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National Comparative Audit of Blood Transfusion

NHS Blood and Transplant

National Comparative Audit of the use of Red Cells in Neonates and Children 2010

St. Elsewhere's Hospital

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Executive summary and recommendations

Sample size
2524 patients with a total of 4020 transfusion episodes were included in the audit. These were from 141 sites, with an overall median 15 cases per site (IQR 8-24 per site).

Organisational audit

- Most responding hospitals (85%) had a policy for neonatal red cell transfusion, but only 68% had one for children. Transfusion practice in these groups of patients is similar but there are important differences which could affect patient safety.
  We therefore recommend that every Trust / Hospital which transfuses children should have guidelines/policies for use of red cell transfusions to all children and not just neonatal groups.

- 40% of hospitals had guidance on minimising excessive/unnecessary blood testing, and 72% used analysers designed for low volume for samples from neonates/small children. A common reason for transfusing neonates is because of excessive or unnecessary blood sampling, resulting in a drop in haemoglobin and the need to transfuse. This places the patient at unnecessary risk.
  We therefore recommend that Trusts / Hospitals should provide guidance for minimising excessive/unnecessary blood testing. They should also explore the use of laboratory analysers designed for low volume for samples from neonates/small children and the use of near patient testing.

Clinical practice

- The most common location for transfusion for patients on wards other than a neonatal unit was the General Paediatric Ward (33%). 21% (279/1302) transfusions to children on wards other than the neonatal unit were to infants less than a year of age, and the most common locations for these transfused infants were Paediatric Intensive Care Unit (PICU) and theatres. Patients are transfused across a wide range of settings and although much of the management is similar there are important differences which could affect patient safety.
  We therefore recommend that education and training about safe prescribing and administration of transfusions for children of all age groups need to be delivered to a wide range of paediatric medical and nursing staff.

- 48% of all patients transfused outside neonatal units had a haematological/malignant diagnosis (leukaemia/cancer, haemoglobinopathy) as the main underlying reason for their admission. Since these are major patient groups it is important that care is tailored as specifically as possible for them.
  We therefore recommend that hospitals should consider developing guidelines specific for these patient groups, based on national guidance.

- 4% infants and children transfused outside neonatal units and 3% of infants transfused on neonatal units did not have a documented haemoglobin (Hb) result taken up to a week pre-transfusion. Up to18% patients outside neonatal units and 8% on neonatal units did not appear to have had a post-transfusion Hb.
  We therefore recommend that the use of red cell transfusions should be guided by the results of Hb pre-transfusion, which should be measured in all cases unless the clinical situation is urgent. Hospitals should be clear if it is acceptable not to measure the post transfusion Hb for some groups of patients.

- Prescription of the volume of red cells to be transfused by units occurred for over a third of all transfusions on wards other than the neonatal unit. This was most common in children over 12 months (median age of 12 years), but was seen at *all* ages and in all locations.

There is a well recognised risk of over transfusion leading to transfusion associated circulatory overload (TACO) as the result of doctors inappropriately prescribing the volume by units rather than millilitres (mls) to infants and young children (repeatedly highlighted by SHOT, see Taylor et al, 2010).

We therefore recommend that, in order to prevent this, blood prescribed to infants and younger children should be prescribed in mls rather than units. Hospitals should be clear in their guidance to prescribers if there are sizes/locations of children for whom it is acceptable to prescribe blood in units.

- 24% of initial red cell transfusions on neonatal units were at a dosage of >20mls/kg. This high volume is surprising and raises the risks of TACO. Moreover, if a transfusion of > 20 mls/kg is given from a single paedipack (approximate volume 40-50 mls) at the standard rate for neonatal top-up transfusions of 5mls/kg/hr, this risks blood being out of controlled temperature for more than the maximum 4 hours and 30 minutes for neonatal red cells.

  While understanding the need to maximise the benefit of transfusion and reduce overall number of transfusions in preterm infants, we recommend that consideration should be given to the risks of transfusing these higher volumes. Neonatal red cells must not be out of controlled temperature for more than a maximum 4 hours and 30 minutes, so the transfusion volume and rate must take this into account.

- A noted benefit of transfusion was reported for only 17.7% (230/1302) transfusions outside neonatal units and 18.9% (515/2718) on neonatal units. This gives rise to the possibility that the efficacy of the transfusion is not being evaluated in many cases and thus the need cannot be demonstrated. It is important to ensure that, having given a transfusion, a check is made on the contribution the transfusion made to improving the patient's clinical outcome. While this may be known empirically at the time the patient is being managed, it cannot always be shown from the records.

  We therefore recommend that a note should be made of the benefit, or lack of benefit, for all blood transfusions given.

- For just over half of the transfusions outside neonatal units anaemia, with or without symptoms, was reported as the main reason for transfusion. 13% transfusions were given for patients with bleeding. Results for pre-transfusion haemoglobin varied, with median values of 7.2, 7.6, and 8.6 g/dl respectively in anaemic patients with symptoms of anaemia, without symptoms of anaemia, and in patients with bleeding. The transfusion triggers were broadly in line the recommendations in the British Committee for Standards in Haematology (BCSH) guidelines, although it is not clear as to the severity of the bleeding and whether this would justify the higher pre-transfusion Hb.

  We therefore recommend that information should be given in the notes as to the indications for transfusion.

- Patients on chronic transfusion programmes had a median pre-transfusion Hb of 9.2 g/dl and a median post-transfusion Hb of 10.0 g/dl. 179/217 (82%) of these were haemoglobinopathy patients.

  We therefore recommend that hospitals periodically review transfusions for children on chronic transfusion programmes, to ensure there is clarity on the pre- and target haemoglobin values depending on the clinical situation.

- On PICU, the main groups of transfused patients were cardiac 38% [58/154] and those with infection/sepsis 18% [27/154]. Median pre-transfusion haemoglobin values in PICU, were 8.4 g/dl, of which 68% (102/149) were from ventilated patients. This is a complex group of patients but the median pre-transfusion haemoglobin was higher than the restrictive threshold of 7 g/dl demonstrated in the recent TRIPICU trial (Lacroix et al, 2007).

- This may be partly because of the inclusion of children with cyanotic heart disease who do need higher Hbs, but there may be some patients on PICU who do not need to be transfused at the levels reported to the audit.

  We therefore recommend that ongoing education about results from randomised trials such as this should be provided.

- On the neonatal unit the median pre-transfusion Hb varied depending on the respiratory status at the time of transfusion. For mechanically ventilated patients it was 10.6 g/dl, for those on Continuous Positive Airway Pressure (CPAP) 9.4 g/dl, and for those on supplementary oxygen without ventilation it was 8.2 g/dl. Patients off oxygen had a median pre-transfusion Hb of 7.6 g/dl. For the initial transfusion, there was a clear effect of postnatal age on pre-transfusion Hb for the infants on respiratory support: the median pre-transfusion Hb fell with age from 11.5 g/dl (postnatal age 0-1 days) to 8.5 g/dl (postnatal age > 28 days).

  In general, the pre-transfusion Hb thresholds reported in the audit were in keeping with or slightly lower than the suggested thresholds in national guidelines apart from infants off oxygen in the older postnatal age group. However, they indicated that neonatologists are not generally transfusing at a Hb of 12 g/dl on the basis of receiving intensive care alone, stratifying both by age and respiratory status. Ongoing education about the results of randomised trials such as Kirpilani et al and Bell et al should be provided and there is a need for the planned review of the national guidelines to reflect the changing nature of practice and the results of the recent trials.

- For transfusion of infants and children on non-neonatal wards, the median (IQR) post-transfusion haemoglobin values reported in the audit were 10.7 (9.4-11.8) g/dl. Whilst it is difficult to make clear evidenced based statements about what that these levels should be, higher levels than 9 or 10 g/dl may be unnecessary for most clinical situations and increase donor exposure if additional packs of red cells are required.

  We therefore recommend that hospitals should ensure their guidance on target haemoglobin values for these patient groups is clear.

- 74% recipients on non-neonatal wards received only a single red cell transfusion during their admission, and 40% (326/822) of these single episode transfusions occurred on the general paediatric ward. On neonatal units, 61% (202/330) recipients ≥ 1500g at first transfusion and 63% (105/166) with gestational age > 32 wks at birth received only a single red cell transfusion.

  We suggest that, while it is accepted that single transfusions per admission may be appropriate for children such as those on a regular transfusion programme, there is an opportunity to consider if any of these single transfusions are avoidable, thus possibly preventing exposure to any blood components.

Recommendations for future developments

It is planned that the data from this audit will be further analysed in order provide further information about the different patient groups included. This will inform the review of the national guidelines, and also act as the basis of future audits to understand more about some of these patient groups, such as the large proportion on the general paediatric ward. Future re-audits should also focus further on the types of symptoms of anaemia that are used to guide the decisions to transfuse different patient groups and to also define the effect of chronic oxygen deficiency on Hb transfusion thresholds. Following this national comparative audit, individual units may wish to re-audit themselves, particularly focussing on the pre- and post-transfusion Hb levels and the recommendations around documentation and prescriptions.

There is a need for additional randomised trials to extend the work on pre-transfusion Hb thresholds that has been published over the last few years, particularly to investigate the effect on long-term neurodevelopmental outcome. There also needs to be further research to achieve a better understanding of the way to ascribe the benefit of transfusion and to capture the full extent of the adverse outcomes of paediatric red cell transfusion.

Introduction

This report presents the findings from the audit. It is largely organised in the sequence of the questions asked, in common with many other national audits, and therefore the results are not necessarily presented in order of importance. You should take the opportunity to look at your results and consider what they say about your local practice. For the responses to selected questions, where the numbers reported at your centre are small, please take care to ensure that the results are not over-interpreted. In some cases, the messages from the combined national data may be more significant but again please ask yourself if the result is important to you, locally, and what the impact of the result is.

Why is this audit necessary?

BCSH published "Transfusion guidelines for neonates and older children" in 2004. Children are a vulnerable group of transfusion recipients and there is evidence from the UK Serious Hazards of Transfusion (SHOT) national haemovigilance scheme that a disproportionate number of adverse events occur in paediatric recipients, particularly in infants aged less than 1 year (Stainsby et al, 2008, Taylor et al, 2009). A recent publication from an analysis of data at 35 academic children's hospitals in the United States indicated that not only is the administration of blood products to children associated with complications, but that for most paediatric patients receiving a transfusion (69%) only a single transfusion episode during their admission was provided (Slonim et al, 2006). There has been increasing interest in improving the evidence base for red cell transfusion practice for neonates and in paediatric intensive care (Bell et al, 2005; Kirpalani et al, 2006; Lacroix et al, 2007). With these considerations in mind, a first national audit was planned to understand current practice alongside a comparison with some key standards in the guidelines.

What does this audit aim to achieve?

- Ascertain current red cell transfusion practice in children of all ages
- Comment on the appropriateness of transfusion in this patient group
- Compare practice with national recommendations.
- Identify clinical areas where further development may be needed.

Who are the principal stakeholders?

NHS Trusts
Independent hospitals
NHS Blood and Transplant
Medical Royal colleges

Data transparency and data sharing

In line with current practice within national clinical audits, the National Comparative Audit of Blood Transfusion is exploring ways of making key results available to organisations such as the Care Quality Commission (CQC). At present we supply to the CQC the names of those hospitals and NHS Trusts who contribute data to our audits, but we have undertaken not to supply other data. In future, our clinical audit project groups will identify which audit data could be shared, and seek permission for sharing from those hospitals wishing to take part in an audit.

In respect of slideshows, which are produced to accompany each audit report, we continue our practice of identifying participants by name, having obtained consent from those participants to do so. The data of those withholding consent are excluded from the slideshows. The slideshows are distributed to participants and Chairs of Regional Transfusion Committees. We have discontinued the practice of making these slideshows publicly available on the Internet.

Methods

How were NHS Trusts and independent hospitals recruited?
Invitations to participate in the audit were sent to NHS Trusts and independent hospitals in England. Trusts and hospitals in Wales, Northern Ireland and Scotland were invited to participate via nominated contacts within the blood services in those countries.

A letter about the audit was sent from the Clinical Audit Lead to the Hospital Transfusion Team, Medical Director and Clinical Audit Manager in each English NHS Trust, and to managers in independent hospitals.

The clinical audit was developed as two separate parts:

1. Patients on neonatal units: '**neonatal transfusions**' to **'neonatal patients'**
2. Patients on wards other than neonatal units: '**paediatric transfusions'** to **'paediatric patients'**

Sampling strategy
The audit sample came from patients admitted and given their first transfusion during the three month audit period from 1st September to 30th November 2009. Hospitals with a neonatal unit were asked to provide audit data on all red cell transfusions given to the first 20 consecutive patients admitted and transfused during the audit period ('neonatal transfusions'). In addition, the hospitals were asked to audit the first transfusion given to the first 20 consecutive patients treated on wards other than the neonatal unit ('paediatric transfusions').

If a hospital did not have a neonatal unit, they were asked to audit the first 40 consecutive paediatric patients, and conversely, if they did not undertake paediatric transfusions, the first 40 consecutive neonatal patients. Regardless of whether the patient was a neonate or a paediatric patient, hospitals were asked to provide information on how many transfusions (for the purposes of this audit, "transfusion" means all the blood that is written up for transfusion at one particular time) the patient had during their stay until the day they were discharged, transferred to another hospital or died, up to a maximum of three months from the date of admission.

All hospitals were requested to complete an organisational questionnaire.

For the purpose of this audit, the upper age limit was 18 years, to be consistent with the SHOT scheme and the definition of a child as a person under 18 years of age in S65 of The Children Act 2004. A neonate is a child in the first 28 days of life, but for the purposes of the audit a neonatal patient was classified as a patient admitted to a neonatal unit. An infant is taken as being a child up to one year of age.

Data collection method
Data entry was undertaken directly onto the audit tool webpage designed for the purpose.

Pilot
8 hospitals kindly agreed to pilot the audit and during August 2009 completed the organisational audit tool once and tested the patient audit tool on 10 patients.

Analysis and Presentation of results

The report is divided into two sections: on patients admitted to neonatal units - termed ‘neonatal audit’ and on patients transfused on wards other than neonatal units - termed ‘paediatric audit’. The main analysis was descriptive. National results are presented as percentages for categorical data and as median and inter-quartile range (IQR) for numerical data. Missing data are reflected by variation in patient denominators. Individual hospital results are shown alongside the national results, to facilitate benchmarking and guide local implementation of audit recommendations. Some of the ‘Your site’ results are based on small numbers of patients and hospitals need to take account of this when interpreting their own results.

Standards and Criteria

British Committee for Standards in Haematology guidelines

a. BCSH Transfusion guidelines for neonates and older children (2004).
These guidelines emphasised the lack of evidence for many transfusion practices in this age group ('it is impossible to produce clear evidence-based criteria for the administration of red cells in the neonatal period'), but made several suggestions and recommendations which are relevant to this audit. These include:

- It is recommended that local transfusion protocols be established in all neonatal units.
- A formula for determining the volume of packed red cells for top up transfusion in neonates and children:
    - (desired Hb – actual Hb) x weight x 3 (stated as usually 10-20ml/kg).
    - recommended rate of transfusion of red cells approx 5 mls/kg/hr.

Neonatal transfusion indications:

- Suggested transfusion thresholds for infants under 4 months of age

Transfusion of red blood cells
Anaemia in the first 24 hours - Hb 12 g/dl (Hct *ca* 0.36)
Cumulative blood loss in 1 week, neonate requiring intensive care - 10% blood volume
Neonate receiving intensive care - Hb 12 g/dl
Acute blood loss - 10%
Chronic oxygen dependency - Hb 11 g/dl
Late anaemia, stable patient - Hb 7 g/dl

    - Table gives proposals for neonatal red cell audit criteria. These are not transfusion triggers per se, but represent standards against which individual nurseries can assess the appropriateness of their local transfusion practice.

- Other comments regarding indications for neonatal red cell transfusions included:
    - Surrogate markers of (neonatal) anaemia include respiratory irregularities, tachycardia, poor weight gain, lethargy, poor suck and increased blood lactate levels.
    - Neonates with severe pulmonary disease are thought to benefit from a higher haemoglobin or haematocrit, which allows oxygen delivery to be optimised in the presence of underlying respiratory insufficiency.

Other children:

- Thalassaemia major: suggest maintain an average Hb of 12 g/dl and a pre-transfusion Hb of 9-10 g/dl.

- Sickle cell disease: for hypertransfusions maintain sickle haemoglobin below 25% and the Hb between 10.0 and 14.5 g/dl:
    - For top-up transfusions pre- surgery suggested aim Hb 8-10 g/dl.

- For children with aplasia, red cell transfusions are usually reserved for symptomatic patients with Hb <7g/dl, as sensitisation to large numbers of transfusions reduces the chance of as successful outcome:
    - Did not give recommendations for other children with haemopoietic SCT and malignancies as there were no controlled trials upon which to base decisions: said to base decision on clinical judgement taking into account the child's general condition, the presence or absence of bleeding and whether or not there are signs of haematological recovery.

- Cardiac surgery:
    - Evidence is available from adult practice to support acceptance of a lower post-operative Hb level of 7g/dl, which should also be appropriate in children with good post-operative cardiac function. There is no evidence to suggest any benefit from attempting to maintain a postoperative Hb concentration within the normal range.

b. BCSH guideline on the administration of blood components (2009).

This guideline made recommendations as to how blood for children should be prescribed, stating that the prescription should include information on:

- Volume or number of units to be transfused (exact number in mls for paediatric transfusion).
- Time over which each unit is to be transfused (rate or exact length of time over which the specified volume is to be transfused for paediatric transfusions).

The guideline made recommendations on the documentation of the indication and outcome of transfusions:

- Minimum documentation of transfusion episodes in the patient clinical records should include the clinical indication for transfusion and relevant pre transfusion indices.
- An indication of whether or not the transfusion achieved the desired effect (either post transfusion increment rates or improvement in patient symptoms) and details of any reactions to the transfusion should be documented in the patient's notes.

Haemoglobinopathy guidelines

The UK guidelines on haemoglobinopathies in children have a number of recommendations on transfusion, and some of these were relevant to this audit.

a. Sickle cell disease in childhood: Standards and guidelines for clinical care (2006).

These give recommendations on Hb triggers and targets in different types of transfusions for children with sickle cell disease:

- The target for a top-up transfusion for the treatment of acute anaemia is to the steady-state haemoglobin level:
    - simple top-up or additive transfusion may be indicated if there has been an acute fall in haemoglobin, usually to below 5 g/dl

- In monthly top-up transfusions (e.g. for the management of stroke where the haemoglobin S is being maintained < 30%), the target haemoglobin is between 12 and 13 g/dl.
- In partial-exchange transfusions the aim is to reduce the haemoglobin S to less than 30% whilst keeping the haemoglobin between 10-12 g/dl.

b. Standards for the clinical care of children and adults with thalassaemia in the UK (2008).
Haemoglobin levels should be maintained above 9.5-10 g/dl; transfusion interval is usually between 3 and 4 weeks.

Since the publication of these guidelines, a small number of randomised controlled trials have been undertaken and published. The tables below summarise the thresholds compared in the two trials performed in neonatal units, both based on a background of then current guidelines using transfusion thresholds considered acceptable to the participating or faculty neonatologists

1. Bell et al 2005:
A single-centre randomised trial of liberal versus restrictive guidelines for red blood cell transfusion in 100 preterm infants, birthweight 500-1300g. Infants were assigned to either the liberal or restrictive transfusion group and for each group transfusions were given only when the haematocrit fell below the assigned level. In each group, the transfusion threshold levels were assigned depending on the clinical condition as indicated by respiratory status, with threshold levels decreasing with improved status:

While tracheally intubated for assisted ventilation (phase 1), infants in the liberal and restrictive transfusion groups received an RBC transfusion if their hematocrit levels fell to <46% and <34%, respectively. While receiving nasal continuous positive airway pressure or supplemental oxygen (phase 2), their hematocrit levels were kept at >38% and >28%, respectively, and if requiring neither positive pressure nor oxygen (phase 3), they were kept at >30% and >22%, respectively.

The conclusion by the study authors was that both transfusion guidelines in the study were well tolerated but that there were more frequent major adverse neurological events in the restrictive transfusion group.

2. Kirpalani et al (2006)
A multi-centre randomised controlled trial of a restrictive versus liberal transfusion threshold in 451 extremely low birthweight infants, gestational age < 31 weeks, birthweight < 1000g. Infants were assigned within 48 hours of birth to either the liberal or restrictive transfusion group and transfused according to threshold Hb levels on the basis of both postnatal age and respiratory support (respiratory support was assisted ventilation, continuous positive airway pressure, or supplemental oxygen):

Hb threshold levels (g/l) triggering red cell transfusion

		Low threshold		**High threshold**	
Age in days	Blood sampling	Respiratory support	No respiratory support	Respiratory support	No respiratory support
1 -7	Capillary	≤ 115	≤ 100	≤ 135	≤ 120
	Central	≤ 104	≤ 90	≤ 122	≤ 109
8 – 14	Capillary	≤ 100	≤ 85	≤ 120	≤ 100
	Central	≤ 90	≤ 77	≤ 109	≤ 90
≥15	Capillary	≤ 85	≤ 75	≤ 100	≤ 85
	Central	≤ 77	≤ 68	≤ 90	≤ 77

The study reported no statistically significant difference in the composite primary outcome (including death or several forms of severe morbidity) or in pre-planned secondary outcomes, although at later follow-up, a posthoc analysis showed a statistically significant difference in cognitive function (Whyte et al, 2009).

In addition a recent randomised trial was performed in Paediatric Intensive Care Units (the TRIPICU trial, Lacroix et al, 2007).
The trial hypothesis was that a restrictive transfusion strategy with pre-storage leuco-depleted red blood cells in stable ICU children would be “as safe as” a liberal transfusion strategy, and decrease the rate of transfusion without worsening organ dysfunction’. In the multi-centre study 637 stable, critically ill children between 3 days of age and 14 years were enrolled. ‘Stable’ was defined clinically as non- hypotensive and with no recent changes to cardiovascular therapy. Randomisation occurred when haemoglobin concentrations were ≤ 9.5 g/dl within the first week of admission. The restrictive group were transfused if the haemoglobin fell below 7 g/dl, with a with post-transfusion target 8.5g to 9.5g. The liberal group were transfused if the haemoglobin fell below 9.5g, with a post-transfusion target of 11g-12g. 20% of patients included in the study had had cardiac surgery.

There was no difference in the primary outcome (including mortality and new or progressive multiple-organ-dysfunction syndrome), rate of nosocomial infections, numbers requiring mechanical ventilation or length of stay between the two groups. The authors recommended a restrictive transfusion strategy in paediatric patients whose condition is stable in PICU. However, this recommendation excluded pre-term infants, children with severe hypoxaemia, haemodynamic instability, active blood loss, or cyanotic heart disease.

Summary of studies
Arguably, the weight of evidence across these clinical settings does not support the more unrestricted use of red cell transfusion in critically ill neonates and children, and argues against an intuitive desire to raise Hb levels in many situations.

Whether higher thresholds are needed for certain sub-groups of children (e.g. small babies with major co- morbidities) remains unanswered. Moreover, the results from the two neonatal studies provide a degree of caution against further reductions in transfusion triggers in small pre-term babies without further evidence of the effects on long-term neurodevelopmental outcome.

RESULTS OF THE ORGANISATIONAL AUDIT

Your site DID have data included in the organisational audit

Table One	National (146) %	N	Your site
Does your hospital have a neonatal unit? %YES	95	(139)	Yes
Does your hospital transfuse children who are not in a neonatal unit? %YES	96	(140)	Yes
Does your hospital have a policy for the transfusion of red blood cells to neonates? %YES	85	(124)	Yes
If YES, which test result is used as a trigger for transfusion decisions?			
• Haemoglobin level	56	(70/124)	Haemoglobin level
• Haematocrit (Hct)	0.8	(1/124)	
• Both	35	(43/124)	
• Other (test results AND clinical picture)	5	(6/124)	
• Other (reasons other than test results)	3	(4/124)	
Does your hospital have a policy for the transfusion of red blood cells to children? %YES	68	(98/145)	Yes
If YES, which test result is used as a trigger for transfusion decisions?			
• Haemoglobin level	69	(68/98)	Haemoglobin level
• Haematocrit (Hct)	-	(0/98)	
• Both	18	(18/98)	
• Other (test results AND clinical picture)	5	(5/98)	
• Other (reasons other than test results)	5	(5/98)	
• Other (Blank)	2	(2/98)	
Does your hospital have a policy/guidance on minimising the need for transfusion because of excessive / unnecessary testing? %YES	40	(59)	Yes
If YES, is it:			
• Hospital wide?	40	(23/58)	No
• Unit specific (e.g. on neonatal unit only)?	71	(42/59)	Yes
• Does it contain guidance on frequency of blood testing?	68	(40/59)	Yes
• Does it contain guidance on minimising sample volumes?	75	(44/59)	Yes
Do you use analysers designed for low volume for samples from neonates. / small children?	72	(105)	Yes

Denominators apply either to the whole sample of organisations or to subsets of the whole if questions were nested. Missing data are reflected by reductions in patient denominators.

Key points:

- Almost all responding hospitals had a neonatal unit and a paediatric unit.
- The majority (85%) of hospitals reported the existence of a policy for neonatal red cell transfusion, but only 68% reported one for transfusions to children, which could affect patient safety.
- Triggers for transfusion decisions in these policies were almost entirely based on the haemoglobin concentration (Hb) or Hb plus haematocrit (Hct), with only a few including the clinical picture in addition.
- 40% of policies had guidance on minimising excessive/unnecessary blood testing.
- 72% of hospitals reported using laboratory analysers designed for low volume for samples from neonates/small children, important in reducing the need to transfuse to replace blood taken for testing.

RESULTS OF THE CLINICAL AUDIT

Nature and size of the overall audit case sample

Data provided by the Royal College of Paediatrics & Child Health suggests that there are 247 hospitals in the UK which treat either children or neonates. Of these, 160 (65%) were represented in this audit. However, since participants had a choice of contributing data either as individual hospitals or as part of a group of hospitals within a Trust, data from all 160 hospitals was provided from 141 sites.

Further work will be done on capturing demographic data for the audit period, including information on the total numbers of patients admitted to neonatal units and paediatric wards, and what percentage of those received a red cell transfusion. Findings from this further work will be analysed in conjunction with the clinical audit data gathered for this report, and a supplementary report will be produced.

In total, 2524 cases were submitted to the audit, from 141 sites, with an overall median 15 cases per site (IQR 8-24 per site).

There were 1302 paediatric patients from 119 sites, median 7 IQR 4-16 per site.

Your hospital contributed data on 4 case(s) to the paediatric audit

There were 1222 neonatal patients from 125 sites, median 8 IQR 4-15 per site.

Your hospital contributed data on 5 case(s) to the neonatal audit

RESULTS OF THE CLINICAL AUDIT – PAEDIATRIC AUDIT

The total audit dataset comprised transfusion details of 2524 patients, of whom 1302 were patients transfused outside the neonatal unit. This section describes the findings for this 'paediatric' group.

Your hospital contributed data on 4 case(s) to the paediatric audit

1 Pre-transfusion patient clinical characteristics

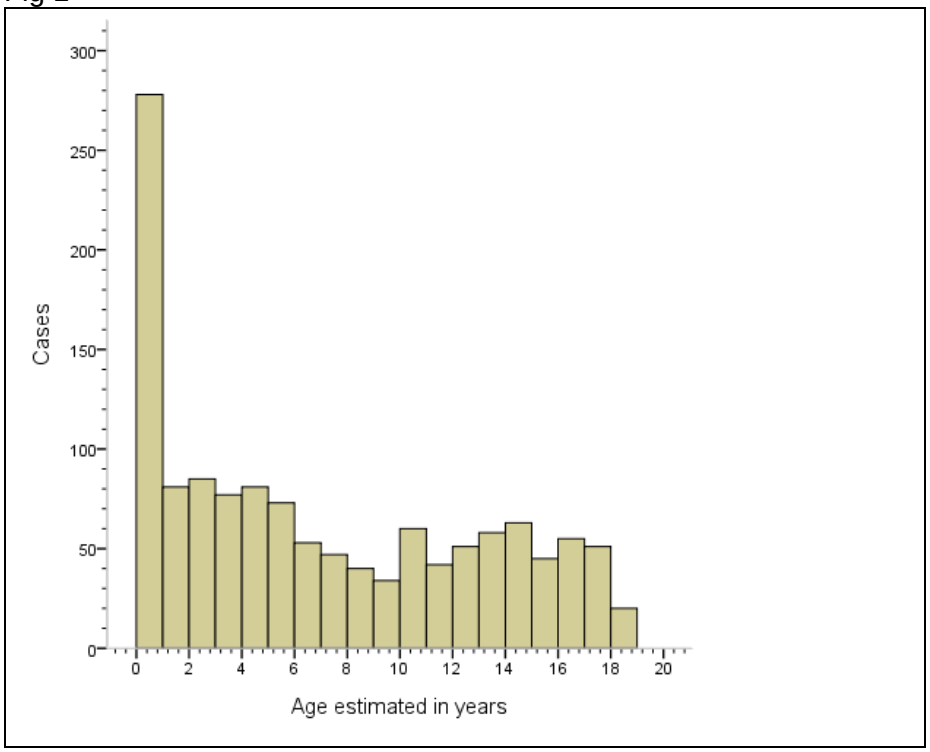
1.1 Patient's age

The median (IQR) age of the audit patients was estimated at 5 (1-12) years for 1294/1302 patients. 78% (1021) transfusion recipients were 1 year or older, and 21% (279) were less than 1 year (2 not known). 8% (102) transfusion recipients were less than 1 month, and 14% (177) were aged >1month but <1year.

Gestational age at birth was known for 235 of those aged less than 1 year, with 28 born under 30 weeks, 23 at 30-34 weeks, 25 at 35-36 weeks, 45 at 37-38 weeks, 23 at 39 weeks, 77 at 40 weeks and 14 at 41-42 weeks.

Histograms showing the variation in estimated age of patients are shown below.
Age has been estimated in years or as a proportion of a year using either number of months or number of days. To obtain a 'numerical' age variable the year of birth was subtracted from year 2009 and the number of months was divided by 12.

Fig 1



.Age estimated in years. Median 5 years, IQR 1-12 years, range from the day of birth to 18.0 years.

Fig 2

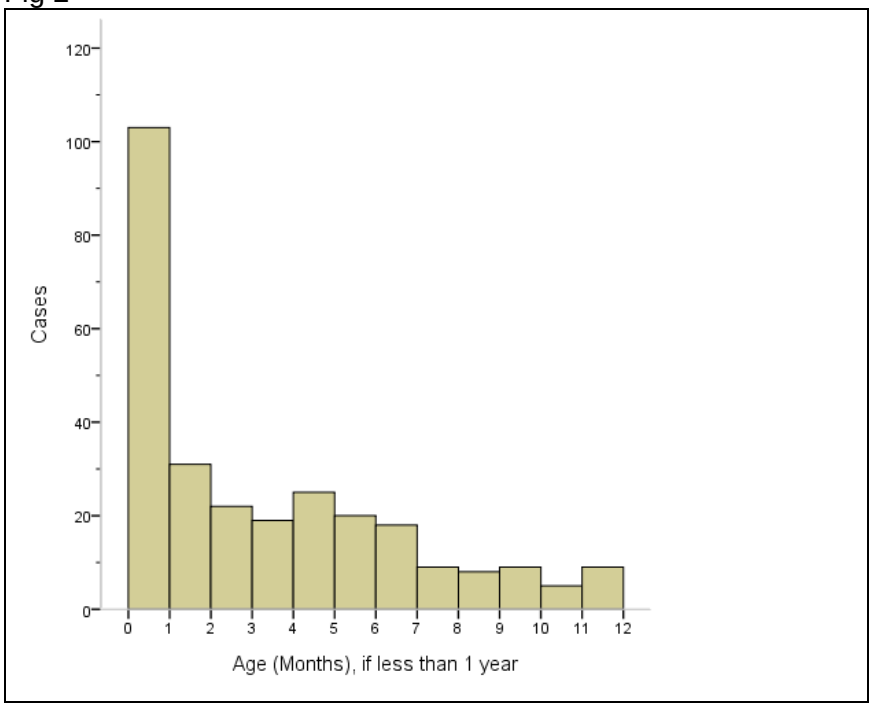
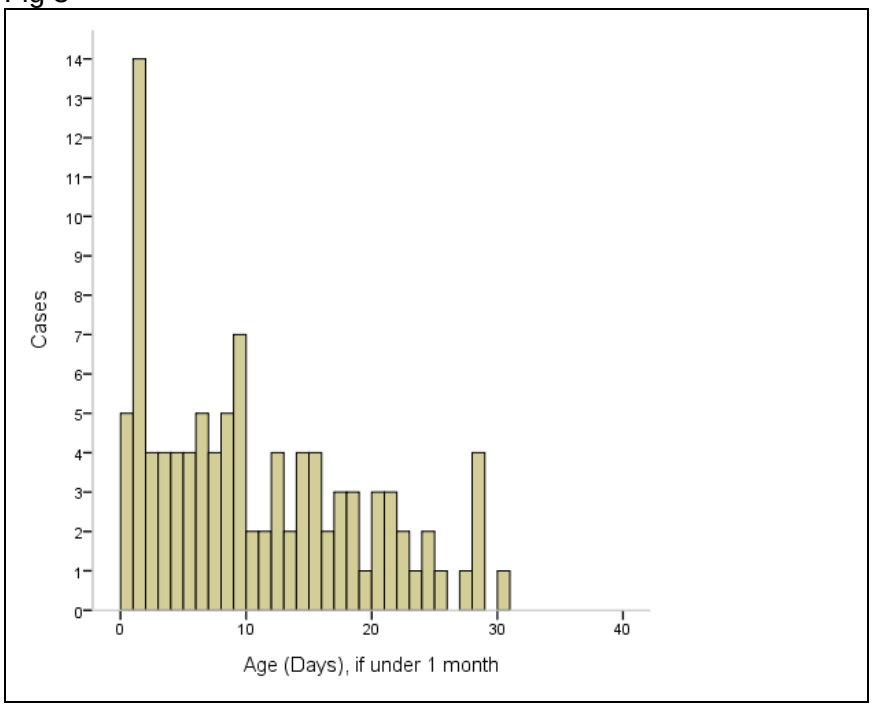

Cases
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12
Age (Months), if less than 1 year

Fig 3


Cases
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0 10 20 30 40
Age (Days), if under 1 month

1.2 Location of the patient when they were transfused

Table Two – Patient location	National (1302)		Your site (4)	
	%	N	%	N
Paediatric Intensive Care Unit	12	(154)	0	0
Haematology/Oncology/Bone Marrow Transplant Ward	15	(192)	0	0
Day care ward	16	(208)	0	0
General Paediatric ward	33	(436)	50	2
Paediatric Surgical ward	4	(47)	0	0
Theatre	14	(180)	0	0
Recovery	0.2	(3)	0	0
A & E	0.5	(6)	0	0
Adult ward	1	(13)	0	0
Other*	5	(63)	50	2

- Other locations were cardiac (12), high dependency/intensive care (21), renal (11), obstetric (11) and miscellaneous (8).

Key points:

The most common location for transfusion was the General Paediatric Ward (33%).

Most other red cells transfusions occurred on PICU, Haematology/Oncology/Bone Marrow Transplant Ward, Day care ward, or Theatre.

1.3 Underlying reason for admission before transfusion

Table Three - Underlying reason for admission	National (1302)		Your site (4)	
	%	N	%	N
Leukaemia / Cancer	28	(363)	25	1
Haemoglobinopathy	20	(263)	0	0
Problems related to prematurity	3	(34)	50	2
Problems relating to term infants	1	(13)	25	1
Bone Marrow Transplant	1	(13)	0	0
Obstetric	1	(12)	0	0
Medical				
Infection/sepsis	6	(77)	0	0
Renal disease	1	(14)	0	0
Liver disease	0.5	(6)	0	0
Surgical				
Cardiac	12	(161)	0	0
Orthopaedic	4	(56)	0	0
Neurology	1	(15)	0	0
Urology/Renal	1	(12)	0	0
Necrotising enterocolitis	0.2	(3)	0	0
Trauma	2	(25)	0	0
General surgery	3	(44)	0	0
Other categories				
Other *	15	(189)	0	0
Not stated	0.2	(2)	0	0

***** Other were craniofacial/general surgery (7), GI tract (46), metabolic (6), non-malignant haematology (52), miscellaneous (78)

Key points:

- 48% of patients transfused outside neonatal units had a haematological/malignant diagnosis (leukaemia/cancer, haemoglobinopathy) as the main underlying reason for their admission, suggesting a need for local transfusion guidelines specific to these patient groups.
- 24% of patients transfused were surgical patients, in particular those having cardiac surgery.

Locations of transfused patients were also analysed by underlying reason for admission and by patient age (tables not shown).

Key points:

Underlying reasons for admission for patients transfused in different locations

- On the day care ward, 62% [129/208] transfusions were for patients with haemoglobinopathies.

- On the haematology/oncology wards, 74% [142/192] transfusions were for patients with leukaemia/cancer and 16% [31/192] were for haemoglobinopathy patients.

- On the general paediatric wards, the patient population was more mixed although common patients groups included leukaemia/cancer 36% [156/436], and haemoglobinopathy 20% [87/436].

- On PICU, the main groups of transfused patients were cardiac 38% [58/154] and infection/sepsis (18% [27/154].

- On surgical wards, 45% [21/47] transfused patients had general surgical or orthopaedic problems.

- For patients transfused in theatres, 51% [91/180] had a cardiac reason for admission and 18% [30/180] were orthopaedic patients.

Locations of transfused patients of different age groups

- 21% (279/1302) transfusions to children on wards other than the neonatal unit were to infants less than a year of age.

- Of all infants receiving transfusions, 37% (102/279) were less than one month old. These patients < 1 month were mostly either in PICU (36% [37/102]), Theatre (39% [40/102]), or on a general paediatric ward (10% [10/102]). 54% (55/102) had a cardiac surgical underlying reason for admission, and 19% (19/102) had problems related to prematurity or term infants.

- Infants > 1 month but < 1 year (177), were also mainly on PICU (31% [55/177]), Theatre (29% [51/177]), or the general paediatric ward (24% [42/177]). Again cardiac surgery was a major underlying reason for admission (34% [60/177]), but others included problems related to prematurity or term infants (15% [26/177]), infection/sepsis (10% [17/177]), general surgery (8% [14/177]), and leukaemia/cancer/haemoglobinopathy (14% [24/177]).

- For children > 1 year (1021), the majority were on the general paediatric ward (38% [383/1021), Day care (19% [195/1021]), or the Haematology/Oncology/Bone Marrow Transplant ward (18% [185/1021]). Leukaemia/Cancer was the most common underlying reason for admission (34% [346/1021]), with 25% (251/1021) having haemoglobinopathy. 16% (162/1021) had a surgical reason for admission.

1.4 Main reason why the red cell transfusion was given

Table Four – Main reason why transfusion was given	National (1302)		Your site (4)	
	%	N	%	N
Anaemia with symptoms	33	(431)	**75**	**3**
Anaemia without symptoms	18	(231)	**0**	**0**
Bleeding	13	(165)	**0**	**0**
Chronic transfusion programme	17	(217)	**0**	**0**
Exchange transfusion for other reason e.g. anaemia sickle cell disease	2	(22)	**0**	**0**
Pre-operatively	2	(25)	**0**	**0**
Other *	10	(135)	**25**	**1**
Don't know / Blank	6	(76)	**0**	**0**

* Other were 'other anaemia' (26), peri-operatively (17), miscellaneous (92)

Key points:

For just over half of the transfusions, anaemia was reported as the main reason for transfusion (with or without symptoms). In 35% (231/662) cases with anaemia, no symptoms of anaemia were documented.

Chronic transfusion programmes accounted for 17% transfusions.

13% transfusions were given for patients with bleeding, but no further information was collected on the severity or type of bleeding.

Only 2% transfusions were given pre-operatively.

1.5 Respiratory status at the time of the transfusion

Knowing the respiratory status of a child is key in helping to understand the reasons why red cell transfusion may be given. The audit asked if patients were either mechanically ventilated, on Continuous Positive Airway Pressure (CPAP) therapy, or on supplementary oxygen.

Table Five – Respiratory status	National (1302) %	N
• Mechanically ventilated	24	(307/1300)
• On CPAP *(but not mechanically ventilated)*	2	(20/1295)
• On supplementary Oxygen *(but not mechanically ventilated or on CPAP)*	4	(52/1248)
ANY OF THE ABOVE	30	(379/1248)
OFF OXYGEN	70	(869/1248)

Table denominators exclude Blank/unknown responses.

Key points:

70% patients receiving red cell transfusions were not on any form of oxygen support, and this may be something that should be considered for those with symptomatic anaemia or who are bleeding.

24% patients were mechanically ventilated (and further analysis revealed that 272/307 [89%] of these were in PICU or theatres).

2 Pre- and Post transfusion Hb testing

It is accepted that the need for red cell transfusion should be guided by the interpretation of appropriate laboratory results, including pre- and post transfusion Hb and Hct. Information was requested on timing of these tests, within a week pre-transfusion, and any time after transfusion.

2.1 Results for Hb and Hct

Table Six – Hb/Hct tests	National (1302)		**Your site (4)**	
	%	N	**%**	**N**
Pre-transfusion Hb done	96	(1256)	**50**	**2**
Pre-transfusion Hct done	86	(1117)	**50**	**2**
BOTH	85	(1112)	**50**	**2**
NEITHER /NOT KNOWN	3	(41)	**50**	**2**
Post-transfusion Hb/done	82	(1074)	**100**	**4**
Post-transfusion Hct done	74	(965)	**100**	**4**
BOTH	74	(965)	**100**	**4**
NEITHER /NOT KNOWN	18	(228)	**0**	**0**

Key points:

96% patients transfused outside neonatal units had a documented Hb result taken up to a week pre-transfusion.

82% had a Hb taken at some stage post-transfusion. Up to 18% appear to have had no post-transfusion Hb.

There were only 5 cases where a pre- or post- transfusion Hct was recorded alone without the Hb.

Table Seven – Timing of tests	National (1302)	
	%	N
Pre-transfusion		
Same day	58	(750)
Day before	25	(325)
2 days before	10	(125)
More than 2 days but less than 1 week before	3	(44)
None of the above	2	(26)
Don't know	2	(32)
Post-transfusion		
Same day	27	(355)
Day after	30	(392)
2 days after	7	(92)
More than 2 days after	18	(234)
Not done	13	(175)
Don't know	4	(54)

Key points:

The majority (83%) had a pre-transfusion Hb taken either on the day of transfusion or the day before.

57% of transfused cases had the post-Hb checked by 2 days after transfusion.

Further results indicated that near patient testing was used for 15% (114/750) of pre-transfusion tests and 28% (99/355) of post transfusion tests taken on the same day of transfusion. This has the advantage of using small volumes and giving an immediate result. Near patient testing was used for very few tests taken at other times, suggesting that it was used primarily for acute monitoring of Hb only.

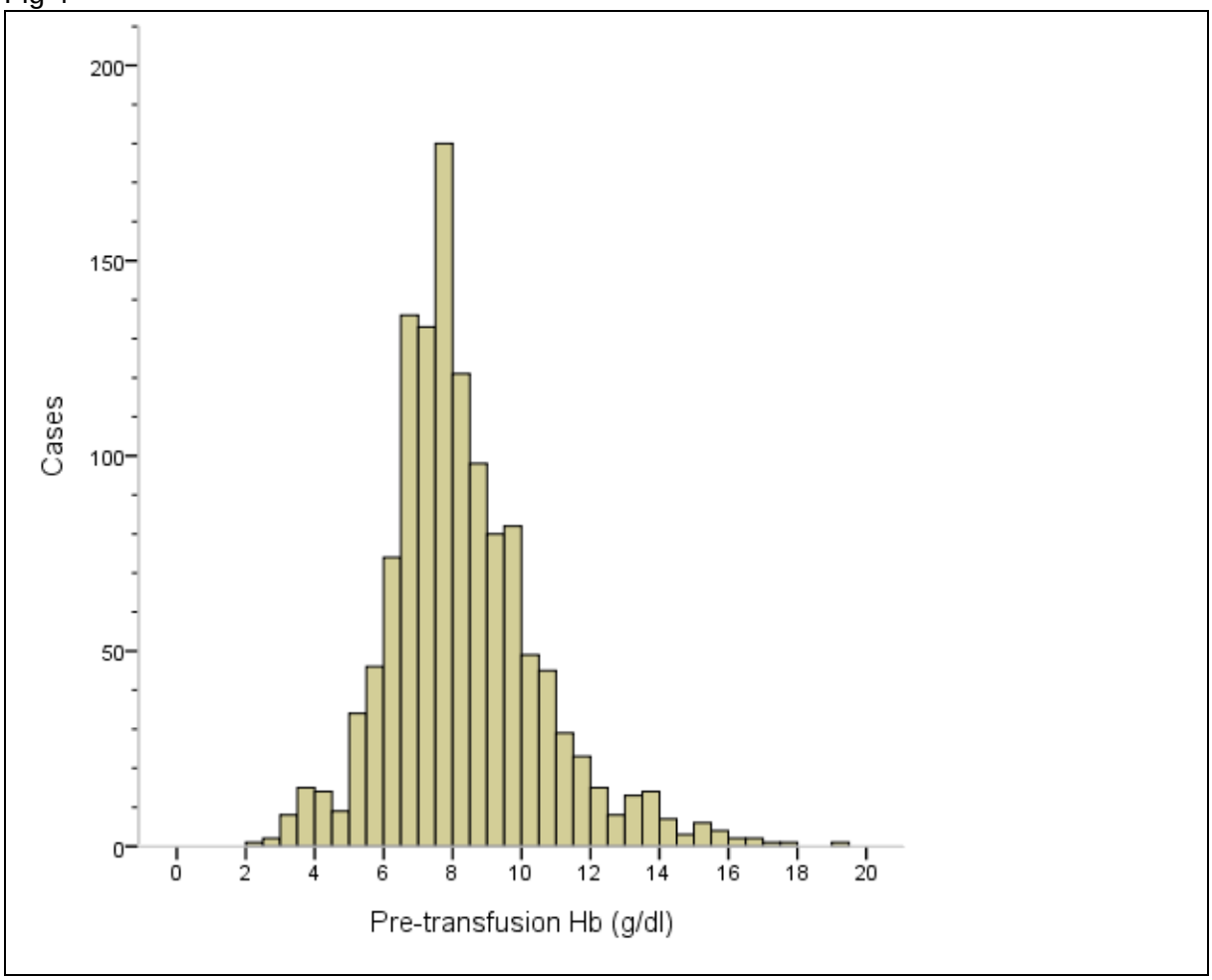
3 Haemoglobin concentration related to transfusions

3.1 Pre- and post transfusion haemoglobin values

The Median (IQR) of pre- transfusion Hb values was 7.9 g/dl (6.9-9.4), n=1256 and the median (IQR) of post transfusion Hb values was 10.7 g/dl (9.4-11.8), n=1074

The histogram below shows the spread of all pre-transfusion Hb concentrations

Fig 4



3.2 Changes in haemoglobin concentration before and after transfusion.

The tables below summarises the pre- and post transfusion results for different subgroups of children receiving a red cell transfusion outside the neonatal unit.

Main reason for transfusion

Table Eight **Main reason why transfusion was given**	National (1302) – All Hbs are shown in g/dl			
	Pre-Transfusion Hb		Post-Transfusion Hb	
	N	Median (IQR)	N	Median (IQR)
Anaemia with symptoms	426/431	7.2 (6.3-8.0)	393/431	10.5 (9.1-11.6)
Anaemia without symptoms	228/231	7.6 (6.7-8.1)	202/231	10.8 (9.5-11.8)
Bleeding	151/165	8.6 (7.1-11.0)	146/165	10.8 (9.7-11.9)
Chronic transfusion programme	214/217	9.2 (8.4-9.9)	103/217	10.0 (9.4-11.2)
Exchange transfusion for other reason e.g. anaemia sickle cell disease	21/22	9.0 (7.1-9.9)	14/22	9.7 (9.2-10.6)
Pre- operatively	25/25	8.5 (7.2-11.7)	23/25	10.1 (9.6-12.1)
Other	126/135	9.4 (7.6-11.2)	125/135	11.1 (9.8-12.8)
Don't know / Blank	65/76	10.0 (7.8-12.5)	68/76	11.5 (10.6-13.1)

Respiratory status at time of transfusion

Table Nine **Respiratory status**	National (1302) – All Hbs are shown in g/dl			
	Pre-Transfusion Hb		Post-Transfusion Hb	
	N	Median (IQR)	N	Median (IQR)
• Mechanically ventilated	278/307	9.6 (7.8-11.8)	292/307	11.5 (10.2-12.8)
• On CPAP *(but not mechanically ventilated)*	19/20	8.5 (7.9-10.5)	20/20	11.4 (10.1-13.5)
• On supplementary Oxygen *(but not mechanically ventilated or on CPAP)*	50/52	7.3 (6.6-8.4)	47/52	9.9 (8.2-11.4)
ANY OF THE ABOVE	347/379	9.0 (7.5-11.3)	359/379	11.3 (10.0-12.5)
OFF OXYGEN	857/869	7.7 (6.8-8.9)	670/869	10.4 (9.3-11.5)

Patient location

Table Ten **Patient location**	National (1302) – All Hbs are shown in g/dl			
	Pre-Transfusion Hb		Post-Transfusion Hb	
	N	Median	N	Median
Paediatric Intensive Care Unit	150/154	8.4 (7.4-9.9)	151/154	11.2 (10.0-12.8)
Haematology/Oncology/Bone Marrow Transplant Ward	191/192	7.6 (6.9-8.2)	172/192	10.7 (9.4-11.5)
Day care ward	207/208	8.9 (7.7-9.8)	125/208	10.2 (9.1-12.0)
General Paediatric ward	429/436	7.3 (6.3-8.2)	348/436	10.4 (9.1-11.4)
Paediatric Surgical ward	45/47	7.6 (6.7-9.0)	35/47	10.1 (8.9-11.1)
Theatre	153/180	10.5 (8.2-12.7)	173/180	11.5 (10.3-12.5)
Recovery	3/3	7.4 (-)	3/3	10.2 (-)
A & E	5/6	7.3 (-)	5/6	8.1 (-)
Adult ward	13/13	7.2 (6.1-9.2)	11/13	9.8 (8.8-12.0)
Other	60/63	7.8 (6.6-10.3)	51/63	10.2 (9.4-11.4)

Key points :

Pre-transfusion

- Pre-transfusion Hb varied, with median values of 7.2, 7.6, and 8.6g/dl respectively in anaemic patients with and without symptoms and in patients with bleeding.
- Patients on chronic transfusion programmes had a median pre-Hb of 9.2 g/dl and a post of 10.0 g/dl.
  179/217 (82%) of these were haemoglobinopathy patients.
- For patients who were mechanically ventilated the median pre-transfusion Hb was 9.6 g/dl, and for those patients on supplementary oxygen but not ventilated or on CPAP it was 7.3 g/dl.
- Median pre-transfusion Hb values in PICU, were 8.4 g/dl, of which 102/149 (68%) were ventilated.
- Median pre-transfusion Hb values were 8.9 g/dl on day care wards. Median pre transfusion Hb values were 7.6 g/dl on Haematology/Oncology/Bone Marrow Transplant wards and on surgical wards.
- Median pre-transfusion Hb value in theatre was 10.5 g/dl (with the majority [94%, 144/153] being mechanically ventilated patients). This is surprisingly high and may be related to concerns about anticipated haemorrhage; it is not in keeping with more restrictive transfusion practices elsewhere.

Post-transfusion

- Median post transfusion Hb concentrations were generally between 10 – 11g/dl.
- Marginally higher post transfusion Hb concentrations (> 11g/dl) were documented in children mechanically ventilated/on CPAP, in children on PICU, and in theatre.

Increments of Hb

- Further analysis indicated that for 734/1302 transfusions, Hb results were available within 2 days pre and post transfusion. For these cases, the post Hb minus pre Hb was a median of 2.8 g/dl (IQR 1.4 – 3.9). The median increment change in Hb was 1.7g/dl (IQR 0.3-3.3) for 115 patients with bleeding.

4 The prescription of red cells

4.1 Form of red cells prescribed

Information was requested on whether red cells were prescribed in either millilitres (mls), paedipacks or units.

Table Eleven– Red cell prescription	National (1302) %	N	**Your site (4) %**	**N**
Known	97	1264	**100**	**4**
Prescribed*:				
• mls	59	(740/1264)	**75**	**3**
• Paedipacks	4	(49/1264)	**0**	**0**
• Units	39	(493/1264)	**25**	**1**

*In 18 cases more than 1 type was prescribed

The table below presents information on red cells prescriptions in either mls, paedipacks or units by bodyweight and age.

Table Twelve	National (1302)						
	Weights Kg		Age (years)		Age (months)		
	N	Median (IQR)	N	Median (IQR)	<1m	1-11m	12m+
Mls	705/740	14.4 (7.0-23.5)	736/740	3.0 (0.7-7.0)	10% (72)	19% (137)	72% (530)
Paedipacks	47/49	3.9 (3.0-6.7)	48/49	0.3 (0.03-0.9)	33% (16)	44% (21)	23% (11)
Units	424/493	33.7 (18.1-51.9)	490/493	12.0 (5.0-15.0)	3% (17)	4% (19)	93% (457)

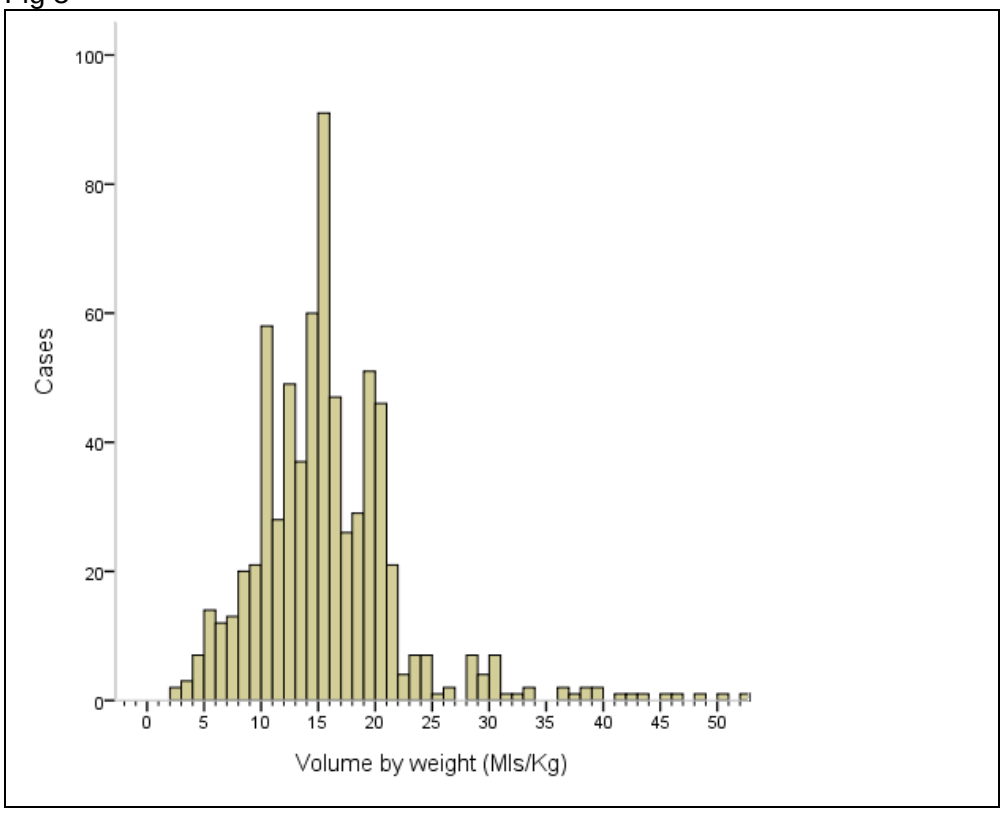
Key points:

- Prescribing by units occurred for 39% paediatric transfusions, with a recipient median age of 12 years and median weight of 33.7 kg. It occurred at all ages, but most commonly in children over 12 months.
- Further analysis indicated that prescribing by units occurred in all locations (data not shown).
- Prescribing as mls occurred for 59% of all transfused cases, with a recipient median age of 3 yrs, and median weight of 14.4.kg.
- A minority (4%) of transfused cases were prescribed as paedipacks, largely to patients < 1 yr of age (77%).

4.2 Volume of red cells prescribed

For those cases where the volume was prescribed in millilitres and the weight was known (705), the histogram below illustrates the variation in transfusion volumes/kg weight prescribed, omitting 13 outliers beyond 50mls/kg (who were prescribed a median of 65 mls/kg [range 52-145]).

Fig 5



Key points:

- The overall median volume prescribed was 15.0 mls/Kg, IQR 11.8-19.2, n=705.
- 13% (92/705) of prescriptions were <10.0 mls/Kg and 17% (119/705) were >20.0mls/Kg.
- The median volume prescribed for 76 patients because of bleeding was 14.5 mls/kg (IQR 10.0-19.6).
- Further analysis indicated that a common median prescription volume of approximately 15 mls/kg was reported across all patient sub-groups, with little difference by main reason for transfusion (e.g. bleeding or not), or location (apart from in theatre when the median transfusion volume was 19.1 mls/kg; n=82).

4.3 Was transfusion completed as prescribed?

In 92% (1201/1299) cases the transfusion was completed as prescribed (data not shown).

5 Total number of transfusion episodes during the patient's admission

For 1110 of the 1302 cases auditors entered the total number of transfusion episodes during the patient's admission (up to a maximum of 3 months), and the results are shown below.
For the 1110 cases there were a total of 1859 transfusion episodes.

Table Thirteen - Number of transfusion episodes during admission	National (1302)		**Your site (4)**	
	%	N	**%**	**N**
Known	85	(1110)	**100**	**4**
If known:				
• 1 episode	74	(822)	**25**	**1**
• 2 episodes	13	(139)	**50**	**2**
• 3-4 episodes	8	(88)	**0**	**0**
• 5-9 episodes	4	(48)	**0**	**0**
• 10-19 episodes	1	(13)	**25**	**1**

Key points

- 74% recipients received only a single red cell transfusion during this patient's admission (up to a maximum of 3 months).
- 40% (326/822) of the single episode transfusions occurred on the general paediatric ward.
- In all locations, the most common number of transfusions per admission was one.

6 Evidence of beneficial effect of transfusion

Good practice dictates that following a transfusion a note should be made in the patient's records as to if the transfusion had a beneficial effect, and what that effect was. For the transfusions audited in paediatric settings, details of a beneficial effect were reported in17.7% (230/1302) and have been classified into the table below, using categories derived from analysis of the raw comments:

Table Fourteen - Benefit of transfusion	National (230)	
	%	N
Increased Hb	37	86
Reduced symptoms	10	23
Reduced need for oxygen	5	11
Improved colour	14	33
Patient generally better	33	77

END OF PAEDIATRIC AUDIT RESULTS

RESULTS OF THE CLINICAL AUDIT – NEONATAL AUDIT

Details of 2718 transfusions from 1222 neonatal patients were submitted for the neonatal audit. There were 586 cases with one audited transfusion episode, 249 with two, 387 with three or more episodes, median 2 (IQR 1-3) episodes per case.

The median (IQR) number of transfusion episodes reported to have taken place during the admission was 2 (1-4), n=1058. This number is calculated from the reported total number of transfusions given during the 3 month audit period, and is not the same as the total number of transfusions audited.

All the data is presented for the first transfusion unless otherwise stated.

Note: Only patients transfused on neonatal units are included in the neonatal category, so some babies from neonatal units may be included in the paediatric group if their first transfusion was in another clinical area such as theatre or paediatric intensive care.

Your hospital contributed 5 cases to the neonatal audit, with 11 episodes audited

1 Pre-transfusion patient clinical characteristics

1.1 Patient's age

Understanding transfusion practice is made easier with knowledge of the patient's age, and if less than 1 year old at the time of transfusion, their gestational age at birth. For the first transfusion given on a neonatal unit, the median postnatal age of recipients was 11 days IQR 2-30 days n=1188/1222 and their median (IQR) gestational age at birth was 27 (26-30) weeks, n=1194.

73% (898) of patients transfused on the neonatal unit were aged < 1 month at first transfusion, 25% (307) were aged >1month but <1year and 1 patient was stated as 1 year or older, unknown for 16.

The median postnatal age for *all* transfusions on the neonatal unit including the first transfusion was 16 days, IQR 5-30 days, n=2677 transfusions, not known for 4.

Histograms showing postnatal age at first transfusion

Fig 6

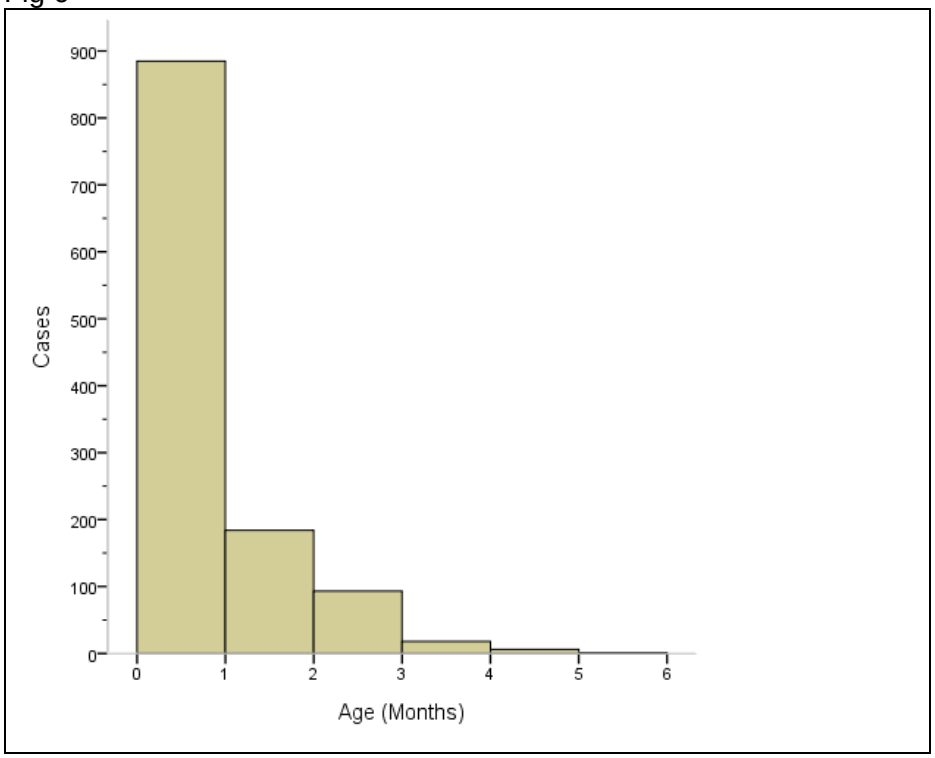
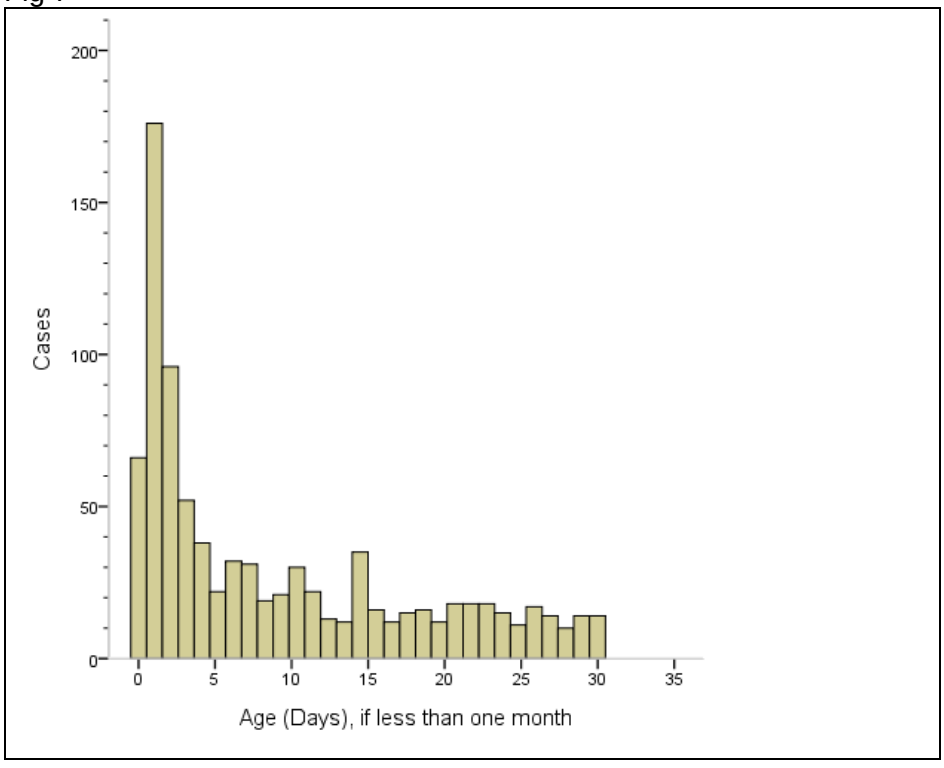


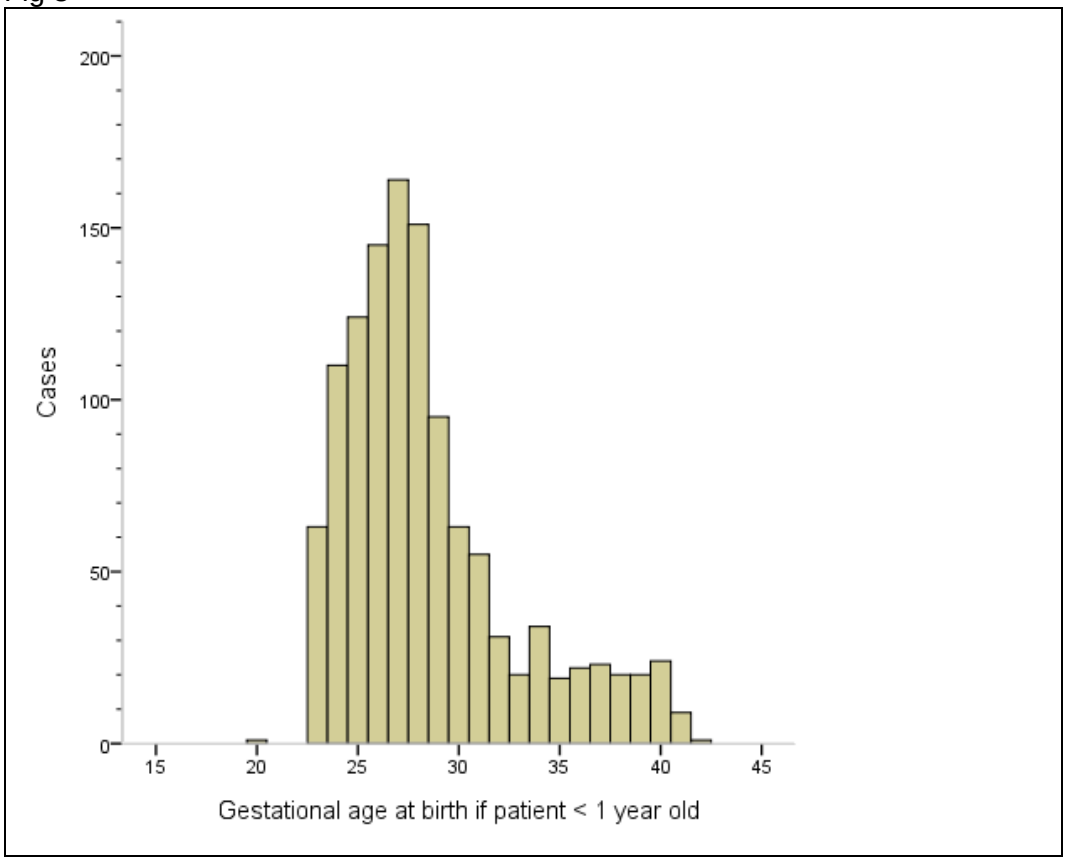
Fig 7



1.2 Gestational age at birth

The median (IQR) gestational age at birth was 27 (26-30) weeks, n=1194, and the majority (81%, 971) of first transfusions were given to infants born at gestational ages < 32 weeks. *Note*: outlying value at 20 weeks may be a data error as the infant would be unlikely to be physically viable.

Fig 8



Patient's weight

Weights were known for 98% (1193) and the median (IQR) weight was 1.18 (0.84-1.80) kilograms.

1.3 Underlying reason for admission

The majority (86%, 1056) of infants transfused on neonatal units were admitted with problems related to prematurity. **YOUR SITE: 80% (4/5)**

The other main reasons were problems relating to term infants (6%, 74) infection/sepsis (2%, 19), general surgery (2%, 21), and necrotising enterocolitis (1%, 15).

1.4 Main reason why the initial red cell transfusion was given.

Table Fifteen – Main reason why transfusion was given – First transfusion only	National (1222)		**Your site (5)**	
	%	N	**%**	**N**
Anaemia with symptoms	60	(734)	**80**	**4**
Anaemia without symptoms	21	(251)	**0**	**0**
Bleeding	5	(67)	**0**	**0**
Exchange transfusion for hyperbilirubinaemia	1	(14)	**0**	**0**
Exchange transfusion for other reason e.g. anaemia sickle cell disease	0.1	(1)	**0**	**0**
Pre- operatively	1	(14)	**0**	**0**
Other*	6	(68)	**20**	**1**
Not known	6	(73)	**0**	**0**

*Other comprises: 'Other anaemia' (22), Miscellaneous (11), Policy (5), Post-operative (4), Respiratory Distress (6), Sampling (9), Sepsis (11).

Key points:

- Most first transfusions were given for anaemia, with (60%) or without (21%) symptoms.
- Only 5% were for bleeding and 1% were exchange transfusions for hyperbilirubinaemia.

1.5 Respiratory status at the time of the transfusion

Knowing the respiratory status of a neonate is key in helping to understand the reasons why red cell transfusion may be given, and the audit asked if patients were either mechanically ventilated, on Continuous Positive Airway Pressure (CPAP) therapy, on supplementary oxygen . There was also a question asking if patients were chronically oxygen dependent (defined as requiring oxygen at 36 weeks old corrected for gestational age) but the data from this question proved inconclusive.

Table Sixteen – Respiratory status	National (1222)	
Initial transfusion	%	N
• Mechanically ventilated	49	(597/1219)
• On CPAP *(but not mechanically ventilated)*	26	(318/1217)
• On supplementary Oxygen *(but not mechanically ventilated or on CPAP)*	11	(133/1203)
ANY OF THE ABOVE	87	(1048/1203)
OFF OXYGEN	13	(155/1203)

Table denominators exclude Blank/unknown responses

Key points:

- The majority of infants (75%) were either mechanically ventilated or on CPAP at the time of their first transfusion.
- Only 13% were off all oxygen.

2 Pre- and Post transfusion Hb testing

It is accepted that transfusion should be guided by the interpretation of appropriate laboratory results, including pre- and post transfusion Hb and Hct. Information was requested on timing of these tests, within a week pre-transfusion, and any time after transfusion.

2.1 Results for Hb and Hct

Table Seventeen – Hb/Hct tests Initial transfusion	National (1222)		**Your site (5)**	
	%	N	**%**	**N**
Pre-transfusion Hb done	97	(1185)	**100**	**5**
Pre-transfusion Hct done	87	(1068)	**100**	**5**
BOTH	87	(1065)	**100**	**5**
NEITHER /NOT KNOWN	3	(34)	**0**	**0**
Post-transfusion Hb/done	92	(1127)	**80**	**4**
Post-transfusion Hct done	84	(1024)	**80**	**4**
BOTH	83	(1018)	**80**	**4**
NEITHER /NOT KNOWN	7	(89)	**20**	**1**

Key points:

- 97% patients had documented Hb taken up to a week pre-transfusion.
- 92% had a Hb taken at some stage post-transfusion. Up to 8% appear to have had no post-transfusion Hb.

For the first transfusion, there was only 1 case where a pre-transfusion or post- transfusion Hct was recorded alone without the Hb, and 6 where a post- transfusion Hct was recorded alone.

2.2 Timing of tests

Table Eighteen – Timing of tests	National (1222)	
INITIAL TRANSFUSION	%	N
Pre-transfusion		
Same day	76	(925)
Day before	18	(225)
2 days before	2	(26)
More than 2 days but less than 1 week before	1	(12)
None of the above	1	(14)
Don't know	2	(20)
Post-transfusion		
Same day	22	(264)
Day after	40	(488)
2 days after	16	(189)
More than 2 days after	16	(192)
Not done	3	(39)
Don't know	4	(50)

Key points:

- Almost all (94%) patients had a pre-transfusion Hb taken either the day of transfusion or the day before.
- The post-transfusion Hb was taken over a longer period of time, which may have been appropriate to the patient's clinical status. The majority (78%) had the post-Hb checked by 2 days after transfusion.
- From data from the initial transfusion, near patient testing was used on the day of transfusion for 6% (59/925) of pre-transfusion Hbs and 17% (46/264) of post-transfusion Hbs, and for occasional tests at later times. This is a lower percentage than for patients transfused on wards other than the neonatal unit.

3 Haemoglobin values related to transfusions

3.1 Pre- and post-transfusion Hb and Hct

The median (IQR)of pre-transfusion Hb values for the first transfusion were 9.7 (8.1-10.9) g/dl, n=1185, and the median (IQR) post-transfusion Hb values for the first transfusion were 12.6 (11.5-14.0) g/dl, n=1127.

Fig 9

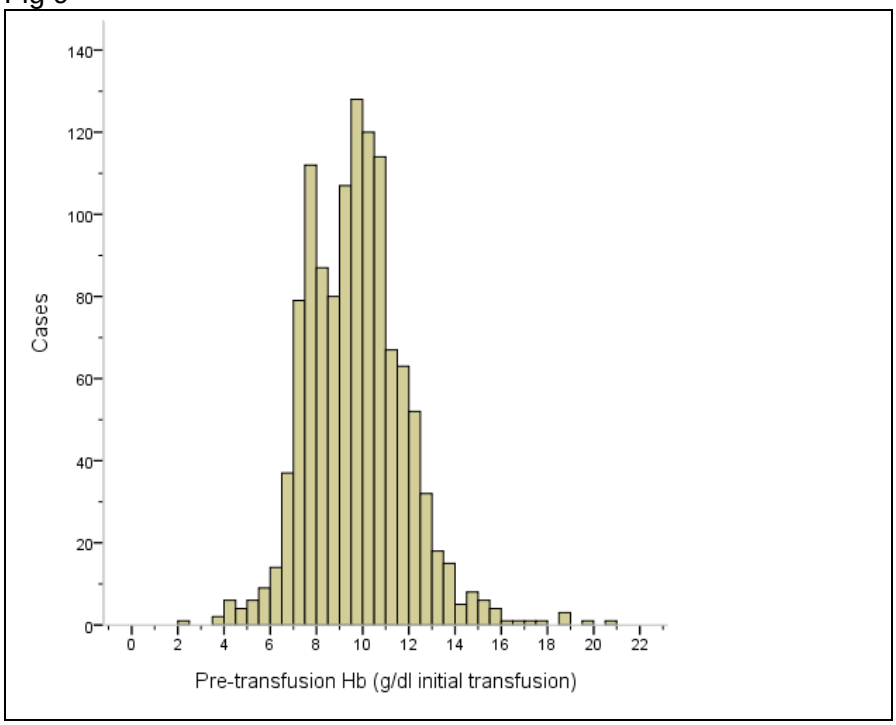
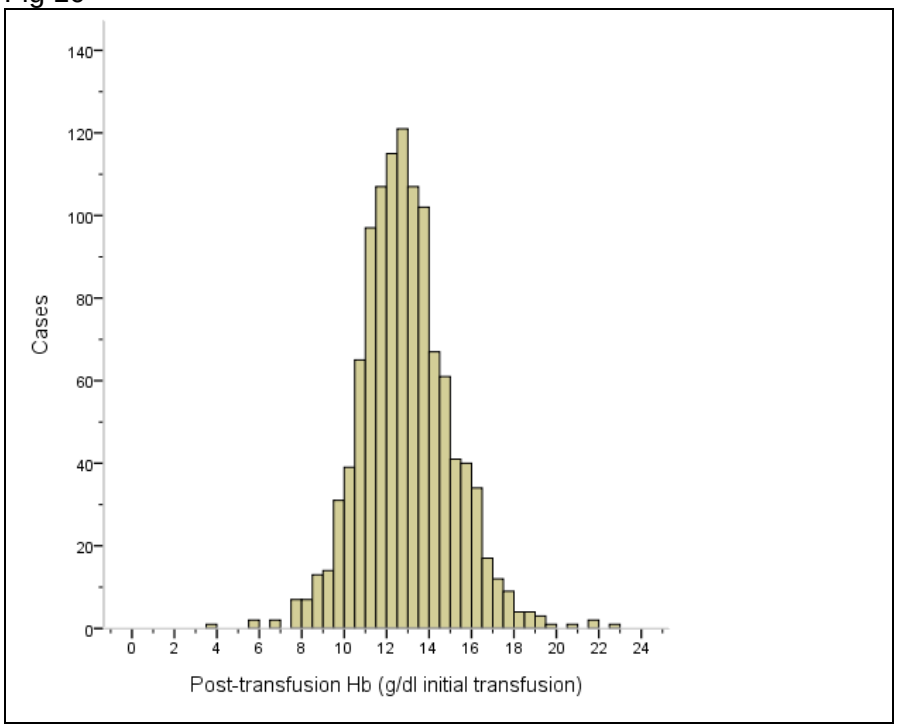


Fig 10



3.2 Further analysis of the haemoglobin concentration before and after red cell transfusion is presented by main reason for transfusion, respiratory status, and post-natal age for the first transfusion only.

Main reason for transfusion

Table Nineteen - Main reason why initial transfusion was given	National (1222) – All Hbs are shown in g/dl			
	Pre-Transfusion Hb		Post-Transfusion Hb	
	N	Median (IQR)	N	Median (IQR)
Anaemia with symptoms	728/734	9.4 (7.9-10.6)	689/734	12.5 (11.3-13.8)
Anaemia without symptoms	250/251	9.9 (8.6-10.9)	239/251	13.1 (11.8-14.4)
Bleeding	56/ 67	11.0 (8.3-13.1)	60/67	12.7 (10.9-14.6)
Exchange transfusion for hyperbilirubinaemia	3/14	17.9 (-)	3/14	17.7 (-)
Exchange transfusion for other reason e.g. anaemia sickle cell disease	1/1	5.2	1/1	10.2
Pre-operatively	14/14	9.8 (8.2-11.6)	13/14	11.9 (11.5-13.5)
Other	63/68	10.2 (8.1-13.0)	57/68	13.7 (12.5-14.9)
Don't know / Blank	70/73	11.0 (9.9-12.1)	65/73	13.0 (11.7-14.7)

Respiratory status at time of transfusion

Table Twenty – Respiratory status	National (1222) Pre-Transfusion Hb		National (1222) Post Transfusion Hb	
Initial transfusion	N	Median (IQR)	N	Median (IQR)
• Mechanically ventilated	575/597	10.6 (9.6-11.8)	550/597	13.3 (12.0-14.8)
• On CPAP *(but not mechanically ventilated)*	315/318	9.4 (8.3-10.2)	303/318	12.5 (11.5-13.9)
• On supplementary Oxygen *(but not mechanically ventilated or on CPAP)*	131/133	8.2 (7.3-9.0)	127/133	12.0 (11.0-13.2)
ANY OF THE ABOVE	1021/1048	9.9 (8.7-11.1)	980/1048	12.9 (11.6-14.3)
OFF OXYGEN	146/155	7.6 (7.0-8.2)	131/155	11.6 (10.7-12.6)

See key points below:

Key points:

Pre-transfusion Hb

Main reason for transfusion

- There was little difference between the pre-transfusion Hb in relation to the main reason for the transfusion being given (generally around 9.5 – 10.0 g/dl) except for the bleeding scenario where the median was 11.0 g/dl. The pre-transfusion Hb was also higher for was higher for exchange transfusion for hyperbilirubinaemia (17.9 g/dl), but the numbers for this indication were very small.

Respiratory status at time of transfusion

- The median pre-transfusion Hb varied depending on the respiratory status at the time of transfusion.
- For mechanically ventilated patients it was 10.6 g/dl, for those on CPAP 9.4 g/dl, and for those on supplementary oxygen without ventilation it was 8.2 g/dl. Patients off oxygen altogether had a median pre-transfusion Hb of 7.6 g/dl.

Post-transfusion Hb

- Excluding exchange transfusions, median post-transfusion Hb concentrations were all ≥ 12 g/dl apart from patients off oxygen (11.6 g/dl) and the small number of patients transfused pre-operatively (11.9 g/dl).

Transfusion increment:

- Further analysis indicated that for 861/1222 initial transfusions, Hb results within 2 days pre and post transfusion were known. The post minus pre Hb is known for 848/861: median 3.2 g/dl, IQR 1.9-4.3.

Pre-transfusion Hb by respiratory status and postnatal age for initial transfusion.

Table Twenty-One :Pre - initial transfusion Hb by Post-natal age by gestation	Postnatal age 0-1 days		Postnatal age 2-7 days		Postnatal age 8-28 days		Postnatal age >28 days	
	N	Median (IQR) Hb	N	Median (IQR) Hb	N	Median (IQR) Hb	N	Median (IQR) Hb
• Mechanically ventilated	187/201	11.6 (10.3-12.6)	195/200	10.7 (9.9-11.6)	116/117	9.9 (9.1-10.7)	60/62	9.5 (8.2-10.5)
• On CPAP *(but not mechanically ventilated)*	17/18	11.2 (9.4-12.2)	54/55	10.3 (9.1-11.0)	148/148	9.3 (8.3-9.9)	86/87	8.4 (7.7-9.8)
• On supplementary Oxygen *(but not mechanically ventilated or on CPAP)*	9/9	5.6 (4.8-9.9)	1/1	8.9	33/33	8.4 (7.4-9.4)	85/86	8.0 (7.4-9.0)
ANY OF THE ABOVE	213/228	11.5 (10.2-12.5)	250/257	10.6 (9.7-11.5)	297/298	9.5 (8.5-10.2)	231/235	8.5 (7.6-9.7)
OFF OXYGEN	9/13	7.9 (5.9-11.1)	9/13	9.5 (7.7-10.6)	45/45	7.6 (7.0-8.5)	76/76	7.5 (6.9-7.9)

Key points:

- For the first transfusion, there was a clear effect of postnatal age on pre-transfusion Hb for the infants on respiratory support. The median pre-transfusion Hb fell from 11.5 g/dl (postnatal age 0-1 days) to 8.5 g/dl (postnatal age >28 days) for these patients. The mechanically ventilated patients were similar to those on CPAP until age >28 days when there was a difference of 9.5 g/dl vs 8.4 g/dl between the two.

- For patient off oxygen, the median pre-transfusion Hb value was most meaningful for the ages ≥ 8 days where there were more patients audited. This value was 7.5-7.6 g/dl.

- For subsequent transfusions, for infants on any respiratory support there was less decrease in median pre-transfusion Hb level with postnatal age than for the first transfusion: the median pre-transfusion Hb fell from 10.8 g/dl (postnatal day 0-1) to 9.4 g/dl (postnatal age > 28 days; table not shown). This may reflect the difference in types of infants being transfused between one who is transfused for the first time > 28 days vs a multiply transfused infant at this age

3.3 Pre-transfusion Hb by Respiratory status and gestational age

Key point:

- Unlike for postnatal age, the pre-transfusion Hb values in various respiratory states were not affected by gestational age (data not shown).

4 The prescription of red cells

Knowing the weight of the patient is crucial since prescription depends on calculating a dosage of 10 - 20ml/kg. Weights were recorded in the audit for 98% (1193) of infants at the time of their first transfusion.

4.1 Form of red cells prescribed

Red cells were prescribed in either millilitres, paedipacks or units.

Table Twenty-Two – Red cell prescription for initial transfusion	National (1222)		**Your site (5)**	
	%	N	**%**	**N**
Known	99	1207	**100**	**5**
Prescribed*:				
• Mls	97	(1165/1207)	**100**	**5**
• Paedipacks	3	(38/1207)	**0**	**0**
• Units	0.5	(6/1207)	**0**	**0**

**In 2 cases more than 1 type was prescribed*

Key points:

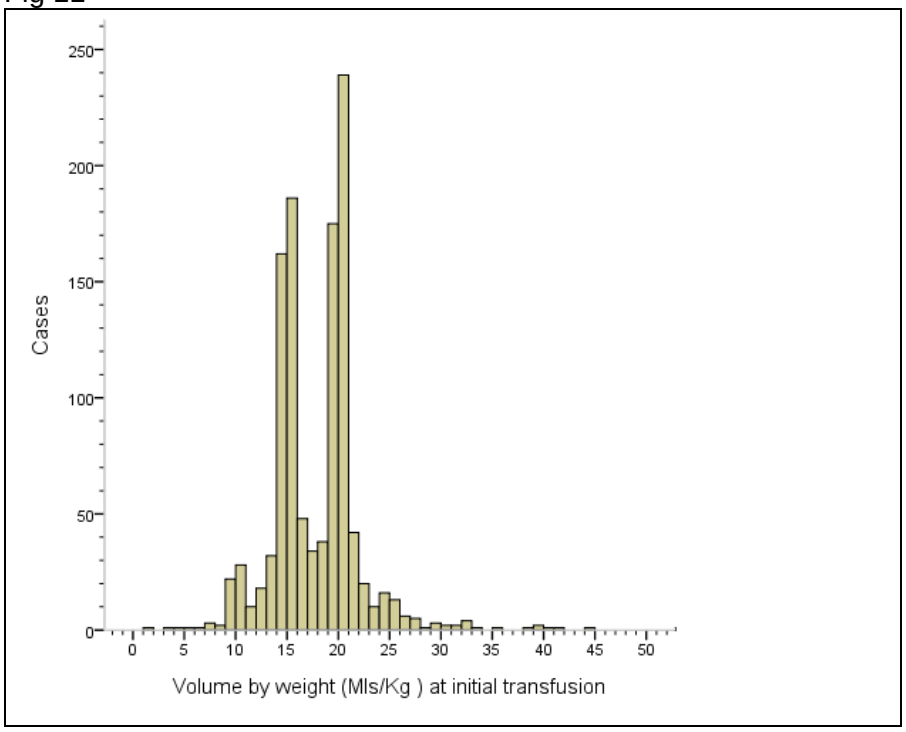
- 3% of initial transfusions were prescribed as paedipaks, and the median (IQR) weight of the recipient was 1.35 (1.00-2.44) kg
- Only 6 transfusions were prescribed as units. Three were exchange transfusions, and one was bleeding.

4.2 Volume of red cells prescribed

For the initial transfusion the median volume prescribed was 18.7 mls/Kg, IQR 15.0-20.0, n=1144; 3% (30/1144) were <10.0 mls/Kg and 24% (277/1144) were >20.0 mls/Kg

For subsequent transfusions, the median volume prescribed was18.5 mls/Kg, IQR 15.0-20.0, n=1163; 3% (33/1163) were <10.0 mls/Kg and 22% (257/163) were >20.0 mls/Kg.

Fig 11



Histogram excludes 10 outliers of more than 50 mls/Kg. 6 being exchange transfusions for hyperbilirubinaemia, 3 anaemia with symptoms, 1 other (falling Hb).

Key points:

- There are peaks of transfusion volumes prescribed at 15 and 20 mls/kg suggesting that this is a common prescription rather than calculating volumes based on a formula.
- 24% first transfusions prescribed were > 20mls/kg, of which only seven were exchange transfusions.
- 3% of first transfusions were < 10mls/kg.

4.3 Was the transfusion completed as prescribed?

Table Twenty-Three Completion of transfusion	National (1222)		Your site	
	%	N	%	N
Initial transfusion	95	(1153/1216)	100	5/5
2nd Transfusion	96	(595/622)	100	4/4
3rd Transfusion	93	(358/385)	100	2/2
4th Transfusion	99	(136/138)		/0
5th - 21st Transfusion combined	98	(325/333)		/0

5. How many transfusion episodes were there during this patient's admission?

Hospitals were asked to provide information on how many transfusions the patient had during their stay until the day they were discharged, transferred to another hospital or died, up to a maximum of 3 months

Table Twenty-Four	National (1222)		Your site (5)	
	%	N	%	N
Number of transfusions stated online by auditor:	87	(1058)	100	5
• 1	37	(389)	20	1
• 2	20	(207)	40	2
• 3-4	21	(218)	20	1
• 5-9	17	(182)	20	1
• 10+	6	(62)	0	0
Median (IQR)	2	(1-4)	Median: 2	

5.1 Number of transfusions related to the gestational age at birth

Table Twenty-Five : Number of transfusions stated online	< 28 wks Gestation (607)		28-32 wks Gestation (395)		> 32 wks Gestation (192)	
	%	N	%	N	%	N
1	19	(117)	41	(162)	55	(105)
2	15	(89)	19	(77)	20	(39)
3-4	22	(135)	17	(68)	6	(12)
5-9	24	(144)	8	(30)	4	(8)
10+	8	(50)	3	(10)	1	(2)
Not known	12	(72)	12	(48)	14	(26)

5.2 Number of transfusions related to the weight at first transfusion

Table Twenty-Six Weight at INITIAL transfusion	National 1222 N	Median (IQR) of N of transfusions	N of transfusions 1	2	3-4	5-9	10+	Not known
• ≤ 750g	194/216	6 (3-8)	22 (11%)	16 (8%)	37 (19%)	84 (43%)	35 (18%)	22
• 751-999g	203/221	3 (2-5)	40 (20%)	35 (17%)	63 (31%)	52 (26%)	13 (6%)	18
• 1000-1249g	186/220	2 (1-4)	56 (30%)	45 (24%)	61 (33%)	19 (10%)	5 (3%)	34
• 1250-1499g	120/146	2 (1-3)	56 (47%)	30 (25%)	22 (18%)	10 (8%)	2 (2%)	26
• 1500-2499g	207/247	1 (1-2)	122 (59%)	51 (25%)	22 (11%)	12 (6%)	0	40
• ≥ 2500g	123/143	1 (1-2)	80 (65%)	26 (21%)	9 (7%)	3 (2%)	5 (4%)	20
• Not known	25/29	1 (1-3)	13 (52%)	4 (16%)	4 (16%)	2 (8%)	2 (8%)	4

Percentages exclude Not known

Key points:

- This table shows that number of transfusions increases with decreasing gestational ages.
- More than half babies transfused > 32 weeks gestation had only a single transfusion.
- Infants with the lowest weight at first transfusion had an increased tendency to have multiple transfusions, with infants < 750g having a median of 6 transfusions, and those > 1500g having a median of 1 transfusion.

5.3 Summary of data on second and subsequent transfusions

There were a total of 636 patients where data on ≥ 2 transfusion episodes was submitted, with a total of 1496 transfusions subsequent to the first. Overall, there were only minor differences between the data from the first and subsequent transfusions and the details of the results are not shown in this audit report for reasons of space.

Key points:

- The main reasons for transfusion were almost identical to the first transfusion for those who had 2-4 transfusions. After the 4th transfusion, the combined subsequent transfusion data showed anaemia with (45% [150/335]) or without (39% [129/335]) symptoms as the most common indications, giving a lower proportion with symptoms than for the initial transfusions.

- For transfusions subsequent to the first, an increasing proportion of the transfused babies were ventilated, such that for transfusions more than the 4th, 72% (242/334) of infants were ventilated, and only 1% (3/334) were off oxygen.

- The median pre-transfusion Hb was similar for each subsequent transfusion (medians 9.9-10.8 g/dl), apart from the few patients who had more than 10 transfusions where the numbers are too small to be considered representative.

- The main difference was that for infants on any respiratory support there was less decrease in median pre-transfusion Hb level with postnatal age for subsequent transfusions than for the first transfusion (see Table Twenty-One).

6 Evidence of beneficial effect of transfusion

Good practice dictates that following a transfusion a note should be made in the patient's records as to if the transfusion had a beneficial effect, and what that effect was. For the transfusions audited in neonatal settings, details of a beneficial effect were reported in 18.9% (515/2718) and have been classified into the table below, using categories derived from analysis of the raw comments:

Table Twenty-seven : Benefit of transfusion	National (515)	
	%	N
Increased Hb	16	81
Reduced symptoms	8	41
Reduced need for oxygen	46	237
Improved colour	21	106
Patient generally better	10	50

Discussion

This audit has provided a significant body of information regarding current red cell transfusion practice for children in the UK, both for infants transfused on neonatal units, and paediatric patients transfused on other wards. The total number of patients audited was 2524, with 1222 from neonatal units and 1302 from other paediatric wards. As multiple neonatal episodes were audited (2718), the total number of transfusions reported to the audit from all children was 4020.

The audit's main focus was on the clinical and laboratory indications for red cell transfusion and the volume transfused together with the outcomes. However, it also included aspects of red cell administration and prescription, together with details of pre- and post-transfusion testing.

The audit has demonstrated several points of interest regarding the use of red cell transfusions for children. First, the most common location for transfusions on non-neonatal wards was the general paediatric wards (33%). This highlights the need to ensure transfusion education and training on these wards as well as in other areas such as PICU and theatres. Second, there was a high percentage of children who received only a single red cell transfusion during their admission: 74% of children on non-neonatal wards, and 63% of infants born at gestational age > 32 weeks on neonatal units. Although many of these transfusions on non-neonatal wards may have been top-up transfusions for leukaemia/cancer patients on treatment, or for haemoglobinopathy patients as part of a regular programme, there is the possibility that a proportion of the others could have been avoided altogether. This emphasises the need for careful consideration and documentation of the need for transfusion in every case. Finally, patients with leukaemia/cancer and haemoglobinopathy as the underlying reason for admission constituted nearly half (48%) of the transfused patients on the non-neonatal wards. This is a substantial group of transfused paediatric patients, many of whom are likely to have special transfusion requirements. Given that there continue to be significant numbers of adverse events related to special requirements not being met reported to SHOT from the paediatric age group (Taylor et al, 2009), this underlines the need for hospitals to have clear guidelines on the transfusion of these groups of patients.

Appropriateness of transfusion

One of the aims of the audit was to comment on the appropriateness of transfusion to neonatal and paediatric patients, with comparison of practice with national recommendations including BCSH guidelines. Overall there was evidence of much good practice but, as detailed in the Executive summary and recommendations, the results highlighted several areas where hospitals should continue to review their guidelines and practice. These may be divided into those relating to administration and blood testing, and to those relating to transfusion triggers, both clinical and laboratory.

Administration/blood testing.

The majority of patients in all wards had a pre- and post- transfusion Hb taken at some stage. However, for a small percentage there was no recorded pre-transfusion test and there appeared to be up to 18% of children transfused on non-neonatal wards who had

no post-transfusion Hb recorded. It is considered good practice to document a pre-transfusion Hb in all cases (BCSH guidelines on administration of blood components, 2009) although this may be difficult in cases of clinical emergency such as a severely bleeding patient, and in general a post-transfusion Hb should be usually checked as part of documenting the outcome. However, it is arguable as to whether it is necessary to check a post-transfusion Hb cases such as chronically transfused patients where the rise in Hb will be reasonably predictable and where the Hb will be checked again as part of the pre-transfusion testing for subsequent transfusions.

Pre- and post- transfusion testing are part of defining the need and outcome of transfusions. It is a clear recommendation of BCSH guidelines on the administration of blood components (2009) that the reason for transfusion and the outcome should be clearly documented in the clinical notes. However, in the audit a record of the benefit of transfusion was reported for only 17.7% transfusions outside neonatal units and 18.9% on neonatal units, suggesting that there is significant room for improvement in documentation of transfusion outcomes.

There were two aspects of the prescription of red cell volumes which were highlighted by the audit. First was the form of the red cell prescription. It is recommended in the BCSH guidelines on the administration of blood components (2009) that transfusions for children should be prescribed as the exact number of mls required. This is in order to address the repeated reports to SHOT of cases of over-transfusion leading to TACO with significant morbidity or mortality (Taylor et al 2010). In the audit, prescribing by units occurred for more than a third of all transfusions on wards other than the neonatal unit. This was most common in children over 12 months (median age of 12 years, median weight 33.7 kg), but was seen at all ages and in all locations, not in accordance with the guidelines. While it may not be inherently unsafe to prescribe red cells units to older children of an adult size, blood prescribed to infants and younger children should be prescribed in mls rather than units in order to reduce the risk of TACO, and consistency of practice across paediatric wards for all age groups is likely to be most straightforward for training purposes for both clinical and laboratory staff. Hospitals should be clear in their guidelines if there are sizes or locations of children for whom it is acceptable to prescribe in units.

The audit also addressed the actual volume of red cells prescribed. For transfusions on the neonatal unit the volume was strikingly high. The BCSH guidelines for transfusion to neonates and children (2004) state that neonatal top-up transfusions are usually 10-20mls/kg. However, in the audit the median volume prescribed for the initial transfusion was 18.7 mls/kg, with 24% prescriptions >20mls/kg, of which only seven were exchange transfusions. The audit did not address the reasons why the volumes >20ml/kg were being given, but one reason is likely to be a desire to reduce the need for repeated subsequent transfusions in these patients. Nonetheless, volumes >20mls/kg may result in an increase risk of TACO. In addition, if a transfusion of >20mls/kg from a single paedipak is given at the standard neonatal red cell transfusion rate of 5mls/kg/hr (McClelland, 2007), then this risks the blood being out of controlled storage for longer than the maximum recommended 4 hours and 30 minutes allowed for neonatal red cells. (BCSH Administration guidelines, 2009).

Transfusion triggers

The audit requested information on the underlying reason for transfusion to gain an understanding of the clinical reasons for transfusion and the different Hb levels used as transfusion triggers in the different clinical contexts. Pre-transfusion Hb levels appeared to be broadly in agreement with existing guidelines and other data from recent studies. For just over half of the transfusions outside neonatal units anaemia, with or without symptoms, was reported as the main reason for transfusion and only 13% transfusions were given for patients with bleeding. Results for pre-transfusion haemoglobin varied, with median values of 7.2, 7.6, and 8.6 g/dl respectively in anaemic patients with symptoms of anaemia, without symptoms of anaemia, and in patients with bleeding. Moreover, median pre- transfusion Hb values were 7.6 g/dl on Haematology/Oncology/Bone Marrow Transplant wards. The transfusion triggers were broadly in line with the recommendations for patients with aplasia in the BCSH guidelines, but those guidelines were not able to make recommendations for children with haemopoietic stem cell transplants and malignancies. In the audit, it was not clear as to the severity of the bleeding and whether this would justify the higher pre-transfusion Hb in those patients.

Patients on chronic transfusion programmes had a median pre-Hb of 9.2 g/dl and a post of 10.0 g/dl. Although this was a mixed population of patients, 82% were haemoglobinopathy patients, and this median pre-transfusion Hb is in line with BCSH guidelines (2004) for thalassaemia transfusions and sickle hypertransfusion programmes, although slightly below the UK thalassaemia guideline recommendation of 9.5-10 g/dl. The post –transfusion Hb of 10.0 g/dl is surprisingly low, but harder to comment on as only 47% (103/217) chronic transfusion patients had a value recorded.

The audit collected information on patients in PICU, and also requested information on the patients' respiratory status as this may affect transfusion decisions. On PICU, the main groups of transfused patients were cardiac (38%) and infection/sepsis (18%). Median pre-transfusion haemoglobin values in PICU, were 8.4 g/dl, of which 68% (102/149) were from ventilated patients. This is a complex group of patients but it is worth noting that the median pre-transfusion haemoglobin was higher than the restrictive threshold of 7 g/dl demonstrated in the recent TRIPICU trial (Lacroix et al, 2007). This may be partly because of the inclusion of children with cyanotic heart disease who may need higher Hbs, but there may be some patients on PICU who may not need to be transfused at the levels reported to the audit.

On the neonatal unit, respiratory status was again compared with transfusion triggers as this enabled a closer comparison with the suggestions in the BCSH neonatal transfusion guidelines (2004) and recent studies (Bell et al, 2005, Kirpalani et al, 2006). In general, it appeared that the median triggers were lower than might be expected from looking at the BCSH guidelines apart from for infants off oxygen in the older postnatal age-group. For transfusions at postnatal age 0-1 days, the median pre-transfusion Hb of those on oxygen (most patients) was 11.5 g/dl. This is just below the BCSH guideline suggested threshold of Hb 12 g/dl for anaemia in the first 24 hrs. BCSH guidelines also suggest a Hb of 12 g/dl as the threshold for neonates receiving intensive care. However, in the audit the median pre-transfusion Hb for mechanically ventilated patients overall (who were therefore receiving intensive care) was lower than this at 10.6 g/dl. It also fell from 11.6 g/dl at postnatal age 0-1days to 9.9 g/dl by postnatal age 8-28 days, demonstrating a greater degree of sub-stratification in practice than suggested by the guideline.

The clear relationship between neonatal postnatal age for patients receiving respiratory support demonstrates an increased tendency to transfuse in the early days of life when preterm neonates are sick and require the most cardiorespiratory support, and is more in keeping with the stratification by respiratory status and postnatal age used in the design of the recent trials, and in other suggested guidelines (Murray and Roberts, 2004). We were unable to assess the appropriateness of transfusions to infants with chronic oxygen deficiency as the data from this question in the audit were inconclusive. However, for patients off oxygen altogether, the median pre-transfusion Hb value was most meaningful for the ages ≥ 8 days where there were more patients audited. This median value was 7.6 g/dl at ages 8-28 days, and 7.5 g/dl at ≥ 28 days, a little above the suggestion of 7 g/dl by BCSH for the 'late anaemia/stable patient' suggesting that this may be one group where some transfusions might be avoidable.

Conclusions

This audit has given many insights into current paediatric red cell transfusion practice for transfusions across both paediatric and neonatal units. In many areas it has been possible to make comments on the appropriateness of practice and there are some areas where there appears to be room for further consideration and improvement to take place. However, much of the current guidance on neonatal and paediatric transfusion is not prescriptive and there has been a lack of evidence to back many of the existing recommendations. The recent and ongoing studies on neonatal and paediatric transfusion are now contributing further to our understanding of this complex field, and it is important to be now developing new guidelines to try to bring together and extend current recommendations as much as possible.

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