Research Article

**Novel web-based real-time dashboard to optimize recycling and use of red cell units at a large multi-site transfusion service**

Christopher Sharpe, Jason G Quinn, Stephanie Watson¹, Donald Doiron¹, Bryan Crocker¹, Calvino Cheng

Department of Pathology and Laboratory Medicine, Division of Hematological Pathology, Dalhousie University, ¹Department of Pathology and Laboratory Medicine, Pathology Informatics, Capital District Health Authority, Halifax, Canada

E-mail: *Calvino Cheng. Calvino.Cheng@cdha.nshealth.ca*

*Corresponding author*

Received: 04 June 2014  Accepted: 21 July 2014  Published: 30 September 2014

**Abstract**

**Background:** Effective blood inventory management reduces outdates of blood products. Multiple strategies have been employed to reduce the rate of red blood cell (RBC) unit outdate. We designed an automated real-time web-based dashboard interfaced with our laboratory information system to effectively recycle red cell units. The objective of our approach is to decrease RBC outdate rates within our transfusion service. **Methods:** The dashboard was deployed in August 2011 and is accessed by a shortcut that was placed on the desktops of all blood transfusion services computers in the Capital District Health Authority region. It was designed to refresh automatically every 10 min. The dashboard provides all vital information on RBC units, and implemented a color coding scheme to indicate an RBC unit's proximity to expiration. **Results:** The overall RBC unit outdate rate in the 7 months period following implementation of the dashboard (September 2011-March 2012) was 1.24% (123 units outdated/9763 units received), compared to similar periods in 2010-2011 and 2009-2010: 2.03% (188/9395) and 2.81% (261/9220), respectively. The odds ratio of a RBC unit outdate postdashboard (2011-2012) compared with 2010-2011 was 0.625 (95% confidence interval: 0.497-0.786; *P* < 0.0001). **Conclusion:** Our dashboard system is an inexpensive and novel blood inventory management system which was associated with a significant reduction in RBC unit outdate rates at our institution over a period of 7 months. This system, or components of it, could be a useful addition to existing RBC management systems at other institutions.

**Key words:** Blood transfusion services, inventory management, O-negative, outdate, red blood cell inventory, red blood cell outdate, transfusion

**INTRODUCTION**

Blood products are altruistically donated and of finite supply, with only a minority (3.7%) of the eligible population actually donating blood in Canada (blood.ca). Red cell units account for the majority of the demand for blood products in Canada and are transfused at a rate of 32.6/1000 population compared with only 4.2/1000 population for platelet products.[¹] Recent supply and demand modeling literature suggests that there will
be increased pressure due to decreasing supply and increasing demand, with possible crossing-over of the supply and demand curves occurring currently or in the future.\cite{2} In addition, a significant cost is associated with obtaining human blood products. A vital role of any blood transfusion service (BTS) is the careful management of these resources to minimize outdates and ensure an adequate supply.

When managing the red blood cell (RBC) inventory, the O-negative blood group is of particular importance due to its utility in the setting of urgent transfusion of uncross matched blood, as well as its role in routine transfusion of O-negative patients. As a result, it is important that blood inventory management systems ensure careful management of O-negative RBC blood supplies.

A variety of strategies have been employed to reduce the rate of RBC unit outdate. Older models of blood inventory management have demonstrated the efficiency of transfusing the oldest available units first in order to avoid outdates, a practice known as First-In-First-Out (FIFO).\cite{3,4} Other strategies can include minimizing the rate and amount of time that an RBC unit is cross matched and assigned to a specific patient within the inventory.\cite{4,6} Another method is to correctly size the inventory in order to minimize its level, but still ensure there is an adequate supply. Data from the blood stocks management scheme has found that wastage as a percentage of issues correlates with the Issuable Stock Index, an indicator for the number of days of the unreserved stock of all blood groups held in inventory, suggesting that reduced inventory levels will improve outdate rates.\cite{6} There is also newer literature on optimizing transfusion delivery through process re-engineering methods such as Lean Sigma, whereby application of this strategy in a large academic hospital decreased overall RBC product outdate from 4.4% to <2.2%.\cite{7} Finally, it has long been recognized that an RBC recycling program within a hospital transfusion service or between multiple transfusion services in a regional setting can significantly lessen RBC outdate rates. This is due to hospitals with lower transfusion turnover being able to offload units to hospitals with higher transfusion turnover.\cite{8-12} One limitation of previous examples of RBC recycling is that there has not been a significant focus on the use of real-time RBC data from existing hospital transfusion service laboratory information systems (LIS) given that those systems are the backbone of all modern transfusion labs.

Our institution (Capital District Health Authority [CDHA], Halifax, Nova Scotia, Canada) wanted to improve our RBC outdate rates, and in particular our O-negative outdate rate. Due to systemic resource constraints, we desired a scalable, low-overhead methodology that could allow for separate transfusion sites to quickly identify units that were candidates for recycling. As a result, we developed a system which, was separate from, but incorporated real-time LIS data, as it has been demonstrated previously that supply chain transparency with knowledge of the data does improve transfusion supply chain performance.\cite{13}

**METHODS**

Capital District Health Authority has a multi-site BTS which transfuses approximately 16,000 RBC units/year and includes a quaternary care emergency and trauma center, cardiac surgery, multi-organ transplantation, and autologous and allogeneic hematopoietic stem cell transplantation services.

The RBC unit inventory at CDHA had previously been decreased to a minimum level prior to dashboard implementation in order to minimize outdates. Our institution also has a policy of transfusing ABO identical RBC units to all patients at all times, as well as an FIFO inventory handling practice. As well, unused RBC units are transferred from smaller affiliated hospitals to larger centers 14 days prior to outdate as a means of minimizing outdate rates. Autologous units are rare in our center and were excluded from our data analysis. It is not standard practice in our institution to transfuse Rh positive units to patients over 50 years of age, and if this is done, there are usually extenuating circumstances such as massive transfusion.

The Pathology Informatics Group at CDHA designed and implemented the RBC dashboard in collaboration with the BTS at CDHA, with additional expertise being provided by CDHA eHealth Services. The RBC dashboard is based on a combination of HTML and JavaScript, with a query from real-time data located on Cerner Millennium (2010.02). The website is distributed across the intranet using a secure https protocol delivered through Microsoft Share point (Microsoft Corporation, Redmond, WA) and is refreshed every 10 min automatically.

The dashboard contains the following RBC unit variables: Unit number and check digit, ABO/Rh group, date and time of expiry, product disposition and location, special product attributes (irradiation and cytomegalovirus status, RBC phenotyping data), and limited recipient data [Figure 1]. The dashboard was color-coded for easy visibility and interpretation: Red (2 days or less to outdate), yellow (between 2 and 5 days outdate), and green (between 5 and 14 days outdate).

The dashboard was deployed and available for user testing in May 2011 and by August 2011, BTS staff had been fully trained in its use. It is available to access through desktop computers in BTS, and is it standard procedure
to consult the dashboard prior to any transfusion. Unit selection is then made based on a variety of factors provided in the dashboard including time to outdated of unit, the urgency of transfusion request, and location of the unit. When it has been indicated by the clinical team that units are needed on an urgent basis, the dashboard can be bypassed.

In order to assess the effect of the dashboard on the expiry of RBC units, three separate time intervals were compared: September 2011–March 2012 (the 7 months period following implementation of the dashboard), September 2010–March 2011, and September 2009–March 2010 (the corresponding time periods 1 and 2 years prior to the existence of the dashboard, respectively).

RESULTS

**O-Negative Inventory**

Following RBC dashboard implementation within the BTS at CDHA in August 2011, there was a significant reduction in O-negative RBC units outdated in the 7 months period thereafter when compared to the same time period in the two preceding years [Table 1]. The O-negative RBC outdate rate for September 2011–March 2012 postdashboard implementation represents a 93% decrease compared to the same period in 2010-2011 and a 95% decrease compared to 2009-2010. The odds ratio (OR) of an O-negative outdate for September 2011–March 2012 versus September 2010–March 2011 was 0.071 (95% CI: 0.0285–0.1755; \( P < 0.0001 \)).

**Overall Red Blood Cell Inventory**

During the 7 months period after implementing the dashboard system there was a significant reduction in total RBC units outdated in the 7 months period thereafter when compared to the same time period in the two preceding years [Table 2]. The overall RBC outdate rate for the period studied during 2011–2012 represents a 38% decrease versus 2010–2011 and 55% decrease compared to 2009–2010. The OR of a RBC unit outdate for September 2011–March 2012 versus September 2010–March 2011 was 0.625 (95% CI: 0.497–0.786; \( P < 0.0001 \)).

DISCUSSION

The RBC dashboard developed and implemented within the BTS at our institution is a novel and scalable method to assist recycling of RBC units between our geographically separate sites. A significant impact on both the overall and O-negative RBC unit expiry rate was observed following the implementation of this system.

Prior to the existence of the RBC dashboard, our institution decreased the inventory level of RBC units between 2009 and 2011 in an attempt to minimize outdate rates. Significant reductions in overall unit outdates were observed between these 2 times periods as the rate fell from 2.81% during September 2009-March 2010 to 2.03% during September 2010-March 2011. The outdate rate of O-negative RBC units decreased from 0.93% to 0.73% in the corresponding periods outlined above. Outdate rates were noted to reach a steady state following this change in the time period of September 2010 until approximately May 2011 [Figure 2]. We were unable to further decrease our inventory, while ensuring adequate reserves under our previous system of inventory management.

The implementation of the RBC dashboard within our BTS was associated with a significant decrease of both overall and O-negative RBC unit outdates. In addition, we were able to significantly decrease our O-negative
discard rate as a proportion of all outdates. It should be noted that no other notable systemic changes occurred in our BTS leading up to or during our data collection period. Therefore, it appears the decrease in RBC unit outdates is likely attributable to the implementation of our dashboard system.

Until date and dynamic information on the location, disposition, and availability of RBC units within the systemic inventory allows for the appropriate and timely designation of available units to recipients, and BTS technologists are continually aware of which unit should be chosen next when blood issuance is required. The color-coded layout of the dashboard highlights RBC units that are nearing expiry in <2 days as it is boldly outlined in red. Of particular importance, the real-time auditing of the RBC inventory by the dashboard allows for the identification of cross matched units which are close to expiry so that they can be released from the designated patient (if not required for transfusion) and subsequently transfused to another patient. Incidentally, this information has also allowed for near-real-time auditing and follow-up of unreturned unit tags after a unit has been transfused.

The dashboard has on going and wide availability to all potential end-users on desktop computers within the BTS at our institution, and it provides a useful resource to modernize the well-understood concept of RBC recycling. The dashboard provides a systemic surveillance system which can decrease RBC unit outdates by allowing for the identification of RBC units nearing expiry at smaller, low-volume transfusion sites within the health authority so that they can be moved to a larger, high-volume transfusion site where they are more likely to be transfused. The geographical distribution of sites within our BTS is relatively small which facilitates relatively rapid recycling and transfer of RBC units between sites by road when they are nearing expiry. The transfusing site which is farthest from the main transfusion service is approximately 75 km distant, while the majority of RBC unit transfusion events within our health district occur within a radius of approximately 10 km.

Cost-wise, the dashboard system may be associated with cost reductions. Capital and personnel expenditures were negligible to implement the dashboard. Though no formal economic impact analysis was done, the economic benefits can be inferred. After implementing this system, our institution saw a 0.79% absolute reduction in unit outdate compared to the previous year. Using an estimated RBC unit value of $430, the annualized cost savings postdashboard implementation (September 2011-March 2012) was calculated at $47,914 compared to the same period in 2010-2011. The utility of the dashboard in decreasing both the outdate rate and potentially cost is further illustrated by the fact that the dashboard concept has since been embraced by the Nova Scotia Provincial Blood Coordinating Program for

Table 1: O− RBC unit outdate comparison

| Time period | Total O− outdated | Total units outdated | Total units received | Overall O− outdate rate (%) | O− proportion of outdates (%) |
|-------------|-------------------|----------------------|----------------------|-----------------------------|-----------------------------|
| 2009-2010a | 96                | 261                  | 9220                 | 0.93                        | 36.8                        |
| 2010-2011a | 68                | 188                  | 9395                 | 0.73                        | 36.2                        |
| 2011-2012a | 5                 | 123                  | 9763                 | 0.05                        | 4.1                         |

aSeptember-March in corresponding years. Bolded text-time period after initiation of dashboard system. RBC: Red blood cell

Table 2: Total RBC unit outdate comparison

| Time period | Total outdated | Total received | Overall outdate rate (%) | A and O outdates | B and AB outdates |
|-------------|----------------|----------------|--------------------------|-----------------|------------------|
| 2009-2010a | 261            | 9220           | 2.81                     | 137             | 124              |
| 2010-2011a | 188            | 9395           | 2.03                     | 92              | 96               |
| 2011-2012a | 123            | 9763           | 1.23                     | 29              | 94               |

aSeptember-March in corresponding years. Bolded text-time period after initiation of dashboard system. RBC: Red blood cell

Figure 2: Monthly red blood cell outdate rates. Solid black line is a linear trend of absolute red blood cell outdates. Broken line is a linear trend of percentage of outdated units. Triangular line is outdate percentage for a specific month.
recycling RBC units on a provincial scale. System-related savings were not quantified.

CONCLUSION

We have demonstrated the implementation of a novel low-overhead RBC recycling dashboard at our institution that is low in overhead to implement and maintain, but improves the workflow and provides cost savings for our institution. Moreover, existing infrastructure within the hospital LIS and intranet was used to implement the dashboard in a manner that was scalable and not cost-prohibitive. Although more time is required to validate its use and fully assess and audit the impact of the dashboard on other quality metrics, this dashboard represents advancement on inventory management practice in the literature, and can be applied to other institutions.

ACKNOWLEDGMENTS

Kara Thompson (Biostatistician in the Department of Medicine Research Office, Dalhousie University), and Lauren Kiri for help with preliminary data analysis.

Technical Specialists at CDHA.

Irene Sadek and Joan Macleod, for allowing and encouraging the use of unconventional methodologies in their transfusion service.

Canadian blood services for providing data.

REFERENCES

1. Devine DV, Sher GD, Reesink HW, Panzer S, Hetzel PA, Wong JK, et al. Inventory management. Vox Sang 2010;98:e295-363.
2. Williamson LM, Devine DV. Challenges in the management of the blood supply. Lancet 2013;381:1866-75.
3. Cohen MA, Fierskilla WP. Management policies for a regional blood bank. Transfusion 1975;15:58-67.
4. Pereira A. Blood inventory management in the type and screen era. Vox Sang 2005;89:245-50.
5. Friedman BA, Abbott RD, Williams GW. A blood ordering strategy for hospital blood banks derived from a computer simulation. Am J Clin Pathol 1982;78:154-60.
6. Perera G, Hyam C, Taylor C, Chapman JF. Hospital blood inventory practice: The factors affecting stock level and wastage. Transfus Med 2009;19:99-104.
7. Heitmiller ES, Hill RB, Marshall CE, Parsons BJ, Berkow LC, Barrasso CA, et al. Blood wastage reduction using Lean Sigma methodology. Transfusion 2010;50:1887-96.
8. Britten AF, Geurtze DG. Weekly rotation of blood inventory - A system for supplying small hospitals. Transfusion 1979;19:738-41.
9. Abbott RD, Friedman BA, Williams GW. Recycling older blood by integration into the inventory of a single large hospital blood bank: A computer simulation application. Transfusion 1978;18:709-15.
10. Lau P, Morand PG. Regional blood inventory management development, implementation and 30-month follow-up. Vox Sang 1981;41:50-5.
11. Brodheim E, Prastacos GP. A regional blood management system with prescheduled deliveries. Transfusion 1979;19:455-62.
12. Deneiuk L, Richardson T, Nahirniak S, Clarke G. Implementation of a redistribution system for near-outdate red blood cell units. Arch Pathol Lab Med 2006;130:1178-83.
13. Chapman J. Unlocking the essentials of effective blood inventory management. Transfusion 2007;47:1905-6.