Zeroing in on red blood cell unit expiry

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BACKGROUND: Expiry of red blood cell (RBC) units is a significant contributor to wastage of precious voluntary donations. Effective strategies aimed at optimal resource utilization are required to minimize wastage.

STUDY DESIGN AND METHODS: This retrospective study analyzed the strategic measures implemented to reduce expiry of RBC units in an Australian tertiary regional hospital. The measures, which included inventory rearrangement, effective stock rotation, and the number of emergency courier services required during a 24-month period, were evaluated.

RESULTS: There was no wastage of RBC units due to expiry over the 12 months after policy changes. Before these changes, approximately half of RBC wastage (261/511) was due to expiry. The total number of transfusions remained constant in this period and there was no increase in the use of emergency couriers. Policy changes implemented were decreasing the RBC inventory level by one-third and effective stock rotation and using a computerized system to link the transfusion services across the area. Effective stock rotation resulted in a reduction in older blood (>28 days) received in the main laboratory rotated from peripheral hospitals, down from 6%-41% to 0%-2.5%.

CONCLUSION: Age-related expiry of blood products is preventable and can be significantly reduced by improving practices in the pathology service. This study provides proof of principle for “zero tolerance for RBC unit expiry” across a large networked blood banking service.

Blood transfusion is indisputably recognized as a vital lifesaving measure in patient care.[1] However, it is also one of the most commonly overused health care interventions.[2]

Several countries have developed patient blood management programs for better transfusion practices in recent years.[3] The “Choosing Wisely Campaign” in the United Kingdom and United States reiterates this with their recommendations on transfusing blood products.[4] Although the significance of minimizing unnecessary transfusion is gradually becoming widely accepted, there are limited studies demonstrating cost-effective strategies in blood inventory management to reduce wastage in the supply chain and, further, to conserve this scarce resource.

ABBREVIATIONS: ARCBS = Australian Red Cross Blood Service; HNELHD = Hunter New England Local Health District; JHH = John Hunter Hospital; NBA = National Blood Authority; NIMF = National Inventory Management Framework; PN-H = Pathology North Hunter; WAPI = wastage rate as a percentage of issue.

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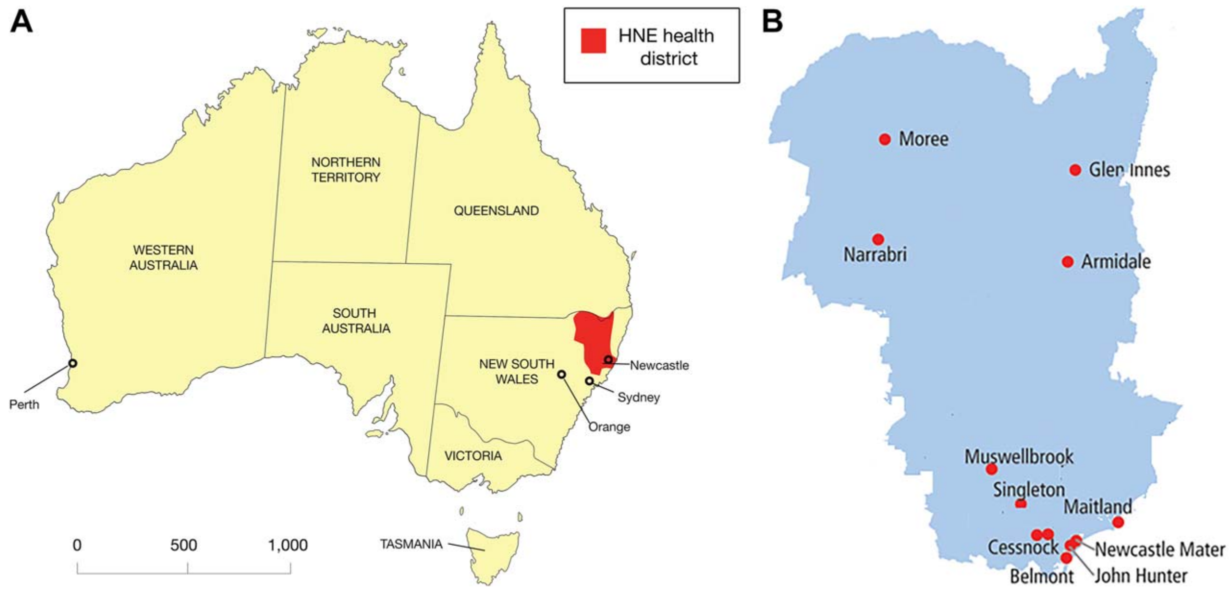

Fig. 1. (A) The Hunter New England Health Area of New South Wales Australia (source Google images). (B) The Blood Service arrangements in the health district (Google images). [Color figure can be viewed at wileyonlinelibrary.com]

The demand for blood products and the costs of blood procurements are increasing worldwide. However, a concomitant increase in voluntary donor pool has not been observed.[5] Recent data suggest that there are 13.6 million whole blood and red blood cell (RBC) units collected in the United States in a year.[6] RBC product wastage in US hospitals was reported to range between 0 and 6.7% based on College of American Pathologists Q-tracks studies performed in early 2000.[7-9] Heitmiller and colleagues[7] demonstrated the importance of reducing wastage using Lean Sigma methodology. In hospitals in the United Kingdom, the wastage rates are similar at 0.26 and 6.7% annually.[10-12]

In Australia, health care expenditure is expected to constitute approximately 16% of the estimated budget for the period of 2016 to 2017, with a growing proportion spent on fresh blood expenditure. Currently, RBCs comprise 25% of the total blood and blood product–related expenditure.[13,14] Recently, the National Blood Authority (NBA) has developed several initiatives to reduce wastage of blood and blood products. The National Blood and Blood Product Wastage Reduction Strategy 2013-17 has now been rolled out by the NBA to reduce unnecessary wastage.[15] The National Inventory Management Framework (NIMF) is a collaboration between the Australian Red Cross Blood Service (ARCBS) and the NBA to define guidelines for effective RBC inventory management.

A certain level of discard of blood and blood product is inevitable and appropriate to ensure adequate availability.[12] However, in many countries the major reasons for blood wastage includes time expiry.[5,16-18] We believe that wastage due to time expiry is avoidable and can be minimized by improving practices within pathology services. Based on the NIMF report guidelines, we aimed to explore the effectiveness of various targeted cost-effective strategies in a regional blood service in New South Wales (NSW) to reduce RBC wastage due to expiry.[19]

The John Hunter Hospital (JHH) in Newcastle, New South Wales, Australia, is a large university-affiliated tertiary care center providing services for the Hunter New England Local Health District (HNELHD). HNELHD consists of 131,785 km^2 or 16% of the state of NSW with an estimated resident population of 873,741 as shown in Fig. 1A.[20] Pathology North Hunter (PN-H), a division of NSW Health Pathology, is the largest regional pathology service provider in NSW and provides services for the public hospitals in HNELHD. PN-H facilitates approximately 15,000 RBC transfusions a year and was the site where the study was carried out.

MATERIALS AND METHODS

This study retrospectively analyzed age-related expiry of RBCs in the HNELHD in the 12 months preceding and after the intervention (i.e., November 2012 to October 2013 and November 2013 to October 2014). Several policy changes were implemented in November 2013 based on the pilot NIMF report to decrease RBC wastage due to expiry.[19]

Description of blood service arrangements in health district

The central laboratory located at the JHH supplies blood products to hospitals in Newcastle including the JHH, the

Calvary Mater Newcastle, and the Royal Newcastle Centre and peripheral hospitals including Belmont Hospital, The Maitland Hospital, The Muswellbrook District Hospital, Singleton District Hospital, and Cessnock District Hospital. The central laboratory receives blood products from the ARCBS located in Sydney and also accepts RBCs returned from regional hospitals within the network including Armidale Hospital, Glen Innes District Hospital, Moree District Health Service, and Narrabri District Hospital, which get their initial own supply from ARCBS. In short, John Hunter Laboratory is responsible for supplying RBCs and other blood products to laboratories within the region and also receiving blood products back from peripheral laboratories when they have not been required for transfusion (Fig. 1B).

Interventions

Effective inventory management

A safety stock calculation was undertaken before the period of intervention. Safety stock, also called buffer stock, is a term used to describe the level of stock to mitigate the risk of stock out (not having sufficient stock to satisfy demand). The RBC safety stock calculation was developed by the ARCBS and NBA in conjunction with statisticians from the Royal Melbourne Institute of Technology.

Safety stock calculations incorporate variability of the number of RBCs that were required for transfusion, variability in the supply from the Blood Service, lead time (the time delay between order and delivery of blood products from ARCBS), and customer service factors (the intended level of order fulfilment). Safety stock was calculated using the formula

$$SS = ZX\sqrt{\mu_L S_D^2 + \mu_D^2 S_L^2},$$

where SS is safety stock, Z is normal distribution service factor based on desired service level, μ_L is the mean lead time (the time to deliver blood products from blood service to the laboratory), S_D is the standard deviation of demand, μ_D is the mean demand, and S_L is the variance of lead time (measured by the units entering inventory per day).

Using these variables, a lower band is calculated and an upper band is set 6 standard deviations (of demand) above. The aim is to be in the middle of the bands. The upper band safeguards against excess stock, therefore minimizing the potential for waste. The calculation was completed for each component at the ABO level with additional adjustments for modified products (e.g., cytomegalovirus [CMV]-negative RBCs). The proposed inventory levels for each feeder hospital were calculated using one routine delivery per weekday to the JHH from ARCBS. As a result of this process, the inventory levels of total RBC units in the area health was decreased.

There was effective stock rearrangement with increased proportions of O+ and O– inventory levels in the area health. JHH stopped stocking group AB RBCs and the proportion of O– blood in peripheral hospitals was also increased. Two O– units were issued in all emergency releases. As soon as the patient was confirmed as male, beyond childbearing age (if female), or D+, then O+ was issued until the blood group could be confirmed. JHH also commenced holding more group O stocks in the peripheral hospitals. The blood fridges at the very remote peripheral labs like Singleton, Muswellbrook, and Cessnock were stocked with only group O blood (O+ and O–) as they did not have a laboratory at site and are not able to determine blood group in an emergency situation. By changing to group O, the availability and usability was increased, while total stock numbers reduced.

Effective stock rotation

Effective stock rotation within the network involved using a courier service to rotate RBC stocks from the satellite laboratories when the age of blood was between 16 to 28 days of age back to the central laboratory for use in the tertiary center. An age limit of 21 days was implemented to accept RBCs back from peripheral hospitals, which ensured that any blood older than 21 days had to be returned to JHH. However, in actual practice, there was a variance in age of blood received ranging from 16 to 28 days. Hence, in this study, we opted for 28 days as cutoff for analysis.

Computer-based system linking transfusion laboratories

John Hunter Hospital uses BloodNet, a Web-based system to order blood and blood products in a standardized way, quickly, easily, and securely from the ARCBS. BloodNet enables staff in pathology laboratories to place orders online for blood and blood products, to record inventory levels, and to record the final fate of each unit (e.g., discarded, transferred, transfused). An in-house computer software, *e-blood,* controls the operation of the transfusion laboratory and is interfaced with BloodNet. The *e-blood* program is networked to all the sites in HNELHD so that blood can be released electronically. The local IT department created a program that allowed the senior scientists in the main laboratory to view the details and expiry of stock at all peripheral hospitals in real time.

Staff training and education

Senior scientists at John Hunter were responsible for ordering blood via BloodNet and effective stock rotation within the network

Outcome measures

The endpoints assessed were the total RBC transfusions during this time period, monthly trends, age of blood received from the ARCBS and peripheral hospitals, and

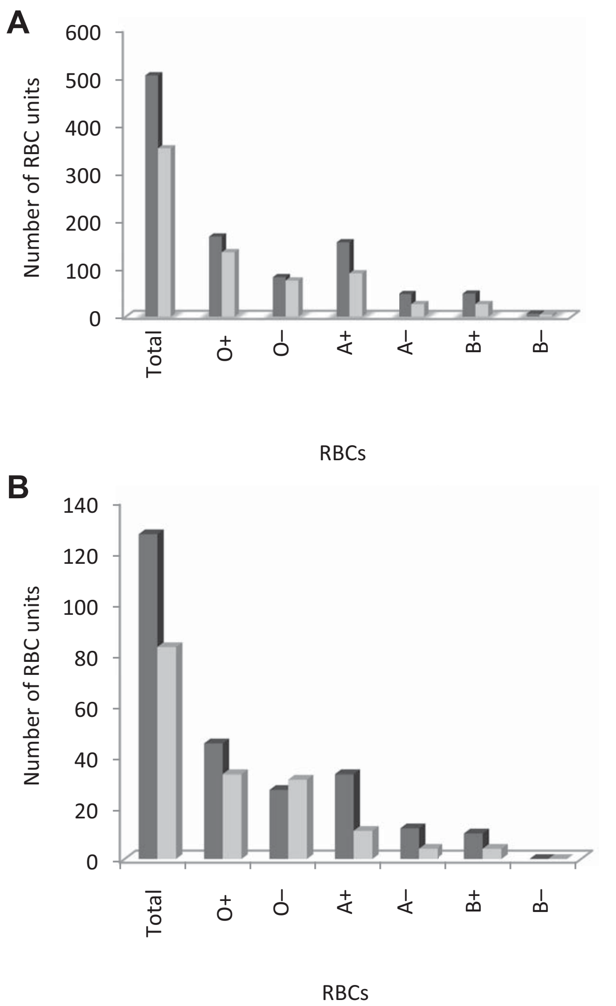

Fig. 2. (A) Change in RBC unit inventory after intervention in the area health. (B) Change in RBC unit inventory after intervention at peripheral hospitals. (■) Before intervention; (■) after intervention.

the number of emergency courier services used in this period. The analysis also included reviewing the key changes in the inventory management.

Statistical analysis

We conducted a two-sample test of proportions using computer software (STATA, Version 13, StataCorp).

RESULTS

Lowering of RBC stock levels and changing the proportion of different blood groups in inventory

One of the key results was reduction in stock levels. Mean stock of RBC units per day was 504 units in the area health before the policy changes. Total inventory levels for RBCs were reduced by 30.1% to 352 units. The area health commenced holding an increased proportion of O blood group (58.8% compared to 49% previously). Further analysis of proportion of stock by group is shown in Fig. 2A.

Increased proportion of O– blood in networked satellite labs

The proportion of RBCs of different blood groups in satellite laboratories was changed based on the assumption that having increased stock of group O– in peripheral hospitals increases the availability and usability of blood. The total number of O– units in peripheral hospitals was increased from 27 to 31 units constituting a 14.81% increase (Fig. 2B).

Rotation of RBC units

Imposing an age limit in the main laboratory for accepting RBCs from peripheral hospitals resulted in 0 to 2.5% of total RBCs received in the main laboratory from peripheral hospitals being older than 28 days, compared to 6 to 41% previously (Fig. 3A). It was also observed that the percentage of blood less than 14 days old received from the Australian Red Cross varied between 38 and 79% during November 2012 to October 2013 while it increased to between 63 and 98% since November 2013 (Fig. 3B).

Usage of RBC units

The total number of RBC transfusions across the network remained fairly constant during the study period. There were 15,462 RBC units transfused over a 12-month period before the policy changes and 15,700 units after policy change. Total number of RBC units received in the JHH laboratory from the Australian Red Cross and from peripheral hospital was 16,070 units before policy changes and 15,994 units after policy changes (Table 1).

Discard rate due to age expiry of RBC units reduced to zero

The total number of RBC units discarded before policy changes was 511 units in the area health, including age-related expiry of 261 units (51.07%). The wastage in the 12 months after changes was reduced to 174 units with zero units wasted due to expiry. A significant reduction in total wastage of RBCs ($p < 0.0001$) was observed after policy changes, particularly with reduction in age-related wastage ($p < 0.0001$). This change in pattern of discarded RBCs is illustrated in Fig. 4.

Wastage rate as a percentage of issue (WAPI) reduced from 3.17 to 1.08%. Wastage due to expiry as percentage of issues also reduced from 1.62 to 0% (Table 1). Lowering the stock level did not increase the use of emergency couriers (data not presented).

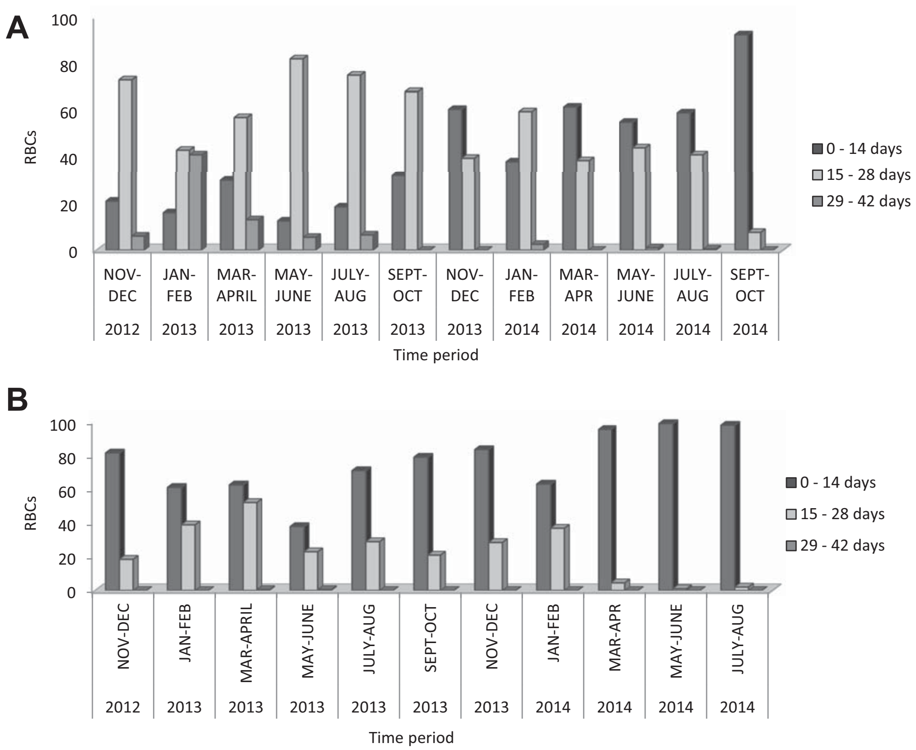

Fig. 3. (A) Age of RBCs received back into main laboratory from peripheral hospitals. (B) Age of RBCs received in the area health from the Australian Red Cross.

TABLE 1. Comparison of before and after intervention for RBCs

	Before intervention	After intervention	p value
Total number of transfusions in HNELHD	15,462	15,700	
Total blood products received in the main laboratory	16,070	15,994	
Number of RBC units discarded in the network	511	174	<0.0001
Number of RBC units discarded due to expiry in the network	261	0	<0.0001
Wastage as a percentage of issues	3.17%	1.08%	
Wastage due to expiry as a percentage of issues	1.62%	0	

DISCUSSION

This is the first study to investigate the age-related RBC expiry in a major Australian regional hospital and provide proof of principle that "zero tolerance" for age-related wastage of RBC units is achievable. There was no wastage of RBC units due to expiry over the 12 months after policy changes. Before these changes, approximately half of RBC wastage was due to expiry. This study demonstrates that a multifaceted and tailored implementation strategy has significantly reduced RBC outdating. Furthermore, this study also provides insight into opportunities and challenges for effective resource utilization in inventory management at regional hospital blood banks. From an operational perspective, these findings provide important cost-effective and optimal resource utilization strategies.

Demand variability, distance from the blood supplier, the relatively short expiry period of RBCs, and requirement to manage multiple peripheral hospitals account for some of the challenges of regional hospital blood banks. RBC outdate targets are often based on distance from the blood supply provider and transfusion volume.[21] This is expressed as WAPI taking into account the difference in RBCs received allowing for national and international comparison.[22] The central laboratory (JHH) is located 160 km away from the blood supplier and our transfusion numbers average around 15,000 units per year. Interestingly, after our intervention in 2013, WAPI (1.08%) was lower than the national average of 5.2%.[23]

We identified excessively high RBC stock as a key issue for wastage, as previously noted by St John of God Pathology, Victoria, Australia.[13,17] Safety stock calculations are employed across a range of industries to balance inventory, risk, and strategy. The ARCBS calculates the safety stock and suggests a target inventory, taking into consideration variability in supply, demand, lead times,

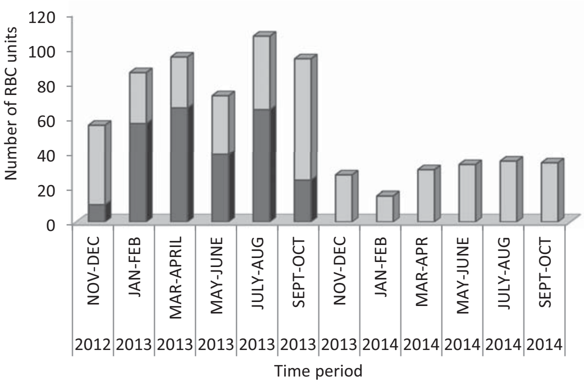

Fig. 4. Proportion of expired RBCs to total wastage in the area health. (■) Discarded RBCs (other reasons); (■) age-expired RBCs.

and customer service factors.[24] The RBC transfusions in the network over a 12-month period including special requirements like irradiated and CMV-negative RBC units were evaluated for safety stock calculation. The inventory levels of total RBCs was reduced by 30.1% based on the safety stock calculation. However, with reduction in inventory there is an inherent risk of stockouts leading to inability to provide blood in an emergency situation. However, in our health network, no such clinical consequences were reported in the period of study. The set inventory levels were appropriate to meet the demand. Moreover, there was no increase in use of emergency couriers, an anticipated cost fallout after these interventions. There was rearrangement of inventory across the health district including peripheral hospitals. A preferential strategy of increased proportion of O blood was employed in network including peripheral hospitals. Number of O– units allocated to peripheral hospitals was also increased.

As suggested by Kendall and Lee,[25] we also focused on effective stock rotation to reduce outdating by implementing an age limit to accept RBCs from peripheral hospitals. Entrusting the responsibility of placing orders and stock rotation with experienced laboratory managers, regular staff training, and awareness programs about the financial impact of wasting units contributes to improved outcomes in inventory.[10] Similarly, in this study, a high level of management skills of laboratory staff and centralized electronic data management system have contributed heavily to the effective implementation of this RBC expiry reduction strategy. Having a robust data management system that controls the operation of transfusion laboratory is crucial in increasing transparency across network hospitals and allowing effective strategic planning.[11,26] Moreover, the new rules limiting return of older units did not affect the functioning of the peripheral laboratories as stock rotation at all sites was managed by senior scientists in the main laboratory based on a hub-and-spoke model.[27] The computerized central stock management and networked courier service linking all the laboratories helped with stock rotation. Importantly, the interventions that were employed are inexpensive and easy to deliver.

The cost of manufacturing a single unit of RBCs is currently approximately AUD 402.[28] Losing 261 units due to expiry amounts to approximately AUD 104,896 per year. Reduction in RBC wastage has a significant positive impact on various aspects of health care including cost savings; improving efficiency, work flow, and quality control in the laboratory; and resource utilization. Reducing wastage in the laboratory may result in the reduction of blood donations required, which would be useful as demand exceeds supply in most countries. The fact that their blood donation is benefitting a recipient and not being wasted may also keep the voluntary nonremunerated altruistic donors motivated to continue donations.

There are several limitations to this study. Since there were multiple interventions introduced simultaneously, we were unable to draw any conclusions about the effect of any individual intervention. It might not be practical to increase the proportion of O– in all hospitals due to donor constraints and this also has potential to create group O shortages.[29] John Hunter is the busiest trauma center in NSW leading to a greater requirement of emergency releases. This analysis has not evaluated the usage of O– in situations where O+ blood could have been used instead. Emergency blood release policies limiting the release of O– RBCs to females of childbearing age would help in conserving precious O– RBCs. However, we are now looking to move toward using O+ for males in keeping with NBA guidelines.[30] The use of increased group O RBCs might be difficult to achieve in other geographic locations based on local availability. The applicability of these interventions across the various geographic locations with different resource limitations is not established as the challenges might be different depending on the blood supply system and the requirements.[31] ARCBS collects AB plasma by whole blood donation as well as by apheresis although there is a move to collect more group AB plasma via apheresis. Since Australia still has whole blood donations of AB plasma, stocking AB RBCs may need to be encouraged with expected wastage allowance.

Age-related expiry of blood products is preventable and can be initiated effectively at the pathology service.[7] Identifying the challenges and implementing strategic interventions such as setting appropriate inventory levels, stock rotation, staff training, and computerized linking of transfusion services can achieve significant reduction in discard rates.[17,25] This study provides proof of principle for zero tolerance for RBC expiry across a large networked blood banking service.

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CONFLICT OF INTEREST

The authors have disclosed no conflicts of interest.

REFERENCES

1. Hasegawa J, Ikeda T, Sekizawa A, et al. Recommendations for saving mothers' lives in Japan: report from the Maternal Death Exploratory Committee (2010-2014). J Obstet Gynaecol Res 2016;42:1637-43.
2. Anthes E. Evidence-based medicine: save blood, save lives. Nature 2015;520:24-6.
3. Hopewell S, Omar O, Hyde C, et al. A systematic review of the effect of red blood cell transfusion on mortality: evidence from large-scale observational studies published between 2006 and 2010. BMJ Open 2013;3. pii: e002154.
4. Murphy MF. The Choosing Wisely campaign to reduce harmful medical overuse: its close association with Patient Blood Management initiatives. Transfus Med 2015; 25:287-92.
5. Far RM, Rad FS, Abdolazimi Z, et al. Determination of rate and causes of wastage of blood and blood products in Iranian hospitals. Turk J Haematol 2014;31:161-7.
6. Blood facts and statistics [Internet]. Washington (DC): American Red Cross [cited 2017 Mar 2]. Available from: http://www.redcrossblood.org/learn-about-blood/blood-facts-and-statistics.
7. Heitmiller ES, Hill RB, Marshall CE, et al. Blood wastage reduction using Lean Sigma methodology. Transfusion 2010; 50:1887-96.
8. Novis DA, Renner S, Friedberg R, et al. Quality indicators of blood utilization: three College of American Pathologists Q-Probes studies of 12,288,404 red blood cell units in 1639 hospitals. Arch Pathol Lab Med 2002;126:150-6.
9. Zarbo RJ, Jones BA, Friedberg RC, et al. Q-tracks: a College of American Pathologists program of continuous laboratory monitoring and longitudinal tracking. Arch Pathol Lab Med 2002;126:1036-44.
10. Stanger SH, Yates N, Wilding R, et al. Blood inventory management: hospital best practice. Transfus Med Rev 2012; 26:153-63.
11. Perera G, Hyam C, Taylor C, et al. Hospital blood inventory practice: the factors affecting stock level and wastage. Transfus Med 2009;19:99-104.
12. Collins RA, Wisniewski MK, Waters JH, et al. Effectiveness of multiple initiatives to reduce blood component wastage. Am J Clin Pathol 2015;143:329-35.
13. Objective 1. Secure the supply of blood and blood products [Internet]. Lyneham: National Blood Authority Australia; 2014 [cited 2017 Mar 2]. Available from: https://www.blood.gov.au/pubs/1314report/html/part2/2.2.html.
14. Budget 2016-17. Statement 5: expenses and net capital investment [Internet]. Parkes: The Commonwealth of Australia [cited 2017 Mar 2]. Available from: http://www.budget.gov.au/2016-17/content/bp1/html/bp1_bs5-01.htm.
15. National blood and blood product wastage reduction strategy 2013-2017 [Internet]. Lyneham: National Blood Authority Australia [cited 2017 Mar 2]. Available from: https://www.blood.gov.au/wastage.
16. Kurup R, Anderson A, Boston C, et al. A study on blood product usage and wastage at the public hospital, Guyana. BMC Res Notes 2016;9:307.
17. Chen S, Davey G, Saravanan L, et al. Red cell inventory management and red cell wastage reduction strategies in a major regional laboratory. Pathology 2015; 47:S89.
18. Cheng CK, Trethewey D, Sadek I. Comprehensive survey of red blood cell unit life cycle at a large teaching institution in eastern Canada. Transfusion 2010;50: 160-5.
19. Australian Red Cross Blood service. Pilot report findings. Institutional document not publicly available. New Lambton, NSW, Australia: John Hunter Hospital.
20. Hunter New England [Internet]. North Sydney: NSW Health [cited 2017 Mar 2]. Available from: http://www.health.nsw.gov.au/lhd/pages/hnelhd.aspx.
21. Barty RL, Gagliardi K, Owens W, et al. A benchmarking program to reduce red blood cell outdating: implementation, evaluation, and a conceptual framework. Transfusion 2015; 55:1621.
22. Managing blood and blood product inventory—Tip 3: set appropriate inventory levels [Internet]. Lyneham: National Blood Authority Australia [cited 2017 Mar 2]. Available from: http://www.blood.gov.au/inv-mgt-guideline-tip-3-set-appropriate-levels.
23. Red blood cell wastage [Internet]. Melbourne: Victoria Health; 2017 [cited 2017 March 2]. Available from: https://www2.health.vic.gov.au/hospitals-and-health-services/patient-care/speciality-diagnostics-therapeutics/blood-matters/red-blood-cell-wastage.
24. 7 hospital inventory management techniques to reduce costs [Internet]. Tuscaloosa (AL): Afflink; 2017 [cited 2017 March 2]. Available from: https://www.afflink.com/blog/7-hospital-inventory-management-techniques-to-reduce-costs
25. Kendall KE, Lee SM. Improving perishable product inventory management using goal programming. J Oper Manag 1980; 1:77-84.

26. Chapman J. Unlocking the essentials of effective blood inventory management. Transfusion 2007;47:190S-6S; discussion 201S.
27. Implementation and hub-spoke arrangements [Internet]. Lyneham: National Blood Authority Australia; [cited 2017 Jun 26]. Available from: https://www.blood.gov.au/Implementation.
28. National Blood Product list [Internet]. Lyneham: National Blood Authority Australia; [cited 2017 Mar 2]. Available from: https://www.blood.gov.au/national-product-list.
29. Hirani R, Wong J, Diaz P, et al. A national review of the clinical use of group O D- red blood cell units. Transfusion 2017; 57:1254-61.
30. Component compatibility [Internet]. Melbourne: Australian Red Cross Blood Service; 2017 [cited 2017 Jun 26]. Available from: https://transfusion.com.au/blood_basics/compatibility.
31. Sullivan P. Developing an administrative plan for transfusion medicine—a global perspective. Transfusion 2005;45:224s-40s.