100.0	71.9	75.2	58.7	47.4	32.9	67.9	-0.6	59.3	90.4	33.5	56	
	PLT	39.4	78.0	63.2	92.2	51.6	58.6	83.5	94.8	91.5	68.9	77.5	78.1	73	
1439	CRYO	60.0	100.0	100.0	68.7	72.4	36.2	80.5	83.7	52.9	67.0	94.7	81.1	75	0.050
	FFP	-8.0	100.0	85.7	60.0	75.6	-58.5	58.5	67.4	17.6	46.2	88.6	55.8	49	
	PLT	14.0	90.1	56.0	19.1	7.3	9.6	-2.4	82.6	25.0	35.2	96.5	91.6	44	
	PRBC	56.0	53.1	65.9	29.6	53.7	28.7	-22.0	56.5	52.2	6.6	41.2	-29.5	33	
1440	CRYO	60.0	100.0	100.0	68.7	72.4	36.2	80.5	83.7	52.9	67.0	94.7	81.1	75	0.04
	FFP	-8.0	100.0	85.7	60.0	75.6	-58.5	58.5	67.4	17.6	46.2	88.6	55.8	49	
	PLT	14.0	90.1	56.0	19.1	7.3	9.6	-2.4	82.6	25.0	35.2	96.5	91.6	44	
	PRBC	56.0	53.1	65.9	29.6	53.7	28.7	-22.0	56.5	52.2	6.6	41.2	-29.5	33	
Total	CRYO	60.0	100.0	100.0	68.7	72.4	36.2	80.5	83.7	52.9	67.0	94.7	81.1	75	0.04
	FFP	-8.0	100.0	85.7	60.0	75.6	-58.5	58.5	67.4	17.6	46.2	88.6	55.8	49	
	PLT	14.0	90.1	56.0	19.1	7.3	9.6	-2.4	82.6	25.0	35.2	96.5	91.6	44	
	PRBC	56.0	53.1	65.9	29.6	53.7	28.7	-22.0	56.5	52.2	6.6	41.2	-29.5	33	

Discussion

Hospitals are the first place the wounded are relocated to when a natural or manufactured disaster occurs, and it may generate many types of injuries that may require the use of blood units. Such events may also occur in mass gatherings such as Hajj and Umrah. For this reason, Blood Banks must be prepared for a rapid supply of units to the patients. For that, this study attempted to analyse the blood unit production and utilisation at SFH-Makkah during 1436–1440. A close view of the blood units' usage would help focus on frequent wastage and improve the blood bank services at Makkah, especially during Hajj and Umrah seasons. Subsequently, it would further help authorities design intervention measures to prevent such issues and improve blood unit management throughout Makkah hospitals.

The current statistics showed that the number of blood donors varies according to the Islamic months, especially during Hajj and Umrah seasons, where the lowest donation number was observed in Ramadan (272), Shawal (355), Dhul Qadah (529), and Dhul Hijjah was (458). This indicates that the blood centre lacks an adequate number of volunteer and non-volunteer blood donors, which can impact the access to enough blood to meet patients' current and future needs. Similarly, Alkahtani and Jilani¹⁰ demonstrated that the number of blood donors decreased in June and September in 2017 and 2018, corresponding to the Ramadan and Hajj periods. They also proved the importance of predicting return donors and analysing blood donation time series using data mining techniques to sustain an adequate blood supply during Islamic seasons. Nevertheless, 43 well-defined blood group systems have more than 340 antigens,¹¹ but generally, only ABO and RhD blood group status is considered for donation and transfusion in Saudi Arabia. This increases the chances of alloimmunisation if the donor and recipient are of different ethnic backgrounds with varied blood antigenic profiles. During Hajj and Umrah, a large diversity of ethnicity is observed, especially since Muslims worldwide visit Makkah during different times of the year.¹² Such diversity can cause a challenge for hospitals to provide suitable blood units for non-Saudi patients if needed. These facts highlight the need to promote local blood donation and the need for extended blood group phenotyping. A Canadian researcher observed a similar finding that proved that global antigen demand affected community-directed recruitment, including blood drives and the benefits of the mass-scale cell genotyping.¹³

According to the results, blood unit use varies by year, month, and kind of blood unit. Furthermore, the results revealed that the Hajj and Umrah seasons influenced unit usage when unit production was insufficient to meet demands. By reviewing the project outcomes with blood bank staff, it was noted that the significant reason for utilising the components might be communication between centres in Makkah. It was also recommended that there is always a more considerable blood shortage, and a need for awareness is essential among laboratory staff, nurses, and physicians on handling blood products. Similar to the results of other studies, where they indicated a significant improvement in blood products management after the educational programme.^{14,15} Packed cells were the most frequently collected of the four blood components collected at SFH-Makkah, followed by fresh frozen plasma, platelet, and cryoprecipitate. The current finding agrees with another research.^{16,17} The present study did not include the

production and utilisation of the Whole blood unit since whole blood is not frequently used except in a patient who lost more than 75% of the blood volume. Consequently, the current results prove that the national health authorities must become more involved in the blood donation, unit production and transfusion field's fundamental improvement. This involves establishing national legislation that acknowledges blood donation and production, unit safety and transfusion as top public health issues. The Saudi Health Ministry must establish a national regulatory agency to manage a national blood bank quality system and the country's blood supply. It would operate as a bridge between the many professionals in the blood transfusion business. A reliable haemovigilance reporting system is also necessary to track quality improvement and evaluate all transfusion-related medium- and long-term consequences.

Blood component management remains an issue for all health services worldwide; it requires inexpensive and easy interventions such as research and staff education, a centralised digital management system, and enhanced transportation. Furthermore, identification modalities are required that can have a critical and dramatic influence on improving the management concerning cost and resource savings.¹⁴ CRYO and FFP have a shelf life of 24 hours after preparation, and it has been noted in the current study that there needs to be a clear policy regarding requesting such units. Moreover, as blood products have a restricted half-life, accurate strategies should be enforced for blood supplies to prevent loss and reduce waste as much as possible.^{4,5} The Saudi health authority needs to create an emergency operations plan that focuses on education, assigning roles, and Makkah blood banks practising and should be based on reviewing the national plan need to occur. There is also a need to integrate Hajj data management systems with blood unit surveillance as an early warning system for blood donation and transfusion control during Hajj and Umrah. Similar findings were also demonstrated if the infectious disease during Hajj^{1,18} also during the COVID-19 pandemic.¹⁹ International engagement is essential to strengthening national blood surveillance because blood groups differ based on ethnicity. This plan should include an intelligent digital management system that improves the current practice and reduces human error during mass gathering events. Such a system should consist of an intellectual multi-period decision-making framework for emergency blood allocation considering supply and demand uncertainties in the disaster maintenance operations.²⁰ Also, it should consider blood groups, age and blood substitution.

The finding of this work presented a clear picture of the limitations and challenges that face the Saudi ministry of health and the ministry of Hajj and Umrah each year during the Hajj and Umrah seasons. Also, they provide insight into the importance of communication and information sharing during that period of the year. Additionally, with the changes in the Umrah allowance periods, now the season is open almost all year long, which presents the sectors with more significant challenges and solutions needed. Additional events of massive gatherings are also planned in the near future, which would add up to the stress of managing emergencies. Thus, recommendations are all aimed at expanding the current study to include all hospitals in Makkah, as these hospitals are the hot spots facing these challenges. Also, to activate the intelligent blood bank centralisation management system. This system should survey, gather data, and analyse it to plan. Also, there should be a clear policy to manage massive gatherings

and procedures to follow to plan care and emergencies, including blood bank supply. This system should also manage the blood group distribution of patients and donors.⁹

Another aspect to consider in future work is expanding the data analysis range to include more details, such as common and rare blood groups and planning to secure sources for such rare types. This is essential to consider as in the hajj and Umrah seasons, people gather from all locations around the world with all possibilities for rare blood antigens. Managing blood banks should be an essential topic in massive gatherings of management studies and policies and regulations.

Conclusion

The study showed blood unit production and utilisation were influenced by Hajj and Umrah seasons at the SFC-Makkah; the most shortage was observed in PRBC and platelets. Globally, the wastage of blood in hospitals is universal and should be addressed with easy and inexpensive interventions to improve blood component management. Programs to encourage blood donations during Hajj and Umrah seasons should be increased to accommodate the needs of blood units during the same period. Moreover, developing national and local guidelines prioritising blood transfusion during seasons and mass gathering is critical. Such guidelines should closely monitor blood needs and supply, including the appropriate response for any events that are essential to avoid sudden blood shortages. Also, an evidence-based emergency blood unit management plan and flexible regulatory policy should be implemented to manage any disaster that leads to blood

shortage. Finally, the current research highly recommends developing an intelligent decision-making system to improve the management of blood units, as blood is a vital and rare resource.

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Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Data and Resource Availability Statement

The data that support the findings of this study are available from SFH Hospital Makkah, but restrictions apply to the availability of these data, which were used under license for the current research and therefore are not publicly available. Data are however available from the authors upon reasonable request and with permission of SFH Hospital Makkah.

Additionally, the resource generated during and/or analysed during the current study is available from the corresponding author upon reasonable request. ■

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