Audit and review for evidence-based red cell wastage reduction measures

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ABSTRACT

Stocks of red blood cells (RBC) are held to ideally match supply and demand; hold too great a stock and unnecessary wastage occurs; too low a stock results in delay or lack of blood for the patient. Blood is a precious resource and its supply needs to be managed effectively. The aim was to identify how RBC units are wasted and propose laboratory-based reduction measures that would not compromise the clinical requirements of the patient. Wastage of RBC was investigated using a 'dashboard' query of a laboratory information management system. By employing service improvement tools, proposals were made to reduce unnecessary RBC waste while ensuring an adequate supply to the patient. The efficacy of those proposals was examined using the same dashboard to compare similar periods before and after their introduction. The reduction in RBC wastage for all groups during an eight month period (December to July) was from 6.4% (5.3% non-AB or B RhD-positive) pre-implementation to 4.4% (2.5% non-AB/B RhD-positive) post-implementation. Group O RhD-negative wastage reduced from 10.4 % to 4.4% after introduction of waste-saving proposals. However, there was an increase in staff time required to introduce the changes and in associated Group and Screen testing (3.4 to 3.8 per unit issued). RBC wastage was significantly reduced ($P<0.0001$) by 32.8% (52%, non-AB/B RhD-positive), saving approximately 225 RBC units per annum. Financially, increased associated costs did not negate the savings made by the measures introduced.

KEY WORDS: Adult.
Anemia.
Blood transfusion.
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Introduction

Using the The National Health Service Institute for Innovation and Improvement[1] PDSA (Plan, Do Study, Act) cycle,[2] described elsewhere,[3] ways to decrease the wastage of adult red blood cell (RBC) are proposed and investigated.

Red blood cell (RBC) issues to hospitals within England has fallen by over 20% since the beginning of the century,[4] a result of better blood transfusion management practices. However, there is still a need to conserve blood from a number of perspectives. Firstly, there is a dwindling donor base, especially in the younger age group. Secondly, there is an ethical consideration to use in a judicious manner that blood which is freely given. Finally, and becoming increasingly important, within the current financial climate there is a need to make increasing financial savings to National Health Service (NHS) budgets. These savings should be made not only with respect to the supply and ethical consequences, but with careful considerations of clinical need.

At the time of the study, Barnet Hospital (BH) and Chase Farm Hospitals (CFH) were part of the same NHS Trust (BCFH) and each had their own blood transfusion (BT) laboratory. They are classed as 'medium' level users by NHS Blood and Transplant (NHSBT), the sole provider of RBC products in England. Neither hospital is a major trauma centre and, until recent changes took effect (November 2013), carried out a broadly similar range of services.

According to the NHSBT financial statement, during the financial year 2011–2012 BCFH received 12,438 adult RBC units, of which 1232 (9.91%) were irradiated. Owing to historical precedents, the cost of blood and blood products is re-charged to the clinical directorates that placed the order – at the CFH site, but remains within the BT budget for BH. As such, there is an expectation for the BT laboratory on the BH site to have a greater interest in wastage reduction as it impacts on their budget. Additionally, BH kept a stock (15 units of different blood groups) of irradiated products for transfusion to patients on the haematology oncology ward.

The pathology department of BCFH uses the Cerner Millennium PathNet laboratory information system (LIMS). Blood and blood products received from NHSBT are logged into the LIMS from the moment of receipt into the BT laboratory until they are 'fated' to their 'final disposition', be it transfused, time-expired, wasted by user, damaged, etc. These final dispositions are manually entered by BT staff, either from the information on returned transfusion crossmatch labels, recovered entries from the patient notes, or the actual physical presence of the blood product.

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Materials and methods

Plan

The 'Dashboard'[3] and Cerner Millennium PathNet LIMS were interrogated to obtain the final destination (also known as 'disposition' or 'fate) of all RBC products (Table 1)

Table 1. Red cell wastage figures by blood group for April 2011 – March 2012 cells.

	Untreated		Irradiated		
Blood group	Total	Wasted (%)	Total	Wasted (%)	Total wasted (%)
A Neg	739	15.43	152	17.76	15.82
A Pos	3250	2.34	314	3.82	2.27
B Neg	336	27.98	0	0.00	27.98
O Neg	792	8.08	146	9.59	8.31
O Pos	3858	0.91	236	2.97	1.03
AB + B Pos	1834	12.32	209	12.92	12.38
Other*	4	100.00	0	0.00	100.00
Total	10813	5.63	1057	8.23	5.86
Total (no AB/B+)	8979	4.27	848	7.08	4.52
nRBC	294	56.12			

*Washed

Group AB and B Rh(D)-positive are considered together as NHSBT refunds the cost of unused units of these groups.

as well as platelets and plasma-based products during the audit period (financial year) April 2011 to March 2012.

Although the wastage figures for platelets and plasma-based products were of some concern in our trust (data not shown) they are ordered on a named-patient basis driven by clinician demand. As such, there is little the BT laboratory can do to drive down waste for these products but will be considered in future improvement projects.

Four hundred and forty-three units of RBC (including 60 irradiated adult RBC) were 'wasted'. There were also 253 group AB or group B RhD-positive units not transfused, for which NHSBT provide refunds if they time-expire (to encourage their use).This gives an overall wastage figure of 5.86%, higher than the 4.5% average hospital wastage for England and North Wales.[5] The principal causes for wastage in our study were time expiry (75.4%), wasted by clinical teams (16.3%), out-of-temperature control (7.4%) and 'other' causes (damaged in laboratory or insertion of blood transfusion giving sets at bedside, 0.9%). The level of time expired wastage is similar to those (range 70.4–79.3%) reported elsewhere[5] for the four annual periods between 2003 and 2007.

A total of 11,870 RBC were fated during the audit period (Table 1); this differs from the NHSBT invoiced figures due to the lag time in fating products purchased in the previous financial period and fating those bought in this audit period that would be fated in the subsequent financial year. The NHSBT does not regard the BCFH wastage figures to be unduly high, but any reduction would be both ethically and financially beneficial.

Do

The BT team met to discuss possible ways to reduce RBC wastage and, using Lean Six Sigma methodology,[6] proposed a number of measures, discussed their risks and ways to mitigate them, and how their efficacy might be determined (Table 2). We chose to concentrate our efforts on the greater cause of red cell wastage (i.e., expiry beyond a product's 35-day shelf life, which could be considered most under direct laboratory control). Clinical contributions to red cell wastage (such as re-evaluation of the maximum blood ordering schedule [MBOS]) were considered to be outside the remit of this project but would be examined in future.

These suggestions (by no means an exhaustive list, but based on those detailed by Perera *et al*.[7]) were then discussed with the stakeholders (primarily the clinicians in anaesthetics, emergency, obstetrics and gynaecology, and paediatrics), adapted in response to suggestions and implemented on 1 December 2012 after informing all concerned by Hospital Transfusion Committee minutes, both trust and BT newsletters, screensaver messages on the trust network and letters to consultants.

An eight-month period was monitored before implementation (December 2011 to July 2012 [Pre]) and compared with a similar period (December 2012 to July 2013 [Post]) after their introduction on 1 December 2012. The target was a 10% reduction in RBC wastage.

Results

Study

Table 3 shows there was a significant reduction in wastage of adult RBC (excluding group AB and B RhD-positive) from 5.28% to 2.54% (an approximate 52% reduction; $P<0.0001$).

Costs have been converted to equivalents of RBC units, at £130/unit (approximate NHSBT cost, 2013–14), so that any savings in RBCs used can be offset against any increase in testing costs or staff resource. Table 4 shows an impact assessment of the new measures

Extra hours were introduced at week-ends to cover the time spent reclaiming RBC beyond its allotted reservation time. This increased biomedical scientist time at weekends negates any savings made – increased biomedical scientist time re-claiming (assessed as equivalent to the cost of 18 units/pa).

Increase in Group and Screen (G&S) testing and/or crossmatching (X/Ms) may show that reservation times are too short and clinicians are having to re-request blood. Table 5 shows the difference in 'Pre' and 'Post' testing rates. Both the number of G&Ss and X/Ms (predominantly electronic) per unit issued were raised in the 'Post' phase. By applying the 'Pre' rates (3.38/unit for G&S and 0.564/unit for

Table 2. Proposals to reduce RBC wastage: risks and mitigation.

Proposal	Risk	Mitigation
1. ***Reduce RBC stock***		
General stock by ~25%	Stock levels too low for clinical need	Can receive blood within 1 hour, if required
Irradiated stock ~ 70% (to irradiated 'Flying Squad' of 2x O RhD-positive and 2x O RhD-negative	Would irradiated RBC be obtainable in time?	Can receive irradiated blood within 1 hour 20 minutes
2. ***Reduce reservation periods***		
24h reservation (previously 3–5 days)	More re-issues, increased testing costs	Re-testing costs = 1/33 unit
Placenta previa changed to group and screen from five day reservation	Failure to supply in time	With valid sample can e-Issue in 10 minutes
		Usually if reclaimed then not re-requested
3. ***More reclaiming***		
Especially at weekends	Increased reclaiming requires more staff time	One RBC saved pays for eight hours of biomedical scientist time
4. ***Traffic light system on blood stock refrigerator***	Time to stock check and complete traffic light chart	Possible saving of a unit
5. ***Recycle Flying Squad earlier***		
Return to laboratory at T–7 days rather than T–5 days	Increased wastage of O RhD-negative?	Can audit wastage of O RhD-negative
6. ***Transfusion of group-compatible blood***		
Transfuse short-dated units which are group-compatible rather than group-specific	Mixed-field reactions (MFR) lead to increased testing costs (X/M), delay as cannot e-Issue	Can e-Issue with MFR if the reason is well-documented in the LIMS (no X/M required)
7. ***Monitor expiry dates of received blood***		
Is blood supplied short-dated resulting in	Time required to audit	Make it part of audit schedule
less time for use	Alienation of supplier	Part of supplier customer service
8. ***Staff involvement***		
Education	Effective communication to all staff	Effective communication to all staff
Display wastage figures	Time to produce figures	Part of communication strategy
Issue of blood not likely to be transfused (e.g., close to expiry and issued late at night)	Wastage brought back into laboratory domain	Wasted in laboratory is more accurate reflection, but, savings may prevent this happening

X/M) to the 'Post' sample numbers, an estimate can be made of the number of extra tests performed – extra testing was performed per unit issued (equivalent to 70 units/pa)

Increased customer complaints/incidents regarding blood supply would evidence the fact that it was not meeting expectations. No incidents were logged during the months under investigation, either 'Pre' or 'Post'. Stakeholders had not been affected by the changes to a degree where they raised their concerns as complaints, either through formal or informal means

Although Table 5 shows 190 fewer adult RBC units were wasted post-implementation, the total number of units (transfused and wasted) had decreased. By applying 'Pre' and 'Post' wastage rates to the post-implementation totals, a more conservative saving of 150 units (equivalent to 225 units/pa) is derived.

Total units saved = 225 units pa (excluding group AB and B RhD-positive):

- less increased G&S/X/M costs = 70 units/pa
- less increased *ad hoc* delivery costs = 22 units/pa
- less increased reclaiming time = 18 units/pa.

Thus, financial savings = 115 units/pa.

Discussion

Other studies, using Lean Six Sigma methodology, have reported on blood wastage reduction.[6] However, 87% of RBC wastage occurred through transport cold chain issues and individual units exceeding the 30 minute 'rule' of being outside the cold chain without being transfused. In our hands, only 7.4% of wastage was due to cold chain issues; far higher was the 75% of RBC wasted due to exceeding their shelf life, which is in keeping with those figures reported by Chapman.[5]

After introduction of a number of waste reduction methods there was a significant reduction (52%, $P<0.0001$) in RBC wastage exceeding our initial aim of a 10% reduction in wastage. However, as so many changes were introduced at the same time, it is difficult to determine the efficacy of any one particular change, or, indeed, if multiple positive changes are masking something detrimental to reducing blood wastage. In one study,[7] many of the potential waste reduction practices, although reducing wastage, did not reach significance. It is possible that only when the measures are employed in tandem do they achieve a demonstrable effect.

Table 3 shows significant reduction ($P=0.0008$ to <0.0001)

Table 3. Red cell wastage by blood group for December 2011–July 2012 and December 2012–July 2013.

	December 2011–July 2012					December 2012–July 2013				
	Untreated		Irradiated		Total Waste (%)	Untreated		Irradiated		Total Waste (%)
	Total	Waste (%)	Total	Waste (%)		Total	Waste (%)	Total	Waste (%)	
A Neg	514	14.20	91	16.48	14.50	473	6.13	2	100	6.53*
A Pos	2078	2.74	200	3.00	2.77	1956	1.33	26	0.00	1.31#
B Neg	227	29.52	0	0.00	29.52	181	10.50	0	0.00	10.50*
O Neg	511	11.15	96	8.33	10.38	425	3.53	75	8.00	4.20*
O Pos	2337	1.84	174	1.75	1.83	2212	1.85	110	0.91	1.81$
AB + B Pos	1202	11.73	175	9.71	11.47	1152	13.80	107	0.00	12.63£
Other	0	0.00	0	0.00	0.00	5	0.00	0.00	0.00	0.00
Total	6869	6.38	736	6.66	6.40	6404	4.51	320	2.81	4.43†
Total (no AB/B+)	5667	5.24	561	5.70	5.28	5252	2.48	213	4.23	2.54†

*Significant reduction, $P<0.0001$ (Fisher Exact Test [FET])

#Significant reduction, $P=0.0008$ (FET)

$Non-significant reduction, $P=0.8301$ (FET)

£Non-significant increase, $P=0.3691$ (FET)

†Significant reduction, $P<0.0001$ (χ^2 test [CST])

for the blood groups A RhD-positive and -negative, B RhD-negative and O RhD-negative (but not for O RhD-positive). It is worth highlighting the wastage of O RhD-negative RBC. NHSBT has requested that hospitals keep their usage of this group below 10.5%.[8] Of the stock held at held at BCFH during the initial study (April 2011 – March 2012, Table 1) 7.9% was O RhD-negative, with a wastage rate of 8.3% (below the 10.0% limit suggested by NHSBT Blood Stocks Management Scheme [BSMS][9]). The 'Pre' phase showed an 8.0% O RhD-negative stock holding (10.4% wastage), which reduced to a 7.4% stock holding (4.2% wastage) after implementation of reduction measures in the 'Post' period. This reduction in stock level of O RhD-negative may well have contributed to the reduced wastage.

Wastage of irradiated RBC (all groups) significantly decreased over the study (from 6.7% to 2.8%, $P=0.0119$). When AB/B RhD-positive irradiated blood is removed from the comparison the reduction fails to reach significance ($P=0.4762$), indicating that wastage in these groups played a major contribution to time expiry of irradiated blood. Irradiated blood has a shorter (14 days post-irradiation) shelf life so carrying a larger stockholding, as in the 'Pre' period, means that stock has to be managed more intensively to avoid wastage. Much of this stock is issued close to its expiry date to patients not actually requiring irradiated blood to avoid wastage. Without examining the individual transfusion requirements of the patients, it is difficult to quantitate to what extent this occurs. However, there is a cost associated with irradiation and each unit used unnecessarily increases the cost of provision of a transfusion service.

Red blood cell usage had decreased over the study period. It is unknown whether or not this was due to fewer procedures being performed. Alternatively, where multi-unit, non-urgent orders had been made, the decreased reservation time leads to subsequent units being reclaimed before use. Clinicians may then more carefully assess the need for additional units before placing further orders than would be the case if the RBC unit was readily accessible.

When supplier (NHSBT) levels of stock are high, the average age of RBC units supplied to hospitals increases, with a resultant increase in wastage.[5,10] Within the hospital, RBC units go through an 'issue cycle' of crossmatching, issue and, if not used, return to stock. If the remaining shelf life of the RBC is reduced, the number of issue cycles it can undergo is also reduced.[5] Carrying greater than normal stock levels is common where reduced donation collection occurs, such as over public holidays. During the study period an audit was carried out (data not shown) and such an increase in age of RBCs was found. The results were notified to the supplier and an explanation received.

Perera *et al*.[7] found wastage to be lower (but not significantly so) in those hospitals with a reduced reservation time. The explanation was the reduced time spent in issue locations allowed a unit to undergo more 'issue cycles', and so increased the likelihood of being transfused. This increased availability is the reason why an earlier return to general stock of 'Flying Squad' blood was proposed (and forms part of BSMS best practice guidance[9]).

It can be seen that the reduction in waste was not due to an increase in cell salvage as the number of procedures and the units that were saved fell in the 'Post' implementation period.

These changes were not without some associated negative effects. Whether or not they were as a direct result of the reduction measures is difficult to determine. *Ad hoc* deliveries were found to have increased by 13.5%. For the purpose of this study, this rise has been included in assessing the cost efficacy of the measures, but in practical terms there has been a decrease in paid-for *ad hoc* deliveries, the increase being met by a free volunteer courier service. It is possible that staff viewed the use of a free service as having no 'cost' and so were more likely to use it than the paid or routine delivery services of the supplier (NHSBT).

There was an increase in testing costs per unit issued.

Table 4. Impact assessment of new measures introduced prior to December 2012–July 2013.

Risk		Pre	Post	Conclusion
Description	**Unit**			
Increase in emergency ('Blue Light') deliveries indicates failure to provide in an adequate timeframe	Number of Emergency deliveries (irradiated blood)	10 (1)	7 (1)	No increase for irradiated or non-irradiated RBC
Increase in Ad Hoc[#] deliveries for indicates a need to return to having a larger irradiated stock	Ad hoc deliveries (by VCS[$])	82 (1)[*]	83 (16)[*]	Similar numbers were made irradiated RBC before and after implementation
Increase in Ad Hoc[#] deliveries for non-irradiated RBC might indicate stock levels too low.	Ad hoc deliveries (by VCS[$])	266 (12)[*]	302 (72)[*]	36 extra ad hoc deliveries were made (= 54 pa), equivalent to a cost of 22 units/pa
An increase in cell salvage might account for any reductions in RBC usage	Units saved by cell salvage	57	11	No increase in cell salvage to account for any savings of RBC units

[#]Ad hoc deliveries are those made outside of routine supply which incur an additional charge

[$]Volunteer Courier Service

[*]Savings due to use of volunteer couriers who provide a free-of-charge service were considered to be outside the remit of this report

However, this must be considered as a 'worst case' as the implementation of the wastage reduction measures ('Post' phase) coincided with the introduction of a requirement for two valid G&S samples to improve patient identification for the issue of RBCs.[11] This will have increased the testing costs, but it is difficult to assess to what extent. Personal observations of one author (GAS) from another trust suggest this requirement would equate to an approximate 15% increase in G&S testing. A 15% increase of the observed 3.38 G&S/unit ('Pre' phase) would become 3.89 G&S/unit, similar to the 3.84 G&S/unit observed 'Post' implementation.

Wastage rates for those RBC which NHSBT provides on a 'sale or return' basis (group AB RhD-positive or negative, group B RhD-positive [since 1 June 2015, NHSBT no longer refunds time-expired group B RhD-positive RBCs]) remained high and even slightly increased over the study period. If the wastage rate in the 'Post' study period (159 units) could be reduced towards that of the non-AB/B RhD-positive rate (2.54%), approximately 190 units more might be saved per annum. It would be interesting to see how the approximately 12% wastage of these groups within our trust compares to national figures and to examine whether or not the reasons it is much higher than for other groups is purely due to the NHSBT refund and a lack of resolve to manage their stock holding effectively.

Act

Perera *et al.*[7] reported some areas where there were significant savings in waste reduction to be made, which were not trialled in this study. They would form the basis of the next phase of the project:

- Computer inventory systems: Currently not available within the trust but purchase of a blood tracking system or partnership with the NHSBT though its Integrated Transfusion Service (ITS) project should realise reduction in RBC wastage. Part of the ITS project is stock control by the primary supplier (i.e., NHSBT).
- Sharing stock: In part this was not investigated because there was not a robust procedure in place to do so. However, with its transport infrastructure and computerised stock control systems, the ITS should be able to move stock between hospitals, not only within the same trust but within the ITS network, to maximise transfusion potential. It would be beneficial to have a designated member of staff within each laboratory to have responsibility for stock control.

Another area not investigated was that of education. Blood transfusion already forms part of the medical induction within the trust, which has been shown to lead to a reduction in wastage (albeit non-significant).[7] As good stock management

Table 5. Difference in testing rates between December 2011–July 2012 and December 2012–July 2013.

	No. RBC Tx	No. G&S	G&S per unit	No. X/M	X/M per unit	No. RBC Tx[*]	Wastage (%)[*]	Wastage (units)[*]
Dec 2011– Jul 2012	7280	24591	3.38	4106	0.564	6228	5.28	329
Dec 2012– Jul 2013	6422	24683	3.84	3717	0.579	5465	2.54	139
Difference	–858	+92	+0.46	–389	+0.015	–763	–2.74	–190
Extrapolation	6422	21706	3.38	3622	0.564	5465	5.28	289
Extra tests/units		2977		95				–150
Extra costs[†]		+44		+3				

[*]Non-AB/B-positive units.

[†]Total test costs shown in RBC unit equivalents (One RBC unit = £130 unit)

lies at the heart of the principal cause of wastage (time expiry) then increasing the level of awareness of laboratory staff should be paramount and form part of their induction.

In conclusion, many of the ideas implemented have been presented elsewhere.[7,12] However, the intention was to document the steps we took to assess the impact of those ideas, and allow others to adapt them for their own use and to help 'improve blood utilisation'.[13] The findings would not be applicable to every hospital setting. It also highlights the wealth of data available to transfusion scientists that, were time to allow, could be 'mined' to improve local practice and inform clinical decisions. We feel, in the ever-increasingly regulated environment in which blood transfusion scientists work, against a backdrop of increasing workloads and requirement to make savings, anything that may avoid duplication of effort (e.g., exchange of better practice, sharing documentation) should be encouraged. □

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