Laboratory Errors n=651 (431 transfused errors and 220 near miss)

14

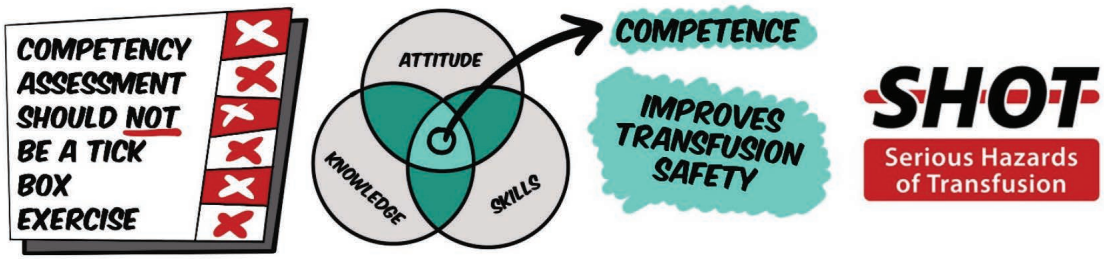
Authors: Victoria Tuckley, Nicola Swarbrick, Heather Clarke and Peter Baker

Abbreviations used in this chapter

ABOi	ABO-incompatible
BMS	Biomedical scientist
CAS	Central alerting system
cffDNA	Cell-free fetal deoxyribonucleic acid
CLAHSE	Component labelling, availability and handling and storage
DHTR	Delayed haemolytic transfusion reaction
EQA	External quality assessment
FFP	Fresh frozen plasma
HSCT	Haemopoietic stem cell transplant
IBCT	Incorrect blood component transfused
ICU	Intensive care unit
Ig	Immunoglobulin
IT	Information technology
LIMS	Laboratory information management systems
MHP	Major haemorrhage protocol
NHSBT	National Health Service Blood and Transplant
NM	Near miss
PID	Patient identification
RBRP	Right blood right patient
SOP	Standard operating procedure
SRNM	Specific requirements not met
SRR	Sample receipt and registration
UK	United Kingdom
UKNEQAS	UK National External Quality Assessment Scheme
UKTLC	UK Transfusion Laboratory Collaborative
WBIT	Wrong blood in tube
WCT	Wrong component transfused

Key SHOT messages

- Sensitisation to the K antigen in patients of childbearing potential is preventable in most circumstances
- A mismatch in workload and staffing levels had some impact upon over half of all laboratory incidents. When staffing levels are unsafe this must be escalated
- Electronic systems should act as an additional barrier. Having transfusion IT systems in place does not negate the need for staff knowledge and skills. Staff should not rely on IT as the only fail-safe mechanism
- Final checking of the unit prior to issue is essential. The use of label verification in LIMS or electronic blood-tracking systems helps to optimise safety. Use of the PAUSE checklist would detect many laboratory errors prior to release of the unit



Recommendations

- Many errors occur due to established procedures not being followed. It is important that laboratory staff understand the 'why' of an action before they move onto the 'how'. The UPTAKE model of competency-assessment (Narayan et al. 2020) remains a useful model to base competency-assessments upon
- Inadvertent sensitisation to the K antigen is classed by SHOT as causing major morbidity and can have devastating consequences in future pregnancies. Standard operating procedures surrounding provision of K-negative components when appropriate should be reviewed to identify any gaps

Action: Transfusion laboratory managers, training leads

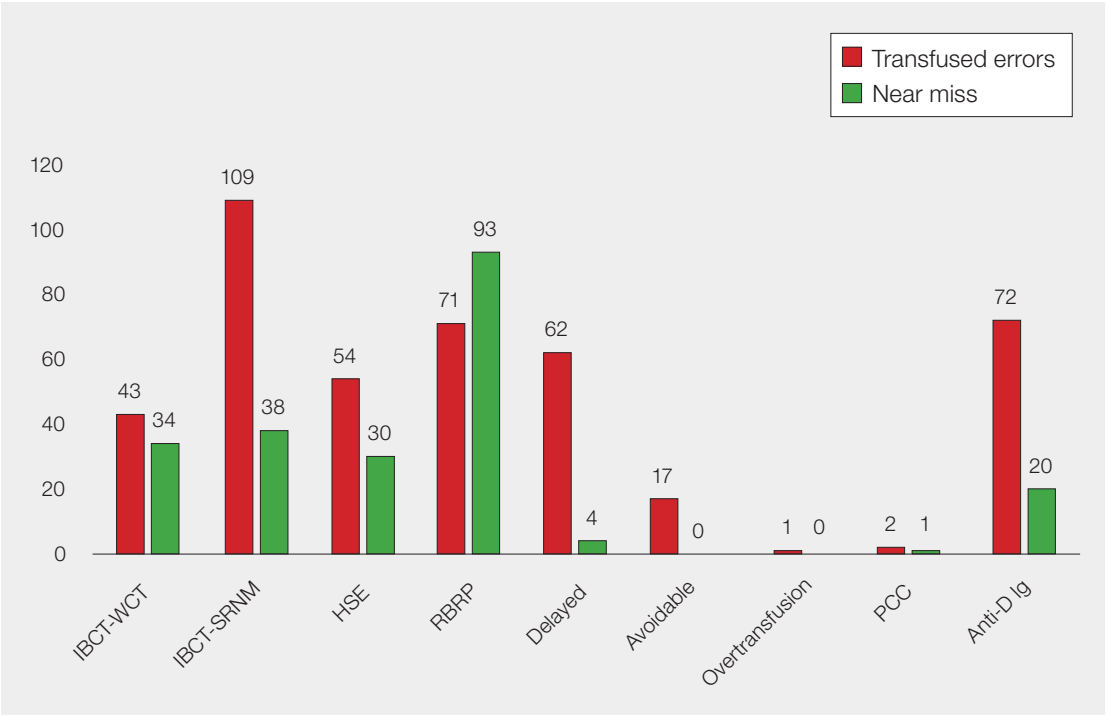
- Staff who are providing training within the laboratory should have the requisite knowledge before delivering this training, in line with UKTLC standards (see 'Recommended resources') to ensure knowledge gaps are not perpetuated

Action: Transfusion laboratory managers, pathology management, training leads

Introduction

In 2022 there were 651 laboratory errors in total, comprising 431 transfused errors, and 220 near miss errors, which is a slight increase from 2021 (573 errors).

Figure 14.1: Laboratory incidents and near misses by category of outcome (n=651)



IBCT-WCT=incorrect blood component transfused-wrong component transfused; IBCT-SRNM=IBCT-specific requirements not met; HSE=handling and storage errors; RBRP=right blood right patient; PCC=prothrombin complex concentrate; Ig=immunoglobulin

The highest proportion of errors occurred within the testing step, 157/431 (36.4%), followed by component labelling, availability, handling, and storage, 146/431 (33.9%), and component selection, 81/431 (18.8%). This highlights the safety critical steps to ensure safe transfusions. Laboratory managers should regularly review their SOP and competency-assessments for staff in these areas to identify any deficiencies. Figure 14.2 illustrates at which stage in the laboratory the error occurred.

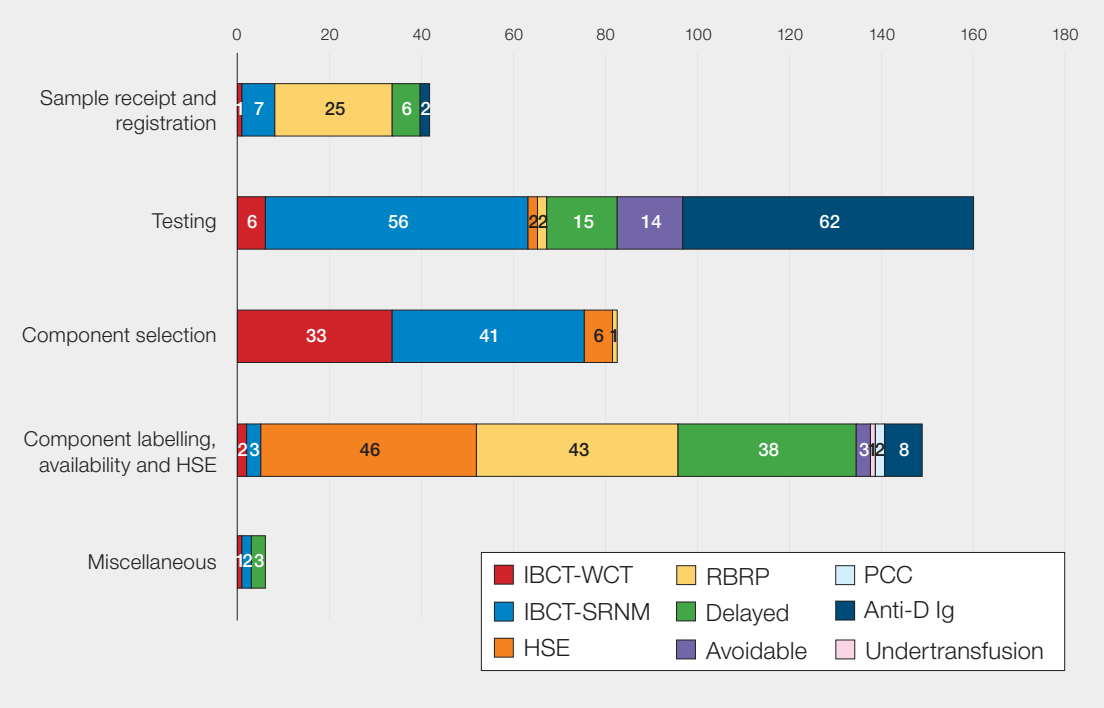


Figure 14.2: SHOT laboratory data across all categories showing the stage in the transfusion process where the primary error occurred (n=431)

Of the 7 incidents classed as 'miscellaneous', 3 resulted in IBCT-SRNM errors, 3 delayed transfusions and 1 IBCT-WCT

Once again, most errors occurred within the IBCT-SRNM category, 109/431 (25.3%) and suggests gaps in staff knowledge related to specific transfusion requirements.

Most NM laboratory errors (Figure 14.3) occurred at the CLAHSE stage, 114/220 (51.8%). Collection errors assigned to the laboratory were instances where the laboratory staff handed over the component to clinical staff themselves. The 1 case identified as 'miscellaneous' was due to a component being received from the Blood Service which contained multiple clots that were identified in the clinical area.

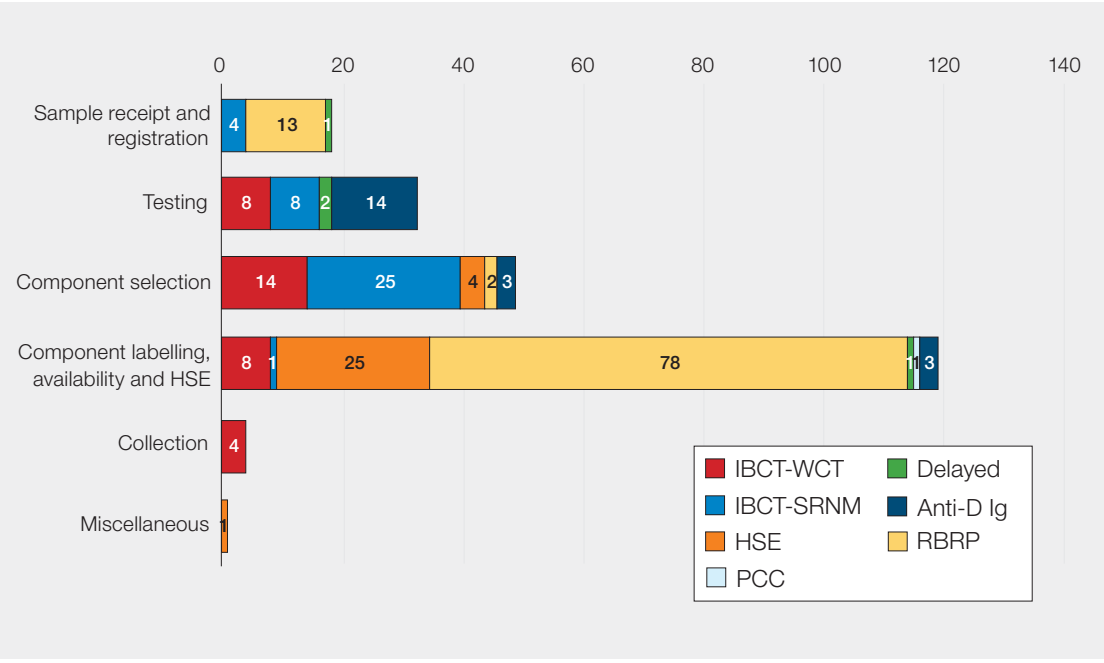


Figure 14.3: SHOT near miss laboratory errors showing at which stage in the transfusion process the primary error occurred with outcome (n=220)

IBCT-WCT=incorrect blood component transfused-wrong component transfused; IBCT-SRNM=IBCT-specific requirements not met; HSE=handling and storage errors; RBRP=right blood right patient; PCC=prothrombin complex concentrate; Ig=immunoglobulin

If unidentified, most NM laboratory errors could have resulted in RBRP events, 93/220 (42.3%). These errors are often identified by vigilant clinical staff and show how teamwork is essential for patient safety.

The use of electronic label verification systems could help reduce both NM-RBRP errors and so many errors that occur at the CLAHSE step. SHOT recommends the use of the PAUSE tool and component exit check as found in the Annual SHOT Reports 2021 and 2020 respectively to ensure components are suitable before release to the clinical area.

Deaths related to transfusion n=0

No deaths occurred due to laboratory transfusion errors.

Major morbidity n=4

There were 4 cases which resulted in major morbidity, all involved sensitisation to the K antigen in patients of childbearing potential and were component selection errors. All patients were females under the age of 34, and in 3/4 cases the transfusion was required for acute bleeding directly related to pregnancy. See Case 14.2.

A further patient required admission to the ICU following a DHTR. This occurred in a patient with sickle cell anaemia who received a non-phenotype matched transfusion. The patient subsequently formed an anti-C. This case is included in the figures and commentary for Chapter 18, Haemolytic Transfusion Reactions (HTR).

ABO-incompatible transfusions n=1

One laboratory error resulted in the ABOi transfusion of group O FFP to a group A patient. The error was detected by laboratory staff prior to transfusion however due to the emergency situation, the transfusion was approved by the clinician and no adverse impact was reported in the patient. This case can be found within the supplementary material for Chapter 9, Incorrect Blood Component Transfused (IBCT) (https://www.shotuk.org/report-summary-and-supplement-2022/).

Errors by step in the transfusion process in the laboratory

Sample receipt and registration (SRR) n=59 (41 transfused errors and 18 NM)

Transfused errors were mostly RBRP PID errors 25/41 (61.0%) and were due to demographic data entry errors. Where IBCT-WCT or IBCT-SRNM errors occurred, this was mainly due to staff not noticing details on the request form which therefore meant that appropriate actions were not taken.

'Many RBRP investigations only address laboratory errors at sample receipt and registration, but this may not be the primary cause. Reporters should look back to the original error (the oversight at sample taking, and why this occurred) to help identify the primary cause and prevent these errors recurring.' (Narayan et al. 2021).

Learning point

- Checking to ensure that all details on the transfusion request, sample and LIMS are aligned helps to identify errors and enhance safety of transfusions

Testing errors n=189 (157 transfused errors and 32 NM)

Testing errors have increased by over 25% from 2021, and are the largest group of laboratory errors, which was last seen in 2020. The majority of these adverse events were in the categories anti-D Ig, 62/157 (39.5%) and IBCT-SRNM, 56/157 (35.7%) (Figure 14.4). IBCT-SRNM errors are discussed further in Chapter 9, Incorrect Blood Component Transfused (IBCT), but in summary were mainly incomplete testing prior to issue of units (21/56) or inappropriate electronic issue (17/56). Antibody identification errors (7/21) and internal quality control issues (7/21) accounted for the largest proportion of incomplete testing (Figure 14.4).

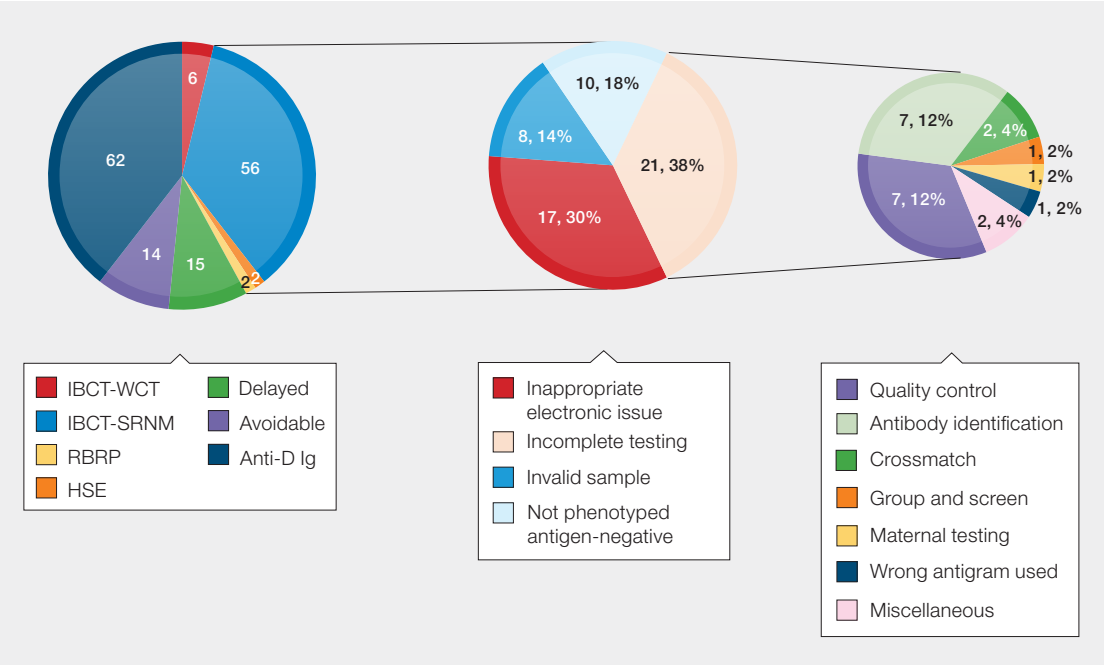


Figure 14.4: Laboratory testing errors by reporting category (n=157) and SRNM testing errors by subcategory (n=56)

IBCT-WCT=incorrect blood component transfused-wrong component transfused; IBCT-SRNM=IBCT-specific requirements not met; HSE=handling and storage errors; RBRP=right blood right patient; Ig=immunoglobulin

Most anti-D testing errors were procedural errors, 18/62 (29.0%), where laboratory staff did not follow the processes set out within the SOP. Additionally, 10/62 (16.1%) were due to communication issues surrounding test results, and errors in result input from referral services.

A total of 19/62 of anti-D testing errors were due to discrepancies in cffDNA results. There were 11/19 that gave a false positive result and 8/19 gave a false negative. This is not aligned with published rates; which state false negatives are up to 200 times less likely than false positives (0.1% false negative compared to <2% false positive) (NHSBT 2022). NHSBT, which is one of multiple providers of cffDNA testing in the UK, have confirmed 13 false negative cffDNA results were reported in 2022. No information about reports are available from other providers of cffDNA testing. It is important to report inaccurate results to both cffDNA testing providers and to SHOT, to ensure accurate data can be published and accurate risk assessments formed. Figure 14.5 shows the number of cffDNA prediction errors reported to SHOT since 2019.

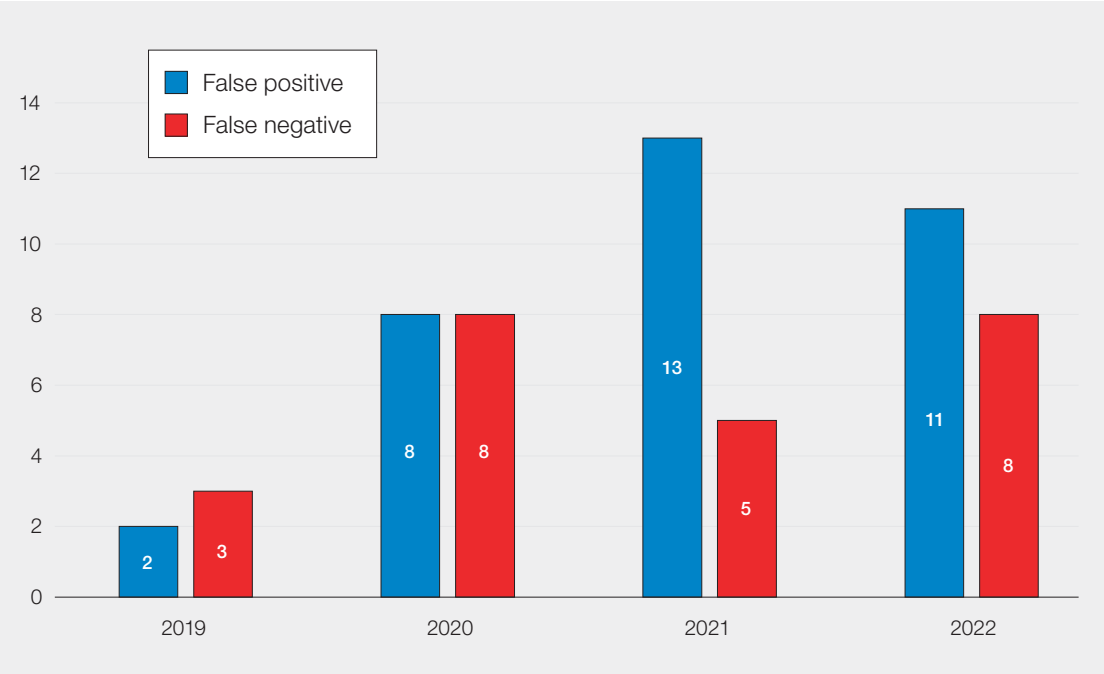


Figure 14.5: Cell-free fetal DNA prediction errors reported to SHOT 2019-2022

Case 14.1: Missed anti-D Ig administration following delivery due to multiple errors with inconclusive cffDNA result

A D-negative woman in her 30s had an emergency caesarean section. The cffDNA result was inconclusive, so cord and maternal samples were sent for testing. The cord sample was found to be positive but no anti-D Ig was issued. The BMS assumed this had been done immediately following delivery as with pregnancies that are predicted D-positive. The ward was not contacted to inform them that anti-D Ig was needed and a Kleihauer test was also not performed. The clinical staff did not check whether anti-D Ig was required, the woman was discharged without having anti-D Ig administration and had to return for this >72 hours after giving birth. The reporter noted that staffing levels directly impacted the correct procedures being followed. The laboratory had implemented contingency plans for staffing and non-registered staff were the only staff present for 4 and a half hours earlier in the day, causing a large backlog of work. This sample was also processed whilst two other major haemorrhages required support by a single member of BMS staff.

Errors in both clinical and laboratory areas can be identified in this incident and multiple factors appeared to be contributory including staff issues, mismatched workload, cognitive bias (assumption) and lack of appropriate checks in the process. Hospital management has a responsibility to ensure that adequate staff are available in clinical and laboratory areas to support safe transfusions. Clear communication between the laboratory and clinical areas is essential to prevent patient harm.

Learning points

- Anti-D testing and results can be complex. Standard operating procedures and competency-assessments must ensure that laboratory scientists have the required fundamental knowledge to issue advice and support patient care
- Failure to administer prophylactic anti-D Ig within 72 hours can cause maternal sensitisation to the D antigen. Ensure postnatal testing and prophylactic anti-D Ig administration are completed before discharge

Component selection errors n=129 (81 transfused errors and 48 NM)

Component selection errors accounted for 81/431 (18.8%) of laboratory errors, with the majority due to specific requirements not being met, 41/81 (50.6%) and wrong component selected for transfusion, 33/81 (40.7%).

Where the components did not meet the patient's specific requirements this included units not phenotyped/antigen-negative when required (14/41), not irradiated (12/41), and K-positive units given to patients of childbearing potential (6/41).

Where wrong components were issued by the laboratory the majority were cases of wrong ABO group selected (28/33), of which 13/28 were related to wrong ABO components issued to HSCT and SOT patients. All these 13 cases stated the error was related to IT, with either the LIMS alerts being overridden by the BMS or limitations within the LIMS rules not clearly stating the requirements for this patient group.

SHOT issued a Safety Notice (see 'Recommended resources') regarding the importance of identifying and providing components with specific requirements in 2022. This was in response to the increasing trend in IBCT-SRNM errors. A gap analysis tool was also made available to assist laboratories in evaluating their current policies and procedures.

Case 14.2: Major morbidity due to a component selection error for a female of childbearing potential

A female in her 30s was found to have an anti-K as part of antenatal screening. She had required two units of red cells post-delivery in a previous pregnancy due to active bleeding. One of these units issued by the BMS was K-positive. The LIMS had an alert for all females less than 50 years to state 'Females of childbearing potential should receive K-negative red blood cells unless they are unavailable in an emergency', but this did not prevent the issue of K-positive red cells to this patient

despite the availability of K-negative units. The investigation stated there was a lack of knowledge in recently qualified BMS staff about K-negative requirements, and that continued recruitment and retention issues had placed a training burden on the remaining staff. Additionally, there were leadership issues due to changes to restructuring.

The preventative actions included a better learning environment for trainees and improved competency-assessments, recruitment of a new band 7 post to assist with training and additional out-of-hours band 3 staff, with the aim of moving to a new LIMS where this issue would be addressed. There were 3 other cases which involved K-positive units issued to K-negative patients of childbearing potential which resulted in sensitisation.

Learning points

- Understanding the reasons for specific transfusion requirements will help reduce errors
- Appropriate LIMS rules and algorithms for patients with specific requirements improves safety

Component labelling, availability and handling and storage errors n=263 (146 transfused errors and 117 NM)

There has been an increase in CLAHSE errors, which accounted for 146/431 (33.9%) of laboratory errors, and included 46 handling and storage errors, 43 right blood right patient errors and 38 delays. Factors leading to these delays involved laboratory staff not having a clear understanding of the request including urgency, communication gaps between laboratory and clinical areas following rejected crossmatch samples and blood availability in MHP/urgent cases. Lack of awareness of concessionary release processes also led to delays in provision of blood components.

There were 30/46 handling and storage errors related to cold chain errors, of which 12/30 were units inappropriately returned to stock and 9/30 refrigerator/equipment failures. There were also 9 cases where the reservation period of the crossmatch sample had been exceeded.

The majority of RBRP errors were due to labelling errors (37/43) of which 25/37 were due to transposed labels between units intended for the same patient.

Learning points

- Incorporating the PAUSE checklist or IT as an additional safety check can help reduce the risk of transposed label errors
- A clearly defined quarantine process will prevent units being inappropriately returned to stock following cold chain issues
- Clear communication between laboratory and clinical areas is essential in understanding transfusion urgency, requirements, and availability of units
- Not informing the clinical area of rejected crossmatch samples can lead to delays in provision of blood
- Errors can be prevented when transfusion laboratory staff check that the date of the required transfusion does not extend beyond the date of the sample expiry

Collection errors n=4 (0 transfused errors and 4 NM)

All these near miss collection errors were due to the transfusion laboratory staff handing over incorrect units to clinical or portering staff at the point of collection, with 3 for the wrong patient, and 1 of the wrong component type.

Miscellaneous errors n=7 (6 transfused errors and 1 NM)

These miscellaneous errors included misunderstanding of requests, data entry errors, misreading of results, LIMS configuration issues, poor communication regarding a transferred patient and 1 case of a red cell unit containing clots.

Laboratories under pressure

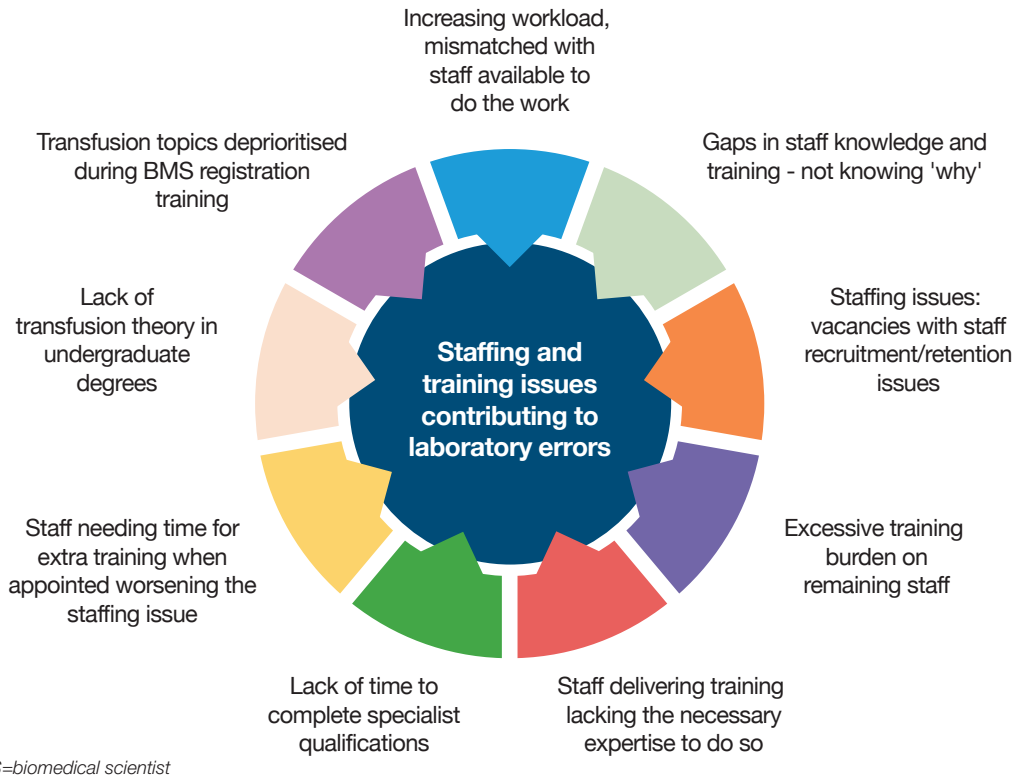
Basic errors in the laboratory continue to occur and, in some cases, have led to major morbidity in patients. Gaps in staff knowledge contribute to transfusion errors. The correct use and configuration of IT systems, underpinned by sufficient levels of knowledge within laboratory staff can prevent these errors. Training, competency, and skills development must be of value, and not a tick box exercise.

There are discrepancies between staff who have completed their competency-assessment and those who have sufficient knowledge to complete the task, with many reporters stating that gaps in knowledge was an influential factor in the laboratory error despite being up to date with competency-assessments. In total 70/431 (16.2%) of reporters stated there was 'some', 'a lot' or 'fully' a mismatch between workload and staffing provision at the time of the incident. Staff should be supported, and transfusion laboratories should be adequately staffed to match workload.

See the supplementary information on the SHOT website for further analysis of the human factors for laboratory incidents (https://www.shotuk.org/shot-reports/report-summary-and-supplement-2022/).

Staffing and workload issues compounded by suboptimal training contribute to errors and are illustrated in the figure below.

Figure 14.6: Summary of issues contributing to laboratory errors



BMS=biomedical scientist

Acknowledging laboratory excellence

Whilst there are many challenges identified in the transfusion laboratory, data submitted to SHOT also identifies areas where laboratory staff are excelling. In 2021 a question was added to the SHOT questionnaire 'Was any specific good practice identified as a result of this incident? If so, please provide details. Within laboratory reports 81/431 (18.8%) identified areas of good practice. Analysis of this data has identified key themes of excellence within the laboratory:

- Swift action - staff were able to identify errors and quickly rectify them to prevent further harm
- Communication and collaboration with clinical areas to improve patient outcomes
- Improved processes following an adverse incident - several processes were reviewed post incidents to identify areas for improvement
- Initiative - in many case the laboratory staff acted upon their knowledge to investigate unusual occurrences, which identified errors and allowed for further follow up
- Candour, escalation and follow up - staff were honest and escalated matters to senior staff where appropriate. Laboratory staff realise the importance of their actions and the impact upon patients

Laboratory processes detected 717 of the 890 reported WBIT samples in 2022, highlighting the important role that the laboratory plays in preventing patient harm.

Instances of excellent practice continue to be under-recognised. Studying excellence in healthcare, including in transfusion laboratories, can create new opportunities for learning, help improve resilience and staff morale. Transfusion laboratory staff have a pivotal role to ensure transfusion safety with decisions having an impact on patient care and outcomes. One such case reported under the acknowledging continuing excellence category this year illustrates how laboratory staff knowledge can be critical in saving lives.

Case 14.3: Good practice by laboratory staff triggers lifesaving treatment of baby

A BMS identified a mixed field result within a group and screen sample for a pregnant patient. This prompted the BMS to contact the clinical area to request an additional sample and highlight the risk of large fetomaternal haemorrhage. The patient was brought back into hospital for cardiotocography, the results of which were suspicious and resulted in early delivery of the baby. The baby was very anaemic and required red cell transfusion. If this had not been noted by the BMS and escalated, the mother may not have been reassessed and the baby not successfully delivered. A 'Greatix' report was raised within the organisation to acknowledge the prompt action of the BMS who has also received acknowledgment throughout the pathology network.

Conclusion

Transfusion laboratories are critical for providing safe and timely blood components. To deliver this life saving service the laboratory must be sufficiently staffed, with trained and competency-assessed staff for the tasks undertaken. There must be the right skill mix to ensure a safe service provision, and those providing training to others must have adequate knowledge to provide this. Embedding a learning culture in all organisations will support the individuals, the organisation as a whole, and the service provided by laboratories.

There needs to be a clear understanding of not only how staff perform steps but why they are required, and how the patient may be impacted should these steps not be followed. This is particularly important to ensure the right components with the correct specifications are provided for patients.

Use of IT supports safe transfusions, but its effectiveness is reliant on correct setup, sufficient staff training, and ongoing system development. Overreliance of IT to 'catch errors' must be avoided, with staff knowledge and understanding being sufficient to prevent the primary error. Alert fatigue must be avoided as this can lead to errors.

Before development of a new process, or the introduction of new equipment, a thorough systems design which incorporates the consideration of human factors must be undertaken. This will aim to reduce the occurrence of future errors, thus improving transfusion safety. Human factors principles must also be incorporated into incident investigation procedures to ensure all influencing factors have been considered, and appropriate corrective and preventative actions can be introduced. Learning from errors, and sharing that learning, is an essential step of these preventative actions.

Laboratories have faced many difficulties over recent years which seem to have been exacerbated following the COVID-19 pandemic. These have included staff shortages, difficulties in recruitment and retention of staff, staff sickness, poor system designs, and insufficient or inadequate resources. These concerns must be addressed to ensure that transfusion laboratories have a stable future, where staff feel supported, and care of patients is not negatively impacted.

UK Transfusion Laboratory Collaborative update

Author: Kerry Dowling, Chair of the UKTLC

The UKTLC continues to support laboratories with an aim to increase the safety of transfusion. This year has seen the release of the 2023 updated version of the UKTLC minimum standards for staff qualifications, training, competency and the use of information technology. The 2022 survey results were also released with the main themes covering ongoing staffing shortages and poor transfusion knowledge for newly registered BMS staff. The survey highlighted negative impacts on laboratory functions related to the COVID-19 pandemic and the formation of networks. Also, despite SHOT and UKTLC recommendations for implementation of EBMS for patient safety, approximately a third of respondents had no electronic blood management system in place and less than a quarter had full vein-to-vein systems.

Following the 2022 CAS alert (preventing transfusion delays in bleeding and critically anaemic patients (SHOT 2022)), the 2022 survey asked about delays associated with staffing and education. Approximately a third of respondents noted an incident or near miss delay in provision of blood due to inadequate staffing levels and/or staff education and knowledge.

On a positive note, the survey data shows that laboratories are embracing learning from excellence and incidents, have introduced business continuity plans and have staff capacity plans.

This year the UKTLC will be reviewing where we can take action with our partner organisations to help laboratories achieve compliance with the standards and to consider tools to help education of BMS staff in the workplace.

UK NEQAS update

Authors: Richard Haggas, Katy Veale and Claire Whitham, UK NEQAS BTLP

Participation in EQA offers the chance to learn from errors. The errors made in EQA exercises can be viewed as 'free lessons', as appropriate corrective action can be taken before the error occurs with a clinical sample.

As in other years, 'procedural' errors (errors caused by sample or result transposition, and/or data transcription into the UK NEQAS website) continue to be a significant cause of penalty during 2022. There were no ABO grouping errors, but three laboratories made a D-typing error as a result of transposition of samples or data entry errors. Understandably, more of these procedural errors occur during 'R' coded exercises, due to the additional tests required over an 'E' coded exercise. Since ABO/D grouping and antibody screening tests are largely automated, with automatic transmission of results to the LIMS, the errors seen in EQA for these tests may not be fully representative of a similar error in a clinical situation, where the automated processes are functioning as intended. However, during analyser and/or LIMS downtime, these procedural errors acquire a greater significance in terms of risk to the patient. Where tests are still performed manually, with no automated transmission of results to the LIMS, the risks of procedural errors are a constant that should be mitigated as far as possible. When testing samples, or entering data for EQA samples, it is important to check that the data is being recorded and transcribed against the correct patient or donor; this also applies to the positive identification of the sample being tested, data entry of results of manual testing of clinical samples into a LIMS, or in the event of LIMS downtime. Care should be taken to confirm the identity of all samples before testing. For clinical samples, this requires a full check of the patient demographic details to ensure that results are assigned to the correct patient. EQA samples should be subject to the same process with a check of the patient number and exercise code on each sample.

Like ABO and D grouping, antibody screening sees very low error rates. Although few in number, false negative antibody screens can have a significant impact, particularly in laboratories employing electronic issue as a means of establishing compatibility. In exercise 22E9, one participant did not notice that the analyser had flagged an 'incorrect volume flag' and this was not acted upon; the participant missed the anti-c+K in the patient plasma sample as a result. Flags against reactions or results on an analyser are intended to draw attention to a problem with testing and laboratories should have a policy in place for handling all flags to ensure invalid results are not accepted.

Antibody identification continues to see the highest proportion of errors, particularly when two antibodies are present in a sample. In exercise 22E1, two laboratories made errors for Patient 1 (anti-E+M), reporting a single antibody (anti-M) without noting the presence of the second specificity. In exercise 22E3, two laboratories recorded a total of three antibody identification errors. The first switched results for Patients 3 and 4 during data entry. The second, recording anti-Fy^{a} only for Patient 3, made a transcription error when recording screening cell results and antigen profiles onto an antibody identification sheet, and also did not take account of reactions obtained in an enzyme panel when reporting. In exercise 22E7 the Patient 2 sample contained anti-D+Jk^{a}; all laboratories were able to identify the anti-D, but seven laboratories misidentified the second specificity (six recording anti-M and one anti-Fy^{b}). In many cases of antibody identification errors there is either a failure to take account of all positive reactions with available panel cells, or a misunderstanding of the BSH guidelines (BSH Milkins et al. 2013) regarding the inclusion and exclusion criteria for antibody identification. To avoid misidentification, every antibody investigation should include a systematic process for exclusion and positive identification of antibody specificities, and all positive reactions should be accounted for before a conclusion is reached. BSH guidance (BSH Milkins et al. 2013) for inclusion of antibody specificities requires that 'the plasma is

reactive with at least two examples of reagent red cells expressing the antigen and non-reactive with at least two examples of reagent red cells lacking the antigen.

In exercise 22R2, one laboratory missed an ABO-incompatibility, selecting a group A donor as theoretically compatible with a group B patient, as they failed to notice the group of the donor on the sample bottle. In exercise 22R5, one laboratory obtained negative serological crossmatching results for Patient 1 (anti-K) vs. Donor Z (K+). In exercise 22R8 four laboratories missed seven incompatibilities for Patient 3 (anti-Fy^{a}) vs. Donors W and Y (Fy(a+b-) and Fy(a+b+) respectively; three recorded false negative reactions in a serological crossmatch and one selected Donor Z as theoretically compatible. The rate of crossmatching errors was six times higher than antibody screening errors in 2022, which likely reflects a number of factors. Antibody screening cells are of a known antigen profile, are prepared at the correct cell suspension and are stored in the optimal medium. Donor cells used for crossmatching, however, are of unknown zygosity, variable condition and require manipulation before testing. Serological crossmatching also involves manual steps even if automation is used.

Recommended resources

SHOT Safety notice 02: Ensuring patient specific transfusion requirements are met
SHOT Safety notice 02: Gap analysis plan
https://www.shotuk.org/resources/current-resources/safety-notices/

PAUSE Checklist
https://www.shotuk.org/resources/current-resources/

UKTLC Standards 2023
https://www.shotuk.org/resources/current-resources/uktlc/

References

BSH Milkins C, Berryman J, Cantwell C, et al. Guidelines for pre-transfusion compatibility procedures in blood transfusion laboratories. *Transfus Med* 2013;**23(1)**:3-35. http://onlinelibrary.wiley.com/doi/10.1111/j.1365-3148.2012.01199.x/full [accessed 27 April 2023].

Narayan S (Ed), Poles D, et al. on behalf of the Serious Hazards of Transfusion (SHOT) Steering Group. The 2019 Annual SHOT Report (2020). https://www.shotuk.org/shot-reports/ [accessed 27 April 2023].

NHSBT. International Blood Group Reference Laboratory (IBGRL) Molecular Diagnostics The future of antenatal care. (2022) https://nhsbtdbe.blob.core.windows.net/umbraco-assets-corp/27022/inf148111-fetal-rhd-screening-brochure-online-version.pdf [accessed 28 April 2023].

SHOT. Preventing transfusion delays in bleeding and critically anaemic patients SHOT/2022/001 (2022) https://www.cas.mhra.gov.uk/ViewandAcknowledgment/ViewAlert.aspx?AlertID=103190 [accessed 28 April 2023].