NHS Blood and Transplant

NHS National Blood Transfusion Committee

SURVEY ON THE USE OF GROUP O D NEGATIVE RED CELLS

Period surveyed: 9-22 September 2024

Acknowledgements

We would like to thank all of you who participated in the 2024 O D Negative survey. We appreciate that all transfusion laboratories are very busy and juggling conflicting demands, but your input in collecting data on O D Negative red cell use is invaluable in helping us to understand and maintain the supply chain.

We would also like to thank the following hospitals for agreeing to pilot the survey:

- Addenbrooke's Hospital, Cambridge,
- Freeman Hospital, Newcastle,
- John Radcliffe Hospital, Oxford.

Thank you on behalf of the NBTC National Transfusion Laboratory Managers Advisory Group (NTLMAG) and NHS Blood and Transplant (NHSBT).

NHS Blood and Transplant

NHS National Blood Transfusion Committee

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Executive Summary

The use of O D Negative red cells remains a critical part of blood transfusion practices, due to their universal compatibility in emergency and substitution scenarios. We acknowledge that stability of O D negative supply chain remains a challenge for all blood services. However, this survey highlights a concerning trend: a decline in the proportion of O D Negative red cells transfused to O D Negative patients and an increase in O D Negative substitution.

The survey, conducted over a two-week period in September 2024, captured data from 203 hospitals, accounting for 5,653 O D Negative red cell units. O D Negative transfused to O D Negative patients decreased to 45.82% in 2024 compared to 59% in 2018 and 70% in 2010. Other key findings reveal that 17.39% of O D Negative units were used as a substitute for another blood group, with 40.08% of those cases involving R_0 patients where group specific R_0 units were unavailable. Another significant finding was that O D Negative units were used for non-O D Negative patients due to various factors, including emergency use (12.84%) and the avoidance of time expiry (12.90%).

The survey further identified regional variations, with London hospitals exhibiting the highest rate of substitutions and transfusions to non-O D Negative patients. Additionally, private hospitals demonstrated the lower rates of transfusion to O D Negative patients (14.35%) and higher wastage rates (17.04%) compared to the overall data.

The impact of the Synnovis cyberattack on the Laboratory Information Management System (LIMS) in London and Southeast England also played a role in transfusion practices during the survey period. Data from affected hospitals were analysed separately, indicating a temporary shift in transfusion patterns to mitigate patient risk.

The findings emphasise the need for stricter adherence to blood transfusion policies, enhanced education for transfusion staff, and improved stock management strategies. Hospitals should prioritise the transfusion of O D Negative blood to O D Negative patients and implement robust policies to minimise unnecessary substitutions. Additionally, refining substitution criteria and optimising stock-sharing agreements could significantly reduce wastage and preserve critical O D Negative reserves.

Recommendations

Key priority:

All organisations need to work together to reduce reliance on the use of O D Negative red cells as a substitute for appropriate ABO and D matched units.

Hospital Transfusion Laboratories

To review

1. Substitutions required to confirm their appropriateness.
2. Staff involved in the supply and issue of red cells should be educated in appropriate substitution to conserve the O D Negative blood supply chain.
3. Electronic blood management systems, including LIMS (Laboratory Information Management Systems) should be configured, where possible, to allow the issue of O D Positive emergency units.

To monitor

4. Stock levels, which should be set to ensure that most O D Negative units are transfused to O D Negative patients.
5. Time Expiry: high levels of O D Negative blood being transfused to prevent time expiry indicates that O D Negative stock levels should be reduced.
6. Stock holding in remote issue fridges, to ensure sufficient levels of O D Positive units are available and to avoid the need to revert to O D Negative in patients who can safely receive D Positive red cells.
7. The ordering and use of high specification units, to ensure that they are utilised appropriately.

To ensure:

8. When procuring and validating new electronic blood management systems including LIMS, ensure that the system is able to issue O D Negative and O D Positive red cells in emergencies.

Clinical areas including pre-hospital teams.

To review:

9. Availability of O D Positive in additional to O D Negative red cells in emergency packs
10. Teams involved in pre-hospital care should have processes in place to allow the use of O D Positive blood for emergency transfusion to adult male patients.

To monitor:

11. Wastage in the clinical area and take action to ensure staff are appropriately trained in managing red cell units.

To ensure:

12. Minimise the use of emergency O D Negative blood by ensuring group and screen samples are immediately available for laboratory testing and crossmatch.

Hospitals Transfusion Committees

To review:

13. Hospital policy to ensure they follow best practice.

To monitor:

14. Usage of O D Negative units and red cell wastage and to take action where necessary.

15. To discuss the monthly BSMS reports and recommendations regarding O D Negative stock holding and wastage data.

To ensure:

16. Implementation of stock sharing arrangements with all local hospitals, including those in the private sector. Stock sharing to make better use of O D Negative blood is good practice. A draft Service Level Agreement (SLA) to support this is available on the Hospital and Sciences website.

NHS Blood and Transplant

To review:

17. Policy documents to ensure they advise appropriate substitutions and avoid over-reliance on O D Negative red cells.

To monitor:

18. All substitution data including substitutions for R_0 and non-R_0 units made by NHSBT Hospital Service as well as RCI laboratories, during the monthly demand analysis meetings.

To ensure:

19. Blood collection and testing strategies are set to meet the demand for extended phenotyped red cells across all ABO groups and limit the need to substitute with O D Negative.
20. Staff involved in the supply and issue of red cells should be educated in appropriate substitution to promote the conservation of O D Negative blood supply.

A list of resources available to help implement these recommendations is available in Appendix 1.

Abbreviations

BSMS	Blood Stocks Management Scheme
ISI	Issuable Stock Index
KPI	Key Performance Indicator
LIMS	Laboratory Information Management System
NHSBT	NHS Blood and Transplant
NTLM	National Transfusion Laboratory Managers
RBCs	Red Blood Cells
RCI	Red Cell Immunohematology
RTC	Regional Transfusion Committees
SLA	Service Level Agreement
TIMEX	Time expiry
VANESA	Brand name, this is the BSMS data management system, where hospital and blood service data is collected.
VL	Very Low users
WAPI	Wastage as percentage of issue

Introduction

O D Negative red cells are considered a "universal" component, which means that their use extends beyond transfusion to patients with the O D Negative blood group. O D Negative red cells are also used for patients who require emergency transfusion before pre-transfusion testing can be completed and as a substitution for patients when suitable group-specific stock is not available. Despite an overall reduction in red cell demand, this does not apply to O D Negative red cells where demand has not reduced. Multiple initiatives to mitigate against this have been launched but have focused on emergency transfusion and the transfusion of O D Negative adult males with O D Positive red cells. Whilst these programmes have been successful, strategies to address the use of O D Negative red cells for substitutions have had a limited impact. NHS Blood and Transplant (NHSBT) has implemented multiple projects to improve the availability of R_0 red cells. However, demand for this phenotype continues to exceed supply. Additionally, the increased adoption of red cell exchange to prevent stroke and other complications in patients with sickle cell anaemia, means that demand will continue to increase.

The increased reliance on O D Negative as a substitute for appropriately matched ABO and D compatible red cells has also been driven by other changes in the transfusion landscape. The use of electronic blood management systems has improved safety and efficiencies within the blood issue process but, unless these are carefully configured to allow the safe and appropriate issue of O D Positive red cells in an emergency, they can result in an increased use of O D Negative red cells. Other issues such as staffing challenges and initiatives to improve efficiency and make savings have also driven an increase in the use of O D Negative as a universal substitution.

In October 2022, NHSBT called an Amber alert for red blood cells for the first time in recent history, when stock levels fell to levels with the potential to impact patient care. Maintaining national red cell stock levels has remained challenging. A second Amber alert was called in July 2024, specifically for group O red cells. This was following an increase in the requirement for O D Negative as part of the hospital contingency measures necessary during the Synnovis cyberattack, affecting the LIMS (Laboratory Information Management Systems). Hospitals affected were predominantly from London and the Southeast. These Amber alerts have highlighted the fragility of the blood component supply chain, especially for group O D Negative red cells. NHSBT and Hospital Transfusion Teams (HTTs) have been collaborating on improving the appropriate use of O D Negative red cells. To ensure measures implemented would be effective, it was recognised that we needed a better understanding of O D Negative red cell usage and hence, this survey was commissioned.

Aims & Objectives

1. To determine the fate of all O D Negative red cells issued by NHSBT to English hospitals during a two-week period, 9-22 September 2024, through a snapshot survey. O D Negative units that were issued by NHSBT Hospital Services as a substitution for another blood group were excluded. O D Negative red cells issued by Red Cell Immunohematology (RCI) Laboratories were included.
2. To determine the proportion of O D Negative red cells that were transfused to non-O D Negative patients and the reasons for this.
3. To understand the use of O D Negative red cells as a substitution for other extended red cell characteristics, e.g. R_0 red cells.
4. To identify areas for targeted improvement activities and recommendations.

Methods

Each hospital that received O D Negative red cells issued between 9 and 22 September 2024 was provided with a link to a dedicated online tool to advise the "fate" of each individual O D Negative red cell unit. The survey opened on the 24 October 2024 and closed on 5 December 2024, to ensure sufficient time for the final fate of all audited red cell units to be recorded. The online form was developed using SNAP software.

On opening the link to the survey, each hospital was required to enter their unique Pulse code, after which they were presented with a list of specific units (with unit numbers) issued to them during the period. Each unit number acted as a link to a specific fating form for that red cell unit and the hospital selected the unit's primary "fate" from a drop-down list. Additional information about the recipient was also requested, including year of birth, blood group and the clinical speciality the recipient was registered under when the transfusion was given.

In total, 7962 O D Negative red cell units were issued to 237 hospitals during the survey period. Data were returned from 203 hospitals and accounted for 5653 units.

The submitted data underwent data cleansing, where duplicate entries and those in which the fate was not recorded were removed. Any unit reported with the fate "other" was manually reviewed and the fate reassigned where its actual fate was available within the drop-down options. Units issued to Group O patients with a variant D, C or E phenotype or genotype were reassigned as being issued to a Group O patient.

Further data cleaning was performed following the issue of individual reports for cases in which the hospital notified us of a discrepancy.

Data were analysed proportionally (%, n) and base data was defined as the number of answers provided for each question. Denominators may therefore vary for each question.

Stakeholders

All stakeholder hospitals received O D Negative red cell units from NHSBT during the two weeks survey period. Both NHS and private hospitals were invited to participate.

Constraints

We recognise that during the survey period a number of events took place that may have affected red cell inventory management.

During the survey multiple hospitals were following contingency processes due to the Synnovis cyberattack. The usage patterns reported by these hospitals was not representative of their normal use. Due to the limitations on these sites as a direct result of the cyberattack many impacted hospitals were unable to participate. Affected hospitals were therefore omitted from data analysis, and the units issued to these sites were not included in the denominator data. These hospitals included a number of large teaching hospitals with a high Blood Stocks Management Scheme (BSMS) usage (see Appendix 3 for information on usage categories).

An Amber alert was in place during the survey period. Hospitals had therefore instigated measures to preserve red cell stocks.

Also, during the survey period, NHSBT had an increased number of short-dated and K positive O D Negative red cells in stock. Some hospitals included in the survey agreed to receive these, to help maintain the supply chain. This may also have had an impact on how those units were utilised. However, such practice is not limited to this time period.

Quality Standards

The following standards have been developed from the National Blood Transfusion Committee guidance for the appropriate use of group O D Negative red cells (see Appendix 1), and NHSBT recommendations to hospitals.

1. **O D Negative red cells should primarily be transfused to O D Negative recipients and substitutions should be kept to a minimum.**

Survey observation: 45.82% (2590/5653) of O D Negative red cells were transfused to O D Negative patients.

2. **O D Negative red cells should be used as a substitution only in the absence of appropriate group specific or O D Positive red cell units.**

Survey observation: 17.39% (983/5653) of O D Negative red cells were transfused as a substitution. Of all substitutions, 40.08% (394/983) of them were in place of a R_0 red cell unit.

3. **In an emergency, it is acceptable to use O D Positive red cells for adult males and females aged over 50 years, who are D Negative (with no anti-D antibodies detected) and for adult males and females aged over 50 years whose D type is unknown.**

Survey observation: 56% (410/726) of O D Negative units issued as an emergency transfusion could have been avoided and replaced by O D Positive blood, based on the patient's sex and age.

4. **D Negative red cell wastage should be less than 4%.**

Survey observation: 4.74% (268/5653) of O D Negative red cells were fated as wasted, with 2.88% (163/5653) wasted due to time expiry. A further 12.90% (729/5653) were transfused to a non-O D Negative patient to prevent time expiry. Blood stocks management scheme (BSMS) recommends hospital wastage targets of Wastage as Percentage of Issue (WAPI) < 4.5% for very high, high and medium usage hospitals; <7% for low users. Very low users should agree a locally defined target (see Appendix 3, for details on BSMS categorisation criteria).

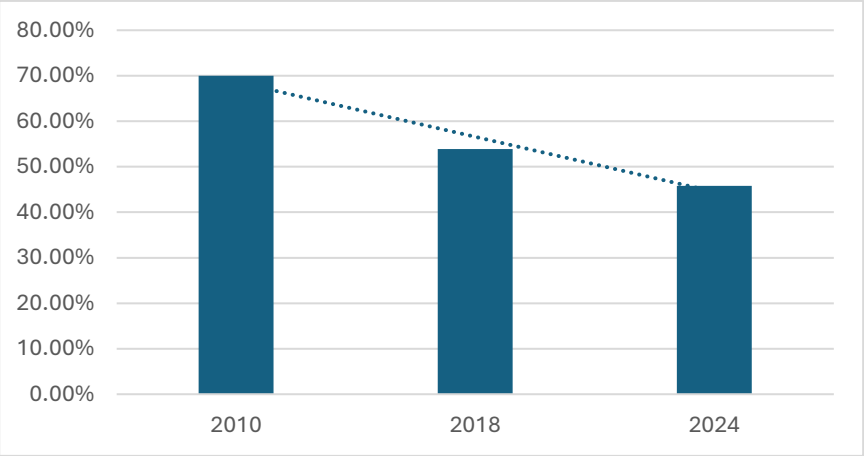
Results

Of hospitals that received O D Negative units from NHSBT during the period 9-22 September 2024 (the survey period), 85.60% (203/237) took part in the survey.

The final fate of 72.26% (5753/7962) of red cell units was recorded. After removing the results of those hospitals impacted by the cyberattack, the fate of 5653 O D Negative red cell units was analysed (70.10% of units issued).

In total, 45.82% (2590/5653) O D Negative red cells were transfused to O D Negative patients. This is a reduction compared to 59% in 2018 and 70% in 2010. There is a downward trend in the proportion of O D Negative units transfused to O D Negative patients (**Figure 1** below).

Figure 1. Shows the proportion of O D Negative units transfused to O D Negative patients, reported in surveys performed in 2010, 2018 and 2024.



Fate of O D Negative Red Cells

The final fate of the O D Negative red cells reported is summarised in **Table 1**.

Table 1. Fate of O D Negative red cells (n=5653) issued by NHSBT 9-22 September 2024

Fate	Number	Percentage
O D Negative - PATIENT	2590	45.82%
Wastage		
Non-O D Neg patient to avoid time expiry	729	12.90%
Wasted due to time expiry	163	2.88%
Wasted out of temperature control in clinical area	75	1.33%
Wasted for another reason	19	0.34%
Wasted out of temperature control in lab	11	0.19%
Emergency Transfusion		
Emergency issue to patient unknown or unconfirmed group issued by Lab	284	5.02%
Transfused from haemorrhage pack/flying squad (without lab involvement)	280	4.95%
Emergency issue to patient with known group issued by Lab	162	2.87%
Transplants		
Allogenic stem cell transplant	162	2.87%
Solid organ transplant	4	0.07%
Substitutions		
Ro patient, group specific Ro units not available	394	6.97%
Non-O D Neg patient due to other specific requirements	257	4.55%
Non-O D Neg patient due to antigen negative requirements for clinically significant antibodies	218	3.86%
Non-O D Neg patient due to ABO matched blood unavailable	114	2.02%
Non-O D Neg patient but no valid sample available	11	0.19%
Other reasons		
Transferred to another site	135	2.39%
Other "fate" not covered by the above	45	0.80%
Grand Total	**5653**	**100.00%**

The majority of the units analysed during the survey were transfused to a patient (95.87%, 5250/5653). Of those analysed, 45.82% (2590/5653) were transfused to an O D Negative patient.

Over seventeen percent of O D Negative red cells (17.39%, 983/5653) were reported as being issued as a substitution; and 20.65% (203/983) of these were initiated by NHSBT Red Cell Immunohaematology (RCI) laboratories.

A further 726 units (12.84%) were issued as uncross-matched for emergency transfusion.

Only 2.87% of units (162/5653) were transfused to patients who had undergone an allogenic stem cell transplant. In 5.56% (9/162) of these patients, however, there was no mismatch in the donor and recipient group and, therefore, group compatible red cells could have been safely transfused. 135/5653 units (2.39%) were transferred to another site. Of the red cell transfers recorded, 48.89% (66/135) where from a private hospital.

A very small percentage of units (0.80%, 45/5653) were fated using the "other fate”. A condensed list of the reasons provided is included as supplementary information at the end of this report.

Substitutions

Over seventeen percent of O D Negative red cells (17.39%, 983/5653) were reported as being issued and transfused as a substitution; and 20.65% (203/983) of these were initiated by NHSBT. In 32.74% of cases (394/983), the substitution was due to group specific R_0 red cells not being available. For all substitution types, the majority of the O D Negative units were given to group O patients.

In addition to those O D Negative red cells reported as being transfused as a substitution, there were other units that were fated under a different category in which the patient could have safely been transfused with either O D Positive red cells or red cells of the patient's own or an alternative compatible ABO group for example stem cell transplant patients.

During the survey period, one participating hospital reviewed all units fated as a substitution by their hospital. It was identified that 8/10 substitutions could have been safely substituted with another blood group.

This survey also reported the use of O D Negative red cells as a substitute for D Positive patients with a variant C and E type, which had not been reported in previous surveys. This practice is likely to increase as genomics becomes more established in transfusion practice. Whilst this is an appropriate use of O D Negative red cells, it increases demand pressure on group O D Negative.

There were also additional substitutions made by the blood service that were excluded from this survey. These were orders for non-group O D Negative red cells submitted to NHSBT via the OBOS system, which NHSBT was unable to fulfil and therefore supplied O D Negative red cells as a substitution. In addition to the 7962 O D Negative red cells issued and included in the survey. NHSBT Hospital Services issued a further 963 O D Negative red cell units to fulfil an order for red cells of another group (**Table 2**).

Table 2. O D Negative units issued as a substitution by NHSBT Hospital Services

ABO group requested	Non-Ro request	Ro request
A D Negative	3	6
A D Positive	0	1
AB D Positive	1	8
B D Negative	3	0
B D Positive	2	0
O D Positive	37	902
Total	**46**	**917**

The actual level of substitutions during this period is in the region of 21.80% (1946/8925), which is significantly higher than the 17.39% reported by this survey. This equates to one in four O D Negative red cells being issued as a substitute for an appropriate ABO and phenotyped matched unit, placing an additional strain on the demand for O D Negative red cells.

The need to substitute O D Negative units when selecting red cells to crossmatch for patients who required extended phenotype matched units (e.g. patients with red cell antibodies) is also affected by NHSBT testing protocols, which prioritise the extended phenotyping of O D Negative red cells.

Emergency Use

Over twelve percent (12.84%,726/5653) of the fated units were transfused to a patient as part of an emergency transfusion. Of these, 38.57% (280/726) were from haemorrhage packs or flying squad blood packs available to the clinical team and were transfused without the involvement of the Transfusion Laboratory.

The proportion of O D Negative red cell units transfused to a patient as part of an emergency transfusion is broken down further in **Table 3**.

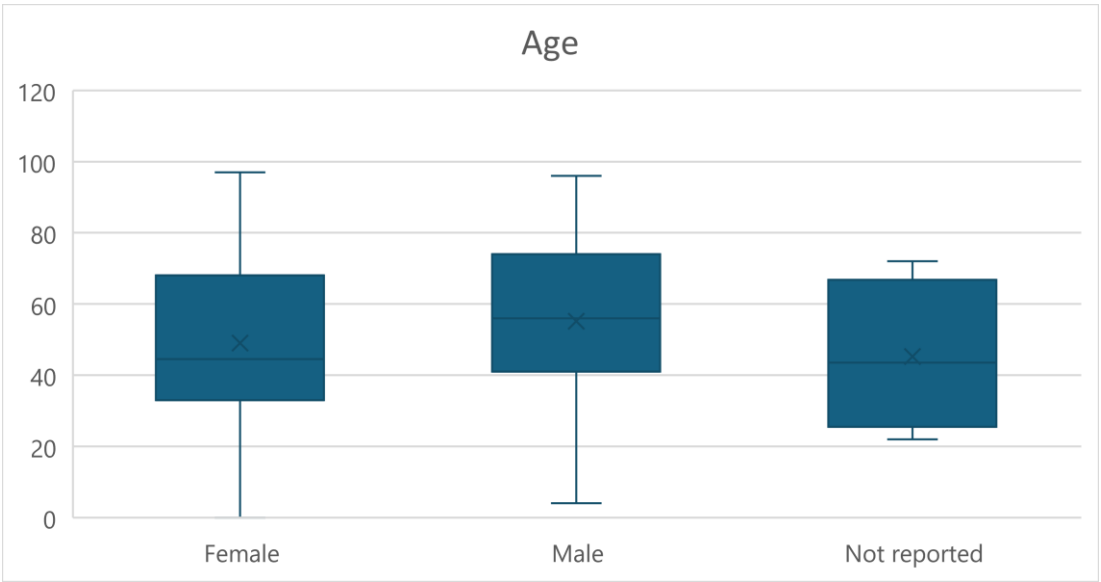
Table 3. Types of emergency issue

Fate	Number	Percentage
Emergency issue to patient unknown or unconfirmed group issued by Lab	284	39.12%
Emergency issue to patient with known group issued by Lab	162	22.31%
Transfused from haemorrhage pack/flying squad (without lab involvement)	280	38.57%
Grand Total	**726**	**100.00%**

As part of an emergency transfusion, 56.47% (410/726) of O D Negative units could have been substituted with O D Positive blood, based on the patient's age as shown in **Figure 2**. This data suggests that during the survey period 7.25% (410/5653) of O D Negative units could have been "saved" by the safe transfusion of O D Positive red cells.

An additional eight O D Negative units were fated under the "other" category due to the hospital's remote issue fridge running out of available O D Positive units.

Figure 2. A box and whisker diagram showing the median age and the age range of patients receiving emergency O D Negative red cells separated by gender. The middle bar in the shaded box indicates the median age, the outer bars of the box represent the upper and lower quartiles. The lines extending from the boxes (whiskers) indicate the lowest and highest values.



Wastage

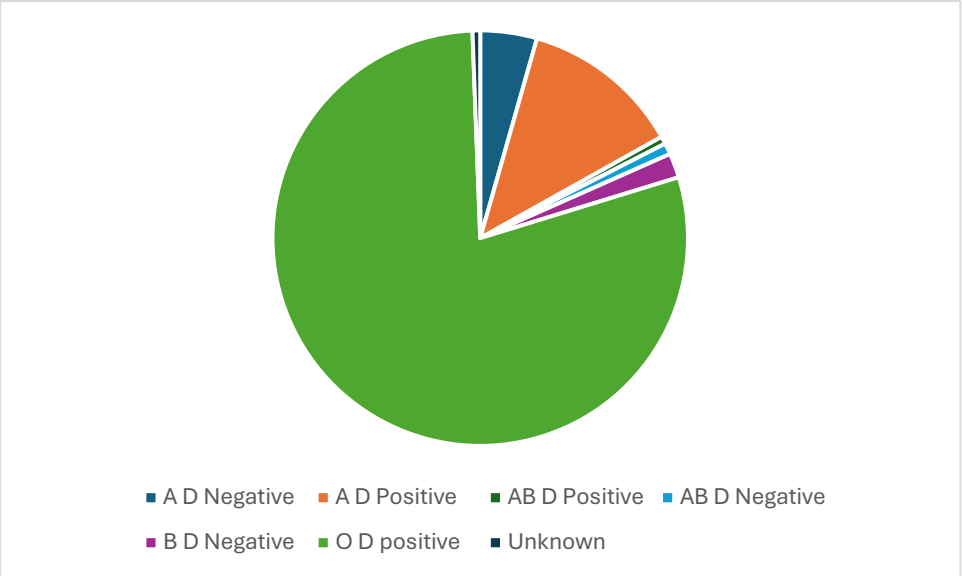
Less than five percent (4.74%, 268/5653) of O D Negative red cells were fated as wasted, with 2.88% (163/5653) wasted due to time expiry. Wastage reasons are shown in **Table 4**.

Table 4. Wastage reasons

Wastage reason	Number	Percentage
Wasted due to time expiry	163	60.82%
Wasted for another reason	19	7.09%
Wasted out of temperature control in clinical area	75	27.99%
Wasted out of temperature control in lab	11	4.10%
Grand Total	**268**	**100.00%**

A further 12.90% (729/5653) of units were transfused to a non-O D Negative patient to prevent time expiry. Almost seventy-four percent (73.94%, 539/729) were transfused to O D Positive patients (**Figure 3**). We know from the Blood Stocks Management Scheme (BSMS) data that an increased frequency of transfusion to prevent time expiry is indicative of unnecessary high stock holding of O D Negative red cells.

Figure 3. Pie chart showing the ABO and D type of patient transfused with O D Negative units to prevent time expiry.

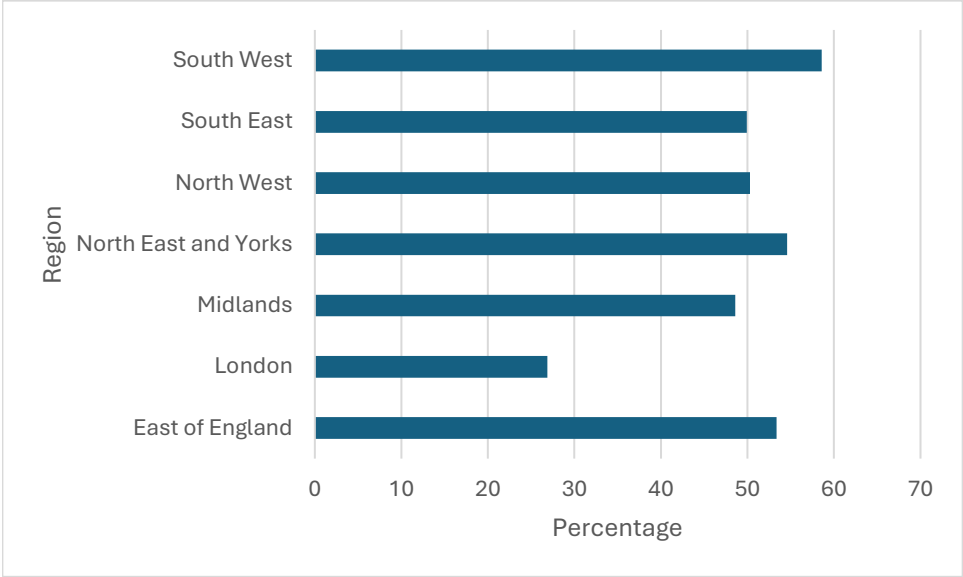


Regional Practice

Specific analysis demonstrated regional variations (**Figure 4** below). Notably, the London region had the lowest proportion of O D Negative units to O D Negative patients, but the highest number of substitutions. This could reflect the high number of hospitals within this region specialising in the treatment of patients predicted to have complex phenotypic transfusion requirements (e.g. sickle cell anaemia patients) or it could be due to differences in regional policies.

The London region had a disproportionate number of units transfused to non-O D Negative patients to prevent time expiry. It is appreciated that most hospitals affected by the cyberattack were with the London region. Hospitals directly impacted by the cyberattack were excluded from this analysis; however, other hospitals within the region included in this analysis were providing support for the affected hospitals. It is therefore possible for their data to be indirectly impacted. It is also known that more hospitals within the London region were taking short-dated red cells during this period. However, it may also highlight the potential for regions to share good practice.

Figure 4. Proportion of O D Negative red cells transfused to O D Negative patients.



Impact of the Cyberattack

The survey period was during the Synnovis cyberattack, which took down the LIMS (Laboratory Information Management Systems) used in a number of Blood Transfusion Laboratories across London and the Southeast. During this time those impacted hospitals were working under contingency measures. In many cases this involved additional use of O D Negative red cells to ensure patient safety and to mitigate against the risk of an ABO incompatible transfusion. The majority of hospitals impacted self-selected not to participate in this survey. However, data was received from four sites. Of these sites, one site submitted data for 60 units and another for 27 units.

The data from these sites was not included in the overall analysis as it was known that their practice at that time was atypical. However separate analysis of the data from just those sites (**Table 5** below) showed that, despite those challenges, the wastage rate remained comparable to the overall data at 4.49% (4/89).

Table 5. Fate of O D Negative red cells at cyberattack impacted hospitals.

Fate	Number	Percentage
Emergency issue to patient unknown or unconfirmed group issued by Lab	18	20.22%
Emergency issue to patient with known group issued by Lab	10	11.24%
Non-O D Neg patient to avoid time expiry	11	12.36%
O D Neg - PATIENT	21	23.60%
Other "fate" not covered by the above	21	23.60%
Solid organ transplant	4	4.49%
Wasted due to time expiry	2	2.25%
Wasted for another reason	1	1.12%
Wasted out of temperature control in clinical area	1	1.12%
Grand Total	**89**	**100.00%**

Practice in private versus NHS hospitals

Variations in practice were seen between the pattern of use of O D Negative red cells by private hospitals when compared to the overall result (**Table 6**). Most notably the number transfused to O D Negative patients was lower within private hospitals (14.35%, 32/223). The data also demonstrated a higher rate for wastage (17.04%, 38/223) and units transfused to prevent time expiry (20.63%, 46/223). However, almost a third of the O D Negative units (29.60%, 66/223) had been transferred to another site, demonstrating good stock-sharing practice.

Table 6. Fate of O D Negative red cells at private hospitals compared to all hospitals surveyed.

	All hospitals		Private hospitals only	
Fate	**Number**	**Percentage**	**Number**	**Percentage**
O D Neg - PATIENT	2590	45.82%	32	14.35%
Wastage				
Non-O D Neg patient to avoid time expiry	729	12.90%	46	20.63%
Wasted due to time expiry	163	2.88%	37	16.59%
Wasted for another reason	19	0.34%	1	0.45%
Wasted out of temperature control in clinical area	75	1.33%	0	0.00%
Wasted out of temperature control in lab	11	0.19%	0	0.00%
Emergency Transfusion				
Emergency issue to patient unknown or unconfirmed group issued by Lab	284	5.02%	1	0.45%
Transfused from haemorrhage pack/flying squad (without lab involvement)	280	4.95%	1	0.45%
Emergency issue to patient with known group issued by Lab	162	2.87%	1	0.45%
Transplants				
Allogenic stem cell transplant	162	2.87%	0	0.00%
Solid organ transplant	4	0.07%	0	0.00%
Substitutions				
Ro patient, group specific Ro units not available	394	6.97%	7	3.14%
Non-O D Neg patient due to other specific requirements	257	4.55%	0	0.00%
Non-O D Neg patient due to antigen negative requirements for clinically significant antibodies	218	3.86%	1	0.45%
Non-O D Neg patient due to ABO matched blood unavailable	114	2.02%	16	7.17%
Non-O D Neg patient but no valid sample available	11	0.19%	0	0.00%
Other reasons				
Transferred to another site	135	2.39%	66	29.60%
Other "fate" not covered by the above	45	0.80%	14	6.28%
Grand Total	**5653**	**100.00%**	**223**	**100.00%**

Although the number of units analysed in the survey by private hospitals is low, the percentage of overall units fated by this group matched the total proportion of O D Negative red cells issued by NHSBT to these sites (3.8%). This provides a level of assurance the results are indicative of practice.

Key Findings

O D Negative red cells to O D Negative patients

- There is a downward trend in the proportion of O D Negative units transfused to O D Negative patients.
- In the 2024 survey, 45.82% (2590/5653) of O D Negative red cells were transfused to O D Negative patients.

Substitutions

- A high level of O D Negative red cell units was transfused to non-O D Negative patients as a substitution.
- The majority of substitutions were transfused to O D Positive R_0 patients.
- The actual level of substitutions was found to be 21.80% (1946/8925) when including substitutions made during both the blood selection and blood ordering processes.
- Inappropriate and avoidable substitutions still occur.

Conclusion

Availability and stability of the supply chain, especially for O D Negative red cells, remains a significant challenge. Over the years we have observed a continuous change in the pattern of O D Negative red cell usage. The proportion being transfused to O D Negative patients has decreased to 45.82%. This finding is even more pronounced within the private hospitals and some regional variation was also noted.

A large proportion of O D Negative units are transfused as a substitute for the patient's own ABO and phenotype. Whilst in some instances substitutions are unavoidable, the scale of substitutions occurring cannot be maintained and requires collaborative actions by hospitals, Regional Transfusion Committees (RTCs) and NHSBT to address problem. Group O D Negative is often used even when it would be safe to transfuse the patient with an alternative compatible ABO group. Policies should be written, therefore, to ensure group O D Negative substitutions are only used in circumstances where there is no safe alternative. Work also needs to be performed to better match the supply chain with the actual blood groups and phenotypes needed.

All teams involved in transfusion need to ensure that good practice, where implemented, is maintained (e.g. good stock holding practice, wastage monitoring and transfusion of O D Positive blood to male trauma patients).

While this survey is helpful in identifying trends, it is understood that it only represents a snapshot. Therefore, individual sites should interpret their own usage with the understanding of any contributory factors that may have had an impact, e.g. accepting short-dated units.

Supplementary information - Other "fate" reasons

Bleeding patient - no RhD Positive RBCs available in remote issue fridge.
Cannot find the reason for this O neg unit being given to this patient, it was emergency issue, but should have been O-pos.
Crossmatched by NHSBT.
Excess of O negs in stock at time of issue.
General rule in the BT Lab, A NEG or O NEG blood for neonate.
Issued for OrganOx units. Liver Donor group was O NEG.
K Pos unit given to Non-O D Neg patient suitable for electronic issue.
Medically ordered not used, time expired.
MH Remote Issue - no O RhD Positive RBCs available on site.
Neonate <1 month.
No specific requirements, no reason in particular, most likely BMS selection.
Not issued, returned back to NHSBT.
Not issued, unit sent back to NHSBT.
Not K tested.
O+ Auto transplant patient, could have either rhesus group.
Ordered initially for a R0 patient but then issued to another patient for stock and then wasted as time expiry.
Patient has an Rh C and e variant - rr advised by IBGRL - sickle cell exchange programme.
Power failure affecting the whole hospital for 4 hours, blood fridges were unable to maintain their temperature. This unit was one of the wasted stock.
Recalled by NHSBT.
Relapsed bone marrow transplant, difficult to get blood group as receiving O negative units every few weeks.
Split/damaged/leak.
Unable to establish the reason retrospectively. Valid G+S, non-emergency, long dated. ? O RhD positive not available at the time / excess O RhD Negative RBCs in stock.
Unit had positive DAT.
Unknown blood group - not emergency.
Unknown reason.
Unsure as to rationale. Possible K- requirement?
Used due to excess O Neg on site following MH to reduce stock on site.
Wasted - medically ordered not used.
We do not stock B neg units, patient was given O neg due to our stock.

Appendix 1 – Resources to support implementation of recommendations

The following resources are available to assist your practice:

Appropriate use

- NBTC appropriate use guide available at NBTC Appropriate use of group O D Negative red cells

Blood stock inventory and wastage management

- https://www.bloodstocks.co.uk

Clinical Transfusion practice

- https://www.nationalbloodtransfusion.co.uk

Substitutions

- Ordering Ro units - Hospitals and Science - NHSBT

Training and Education

- Transfusion Training Hub | National Blood Transfusion Committee

Stock sharing

- Draft SLA for stock sharing available at Blood stocks - Hospitals and Science - NHSBT (under the "Best Practice" heading)

You can also contact the NTLM Advisory Group, or the BSMS team directly for support (bloodstock.managementscheme@nhsbt.nhs.uk).

Appendix 2 – Additional considerations to conserve O D Negative red cells during severe blood shortages

The NBTC red cell shortage plan published on the NBTC website provides guidance on managing transfusion practice during a severe blood shortage (https://www.nationalbloodtransfusion.co.uk/index.php/recommendations). The objective of the NBTC red cell shortage plan is to ensure that patients who need blood are still able to receive timely transfusion support. The plan designed to ensure that:

- Red cells units are available for all essential transfusions.
- Overall red cell usage is reduced to ensure supply remains available for the patients who need it most.

The NBTC shortage plan makes the following recommendation:

1. **"Conserve group O D Negative red cells for O D Negative patients in line with guidelines"**

The survey found that 45.82% (2590/5653) of O D Negative red cells were transfused to O D Negative patients.

2. **"In severe shortage of O D Negative red cells, in the event of unavailability of O D Negative red cells, to prevent delay in transfusion, use of O D Positive red cells for all patients (including those of childbearing potential / children)"**

The survey found that out of the 4771 O D Negative red cell units transfused to males, 53.62% (2558/4771) of the men were over the age of 18. Out of 2512 O D Negative red cell units transfused to females, 60.82% (1528/2512) of the women were over the age of 50. During a severe blood shortage this would have the potential to release 4086 O D Negative red cell units.

3. **"The provision of group O red cell units for use in the pre-hospital setting may also need review. The care in this setting is Consultant-led and the decision to suspend the supply needs multidisciplinary agreement as to whether the service is suspended, or the provision of the number of red cell units provided is reduced. In addition, all efforts should be made to ensure that unused red cell units are returned to stock."**

During the survey over twelve percent (12.84%,726/5653) of the fated units were transfused to a patient as part of an emergency transfusion. Thirty eight percent (38.57%, 280/726) of these were from haemorrhage packs or flying squad blood packs available to the clinical team and transfused without the involvement of the Transfusion Laboratory.

4. **"Consider the use of temperature loggers in blood boxes to reduce wastage because of uncertainty in cold chain management."**

The overall wastage level reported during the survey was 4.74% (268/5653). Of these, in one third of cases (32.09%, 86/268) the wastage reason was due to a failure to maintain the cold chain.

Appendix 3 - Inventory Management to prevent O D Negative red cell wastage (including transfusion to prevent time expiry)

It has been stated that continual periodic review of blood inventory management practice enables hospital staff to monitor and adjust stock levels, whilst reducing wastage due to time expiry (TIMEX), and promotes the efficient use of blood (*Stanger et al, 2012*). The dynamic of component stock management and associated wastage is far from simple, however, and often wastage is the combined result of multiple factors that can vary from hospital to hospital. The principles to stock management should therefore ideally include general good practice, local understanding and expertise, and a team ethic to preserve a precious resource and maximise its use in the support of patient care.

The key factors when considering red cell stock levels are outlined in the Blood Stocks Management Scheme Inventory Management Guide and do not need to be restated here; however, what does require discussion is that the practical application of these suggestions may not be applicable across all red cell blood groups. Certainly, the reason for focus on O D Negative red cells suggests that there is something more challenging about the management and supply of O D Negative red cells that other blood groups may not experience to the same degree. Indeed, not all hospitals will hold all red cell blood groups in their inventory; yet all will hold O D Negative red cells.

The foundation to good red cell stock management relies on a thorough understanding of the local demand (and not assuming based on historical practices) and setting an appropriate stock level within the context of the national supply chain picture. If two hospitals with similar clinical red cell demand and practices have differing inventory levels, the site with the higher stock level will almost certainly experience a greater challenge managing the inventory and minimising wastage. Whilst lower stock levels are not a pre-cursor for lower wastage, they should be considered as an essential building block to support transfusion laboratory staff in good stock management practices.

The Blood Stocks Management System (BSMS) collects and analyses data supplied by hospitals and provides monthly component reports to all participants. Hospital performance is benchmarked by the Component User Group (currently based on annual red cell issues) and includes evaluation of Issuable Stock Index (ISI) and Wastage as percentage of issue (WAPI) against established and reviewed reference targets. Using the information within these reports should form an essential part of local laboratory review including discussion and monitoring by the Hospital Transfusion Team/Hospital Transfusion Committee.

***What action should I take if I am out of consensus*?**

Issuable Stock Index

If you have a higher than target Key Performance Indicator (KPI) for ISI, this could indicate that your stock levels are set too high. It is important to note that ISI targets may not be suitable for every site/organisation as there are many factors to consider. However, if your wastage KPIs are also higher than average, stock levels should be reviewed and reduced where applicable. This can be performed in stages to increase staff confidence.

Wastage as percentage of Issue

If you have a higher than target KPI for WAPI (red cell or platelet) this could be attributed to different reasons. A breakdown of the wastage categories will provide you with a main cause for the wastage, allowing you to target an area and suggest improvements. It is important to note that WAPI targets may be complex as there are many factors to consider. However, if your wastage KPIs are mainly attributed to TIMEX, then stock levels should be reviewed and reduced where applicable.

Where can I get help? BSMS can provide you with a detailed breakdown of stock, issues and wastage, as evidence to promote changes where applicable. For advice and guidance on specific KPIs contact Blood Stocks Management Scheme at ✉ BSMS@nhsbt.nhs.uk.

What red cell stock should I hold?

The BSMS can only review what information is available to them and there may be some initial analysis required by each hospital that would be beneficial to include as part of the scrutiny, namely the demographic composition of your hospital activity, which should include population sex, age profile, blood group demographic of your hospital population.

Red Blood Cells

- Red Blood Cells (RBCs) are the primary component used in hospitals and all hospitals are likely to hold some stock irrespective of size or patient demographic.
- The volume of red cells held is likely dependent on usage (plus other factors) but generally there are two models:
    - *Hold red cell stock proportionate to expected use (with the expectation of O D Negative) +/- patient variability i.e. hold quantity of red cell stock according to distribution of patient blood groups; hold more O D Positive and A D Positive red cells and less B D Negative – this includes most NHS hospitals (excludes Group AB red cells). It is worthwhile considering the pros and cons of holding all red cell groups as stock items, depending on overall red cell demand and perhaps more importantly in the context of this audit the impact on O D Negative supply chain if you do not. The volume of units held should be guided by calculated analysis and should form the baseline for further conversation. Inventory levels should consider local constraints but should be reviewed at least every six months.*
    - *Hold RBC stock as precautionary measure in the "just in case" scenario; likely has higher expected wastage; relies on "high value" red cells to maximise opportunity for use and "re-sell" to other hospitals. There is crossover with an element of this practice shown by all when considering the supply of O D Negative red cells for emergency use – but is mostly utilised by private and independent hospitals but should not be the sole practice employed.*
- The specification of RBCs used extends beyond the ABO and D type of a donated unit – adding to the complexity of the supply chain model (antigen phenotyping, CMV, HbS negative, Irradiated, Washed, IgA Neg, HPA, IUT/ET, neonatal).
- Hospitals will all have ideal stock levels, but these can easily be undone by a single order and once in stock can take up to 21 days to either be transfused or wasted. It is advised to establish both maximum and minimum red cell levels at a blood group level to prevent this from happening include all staff working in transfusion in these discussions.
- Hospital stock should be set to accommodate the normal rather than the unexpected but the ability to restock quickly maybe a barrier to holding lower stock.

What factors might influence hospitals when setting red cell stock levels; both red cell demand and blood group distribution are two main factors; plus, the additional considerations below at **App, Figure 1**.

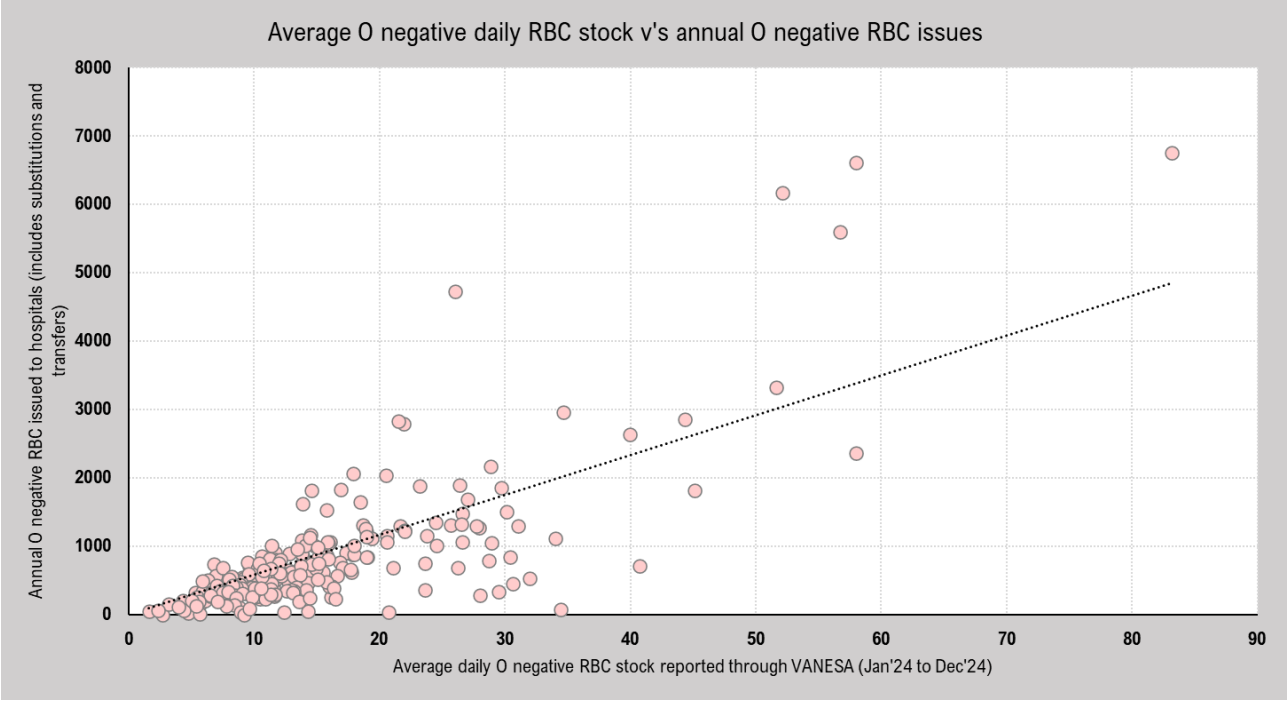
App. Figure 1

- Staff muscle memory plays an important role in maintenance of appropriate stock and can be both a positive and a negative lever.
- Transport and the ability to easily restock is probably the biggest blocker to change.

Hospital O D Negative red cell analysis

We have reviewed the data from January 2024 to December 2024, to provide some context to any stock recommendations made in this report. The graph in **App. Figure 2** plots annual O D Negative red cell issues (net issues will include NHSBT substitutions and inter-trust component movements) against the average daily O D Negative red cell stock value as submitted by hospitals through VANESA. We have excluded the VL hospital sites (very low users) from this analysis and remove any point where daily stock data has not been provided.

App. Figure 2



Hospitals very close to the x axis are likely to be sites where a significant quantity of the red cells have been transferred to another hospital. The overall trend is one that you would expect, the higher the overall O D Negative red cell issues the more inventory is held. However, there is a high

degree of variability it may be more reasonable to review this data by using O D Negative red cell request data (the volume of O D Negative red cells actually requested by each hospital) and provide more granularity of the difference between the RBC User Group categories.

In **App. Figure 3** below, each dot represents a hospital (defined by a separate Pulse code) and the colour indicates which BSMS RBC User Group each hospital belongs to.

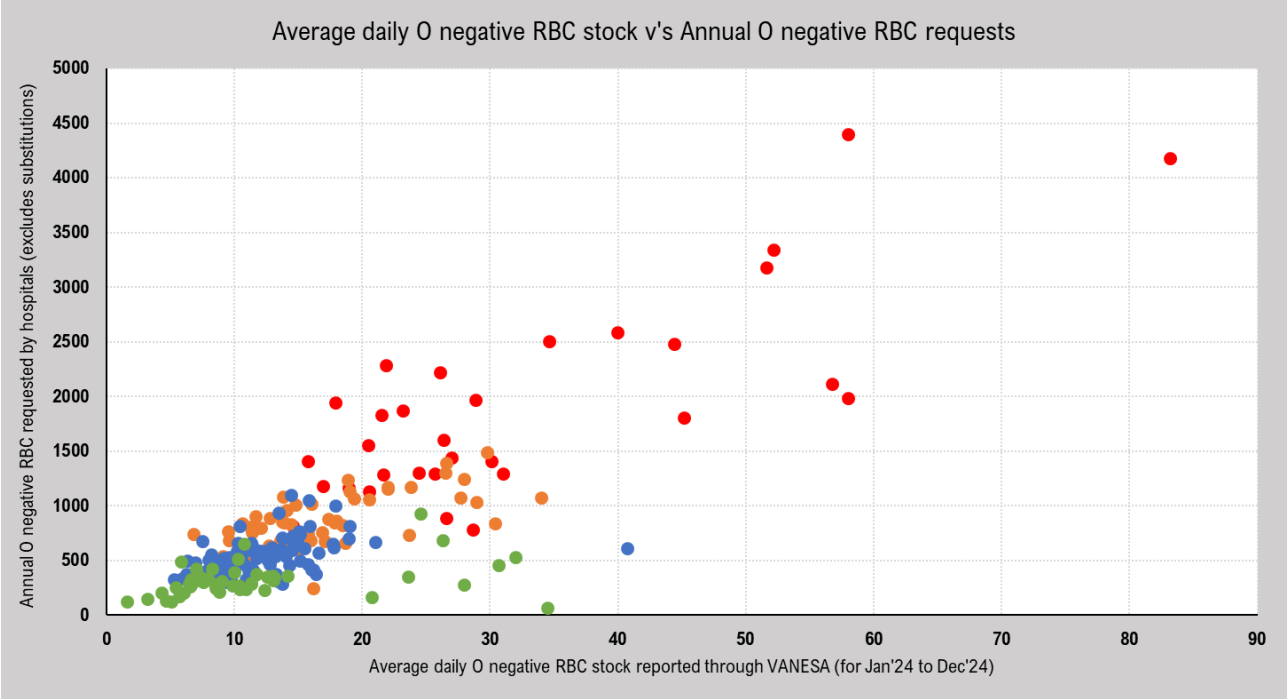
(*These colour key tables apply to the scatter graphs **App. Figure 3** to **App. Figure 5** of this Appendix 3*)

Colour	BSMS Red Cell User Group
VH	Very High User Group
H	High User Group
M	Moderate User Group
L	Low User Group
VL	Very Low User Group

*User groups threshold during audit

Component Type: Red Blood Cells		
BSMS user category	N°. of Hospitals	Annual RBC issues
Very High	31	> 10,000
High	50	> 6,000 & ≤ 10,000
Moderate	89	> 3,000 & ≤ 6,000
Low	49	> 500 & ≤ 3,000
Very Low	22	≤ 500

App. Figure 3

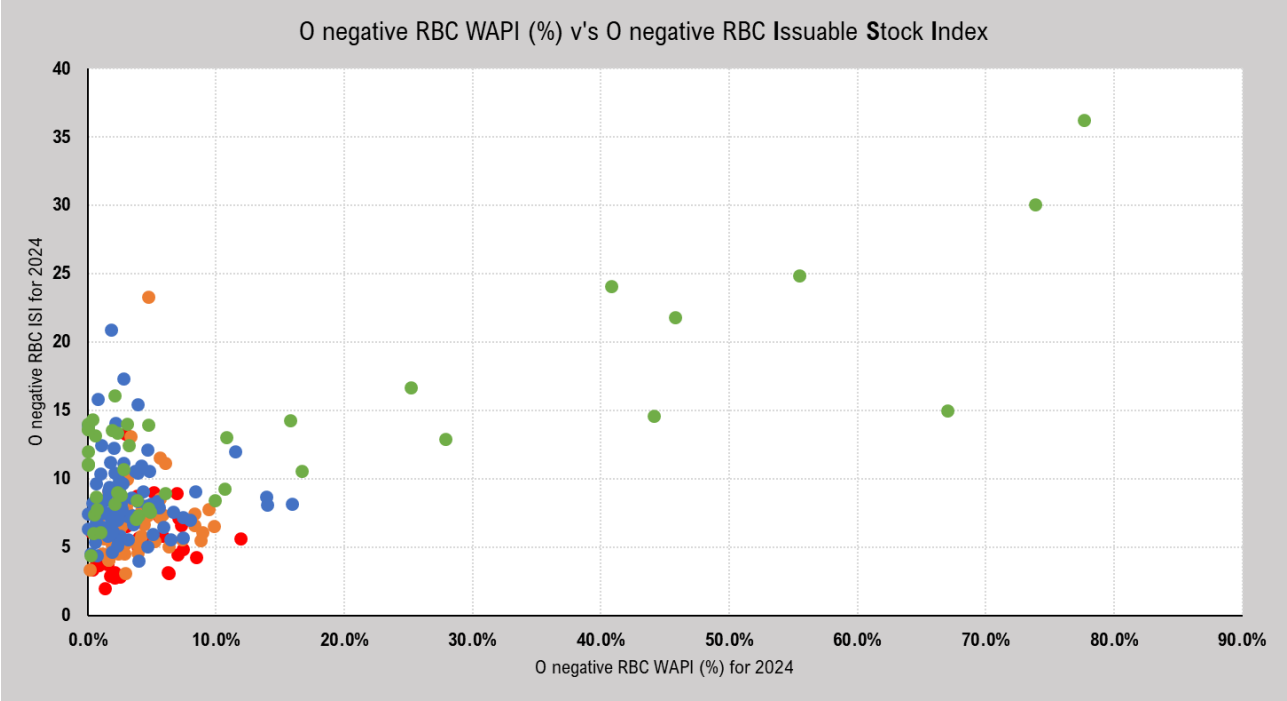


There is good clustering of hospitals evident in the Low, Moderate and High groups, but less so in the Very High User Group. This is perhaps surprising considering the spread in red cell issue volume across the group and the impact of O D Negative substitution observed in some of the sites.

In 2006, G. Perera et al wrote, “the relationship between WAPI and ISI was determined by Pearson product moment correlation for each hospital for the calendar year 2006. The correlation coefficient of 061 (n = 256 and P < 0.001) suggesting that there is a strong relationship between hospital ISI and WAPI”. It was suggested that, “A strong correlation was found between ISI and WAPI, indicating that hospital blood transfusion laboratories may reduce wastage by keeping the ISI to a minimum”. The question is how relevant is that statement today and can we evidence it.[1]

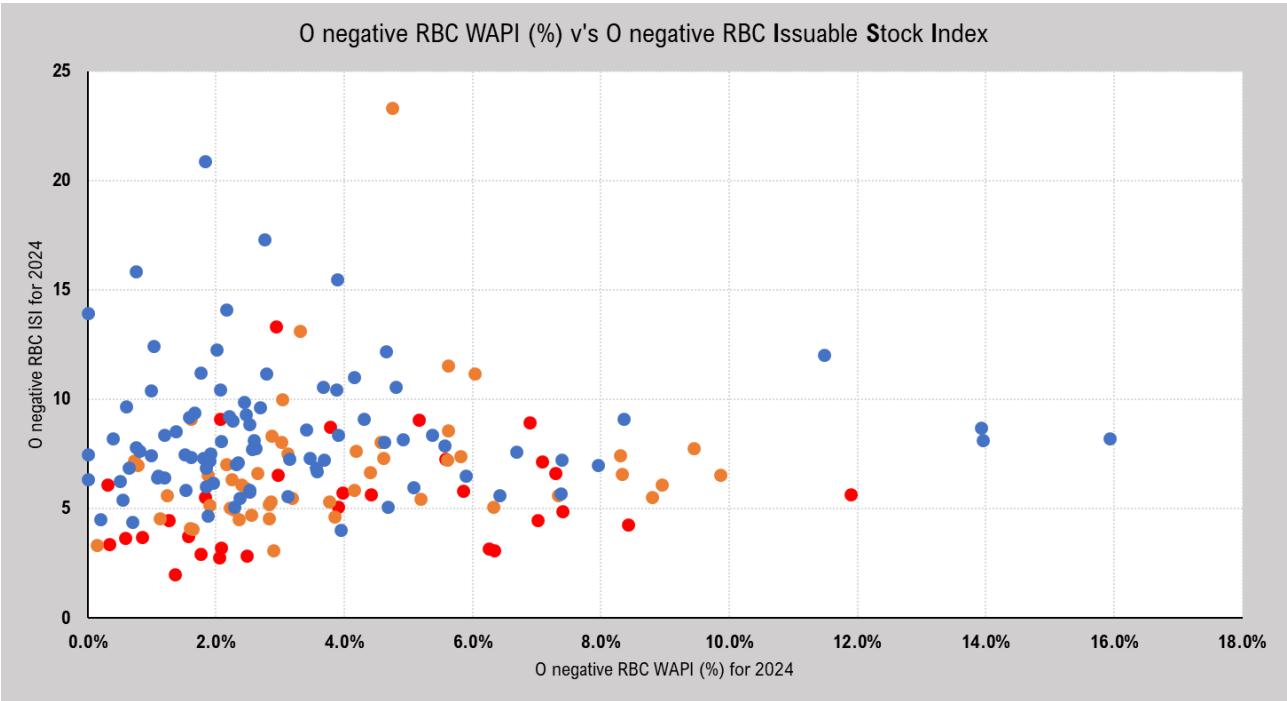
Using data supplied to the BSMS, we analysed data from January 2024 to December 2024 (which covers the period of the O D Negative audit) to assess the relationship between O D Negative RBC wastage (expressed as WAPI) and O D Negative RBC ISI values.

App. Figure 4



The data shows good correlation between O D Negative ISI and O D Negative WAPI for the Low User group (shown in green); but it is less clear for the Very High, High and Moderate User Groups. If we focus on these three groups, can we see anything different?

App. Figure 5



The aim is for each hospital to be with the bottom left corner of the graph to meet KPI targets for ISI and WAPI – and whilst there is evidence of this being achieved there remains a high degree of variability.

Perhaps we can view this another way by comparing the WAPI of hospitals who achieve the target ISI and those who do not within each of the user groups (see the tables at **Appendix 3a** below).

- For the Very High (VH) User Group, the average WAPI for hospitals not achieving the O D Negative ISI target of <5 was 4.7%; the average WAPI for hospitals achieving the O D Negative ISI target of <5 was 3.3%.
- For the High (H) User Group, the average WAPI for hospitals not achieving the O D Negative ISI target of <6 was 4.5%; the average WAPI for hospitals achieving the O D Negative ISI target of <6 was 3.2%.
- For the Moderate (M) User Group, the average WAPI for hospitals not achieving the O D Negative ISI target of <7 was 3.5%; the average WAPI for hospitals achieving the O D Negative ISI target of <7 was 2.7%.
- For the Low (L) User Group, the average WAPI for hospitals not achieving the O D Negative ISI target of <9 was 17.8%; the average WAPI for hospitals achieving the O D Negative ISI target of <9 was 2.8%.

This data proves that managing O D Negative inventory by measuring the ISI can improve the likelihood of lower O D Negative wastage and this starts with setting and setting and maintaining lower O D Negative inventory. This is the reason BSMS continues to calculate, analyse and report ISI values to hospitals and why we encourage hospitals to share good practice amongst each other to improve performance.

Reference

[1] Authors: *Perera G, Hyam C, Taylor C, Chapman JF* - ***Hospital blood inventory practice: the factors affecting stock level and wastage*** - Transfusion Medicine 2009 April; 19(2):99-104 - DOI link: 10.1111/j.1365-3148.2009.00914.x - PMID: 19392951

Appendix 3a

VERY HIGH RBC User Group				
FALSE	0- ISI	Distance from SHU (miles)	0- WAPI	0- TIMEX WAPI
Average	7.3	23.0	4.7%	2.1%
Max	13.3	81.0	11.9%	6.2%
Min	5.1	1.0	0.3%	0.0%
Count	16	16	16	16

HIGH RBC User Group				
FALSE	0- ISI	Distance from SHU (miles)	0- WAPI	0- TIMEX WAPI
Average	8.4	23.7	4.5%	2.8%
Max	23.3	58.0	9.9%	7.3%
Min	6.1	1.0	0.7%	0.1%
Count	28	28	28	28

MODERATE RBC User Group				
FALSE	0- ISI	Distance from SHU (miles)	0- WAPI	0- TIMEX WAPI
Average	9.6	31.4	3.5%	2.4%
Max	20.9	98.0	15.9%	14.2%
Min	7.0	1.0	0.0%	0.0%
Count	60	60	60	60

LOW RBC User Group				
FALSE	0- ISI	Distance from SHU (miles)	0- WAPI	0- TIMEX WAPI
Average	16.3	24.9	17.8%	17.2%
Max	39.0	98.0	77.7%	77.7%
Min	9.0	1.0	0.0%	0.0%
Count	30	30	30	30

VERY HIGH RBC User Group				
TRUE	0- ISI	Distance from SHU (miles)	0- WAPI	0- TIMEX WAPI
Average	3.5	16.0	3.3%	1.7%
Max	4.9	69.0	8.4%	6.6%
Min	2.0	1.0	0.3%	0.1%
Count	15	15	15	15

HIGH RBC User Group				
TRUE	0- ISI	Distance from SHU (miles)	0- WAPI	0- TIMEX WAPI
Average	4.9	23.6	3.2%	1.9%
Max	5.9	75.0	8.8%	6.9%
Min	3.1	1.0	0.1%	0.1%
Count	23	23	23	23

MODERATE RBC User Group				
TRUE	0- ISI	Distance from SHU (miles)	0- WAPI	0- TIMEX WAPI
Average	5.9	32.4	2.7%	1.6%
Max	7.0	89.0	7.9%	7.9%
Min	4.0	2.0	0.0%	0.0%
Count	28	28	28	28

LOW RBC User Group				
TRUE	0- ISI	Distance from SHU (miles)	0- WAPI	0- TIMEX WAPI
Average	7.1	17.6	2.8%	2.2%
Max	9.0	44.0	9.9%	9.9%
Min	0.0	1.0	0.0%	0.0%
Count	16	16	16	16

The tables labelled **FALSE** in the first column are where a hospital group failed to achieve ISI targets for each user group; the tables labelled **TRUE** are the hospital group achieving ISI targets for each user group.

Appendix 4 - Participating hospitals

Addenbrooke's Hospital
Airedale General Hospital
Alder Hey Children's Hospital
Alexandra Hospital, Redditch
Arrowe Park Hospital
Barnet General Hospital
Barnsley District General Hospital
Basildon Hospital
Basingstoke and North Hampshire Foundation Trust
Bassetlaw District General Hospital
Bedford Hospital
Birmingham Children's Hospital
Birmingham Heartlands Hospital
Birmingham Women's Hospital
Blackpool Victoria Hospital
BMI The Ridgeway Hospital
Bradford Royal Infirmary
Bristol Royal Infirmary
Broomfield Hospital
Burnley General Hospital
Calderdale Royal Hospital
Central Middlesex Hospital
Charing Cross Hospital
Chelsea and Westminster Hospital
Cheltenham General Hospital
Chesterfield and North Derbyshire Royal Hospital
Churchill Hospital Oxford
City Hospital Campus (Nottingham University Hospitals NHS Trust)
City Hospital, Birmingham
Cleveland Clinic London
Colchester General Hospital
Conquest Hospital
Countess of Chester Hospital
County Hospital (Stafford)
Croydon University Hospital
Cumberland Infirmary, Carlisle
Darent Valley Hospital
Darlington Memorial Hospital
Derriford Hospital
Dewsbury and District Hospital
Diana Princess of Wales Hospital, Grimsby
Doncaster Royal Infirmary
Dorset County Hospital NHS Foundation Trust

Ealing Hospital
East Surrey Hospital
Eastbourne Hospital
Epsom Hospital
Fairfield General Hospital
Freeman Hospital, Newcastle
Frimley Park Hospital
Furness General Hospital
George Eliot Hospital, Nuneaton
Gloucester Royal Hospital
Grantham and District Hospital
Great Ormond Street Hospital for Children
Great Western Hospital, Swindon
Halton General Hospital
Hammersmith Hospital
Harrogate District Hospital
HCA Laboratories
Hillingdon Hospital
Hinchingbrooke Hospital
Homerton Hospital
Horton Hospital, Banbury
Hospital of St John and St Elizabeth
Huddersfield Royal Infirmary
Ipswich Hospital
James Paget Hospital
Kent and Canterbury Hospital
Kettering General Hospital
King George Hospital
Leeds General Infirmary
Leicester Royal Infirmary
Leighton Hospital
Lewisham Hospital (University Hospital Lewisham)
Lincoln County Hospital
Luton and Dunstable Hospital
Macclesfield District General Hospital
Maidstone Hospital
Manchester University NHS Foundation Trust (MFT)
Medway Maritime Hospital
Milton Keynes Hospital NHS Foundation Trust
Musgrove Park Hospital
New Cross Hospital, Wolverhampton
Newham General Hospital
North Devon District Hospital, Barnstaple
North Manchester General Hospital
North Middlesex Hospital
Northampton General Hospital
Northern General Hospital
Northumbria Specialist Emergency Care Hospital

Northwick Park Hospital
Nuffield Health Brentwood Hospital
Nuffield Health Cheltenham Hospital
Nuffield Health Guildford Hospital
Nuffield Health Leeds Hospital
Nuffield Health Newcastle upon Tyne Hospital
Nuffield Health The Manor Hospital Oxford Hospital
Nuffield Health Warwickshire Hospital
Nuffield Health Wolverhampton Hospital
Peterborough City Hospital
Pinderfields Hospital
Poole Hospital NHS Foundation Trust
Princess Alexandra Hospital, Harlow
Princess Royal Haywards Heath Hospital
Princess Royal Hospital, Telford
QEQM Margate Hospital (Queen Elizabeth the Queen Mother Hospital)
Queen Alexandra Hospital, Portsmouth
Queen Elizabeth Hospital, Gateshead
Queen Elizabeth Hospital, Kings Lynn
Queen Elizabeth Hospital, Woolwich
Queen's Hospital, Burton
Queen's Hospital, Romford
Queen's Medical Centre Campus (Nottingham University Hospital)
Ramsey Rivers Hospital
Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry
Rotherham District General Hospital
Royal Berkshire Hospital, Reading
Royal Blackburn Hospital
Royal Bolton Hospital NHS Foundation Trust
Royal Bournemouth Hospital
Royal Cornwall Hospital, Truro
Royal Derby Hospital
Royal Devon and Exeter Hospital
Royal Free Hospital
Royal Hallamshire Hospital
Royal Hampshire County Hospital, Winchester
Royal Lancaster Infirmary
Royal London Hospital
Royal Marsden Hospital, Fulham
Royal National Orthopaedic Hospital (Stanmore)
Royal Oldham Hospital
Royal Papworth Hospital at Cambridge Biomed Campus
Royal Preston Hospital
Royal Shrewsbury Hospital
Royal Stoke University Hospital
Royal Surrey Guildford
Royal Sussex County Hospital, Brighton
Royal Victoria Infirmary, Newcastle

Russells Hall Hospital
Salford Royal Hospital
Salisbury Hospital NHS Foundation Trust
Sandwell District General Hospital, Birmingham
Scunthorpe General Hospital
Solihull Hospital
South Tyneside District Hospital
Southampton General Hospital
Southend University Hospital
Southmead Hospital
Southport and Formby District General Hospital
Spire Bristol Hospital (The Glen)
Spire Hartswood Hospital
Spire Leeds Hospital
Spire Manchester Hospital
Spire Nottingham Hospital
Spire Parkway Hospital
Spire Southampton Hospital
Spire St. Anthony's Hospital
St Bartholomew's Hospital
St Helier Hospital
St Mary's Hospital (Praed St. London W2)
St Mary's Hospital Newport, Isle of Wight
St Peter's Hospital
St Richard's Hospital
Stepping Hill Hospital
Stoke Mandeville Hospital
Sunderland Royal Hospital
Tameside General Hospital
TDL Manchester BMI (The Doctors Laboratory, Salford)
The Christie Hospital
The James Cook University Hospital, Middlesborough
The John Radcliffe Hospital, Oxford
The Royal Marsden Hospital, Sutton
Torbay Hospital
Trafford General Hospital
Tunbridge Wells Hospital at Pembury
University College London, Whitfield Street
University Hospital Coventry & Warwickshire
University Hospital of North Durham
University Hospital of North Tees
Walsall Manor Hospital
Warrington Hospital
Warwick Hospital
West Cumberland Hospital, Whitehaven
West Middlesex University Hospital
West Suffolk Hospital
Westmorland General Hospital

Weston General Hospital
Wexham Park Hospital, Slough
Whiston Hospital
Whittington Hospital
William Harvey Hospital
Worcestershire Royal Hospital
Worthing Hospital
Wycombe Hospital, High Wycombe
Wye Valley NHS Trust
Wythenshawe Hospital
Yeovil District Hospital

These last four hospitals submitted data but were not included in the analysis, due to having been affected by the Synnovis cyberattack.

Guy's Hospital
Harefield Hospital
Princess Royal University, Farnborough
Royal Brompton