

AUSTRALIAN CENTRE FOR EFFECTIVE HEALTHCARE

**RED BLOOD CELL TRANSFUSION PRACTICES
IN NEW SOUTH WALES**

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Report prepared for the NSW Ministerial Advisory Committee on Quality in Healthcare

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EXECUTIVE SUMMARY

Reported international estimates of inappropriate red blood cell (RBC) transfusion range from 16 to 66%. The study reported here sought to determine the level of inappropriate RBC transfusion practice in Sydney metropolitan hospitals in 1998-1999 and to test the effectiveness of interventions to improve transfusion practices.

A systematic review commissioned as part of the study (Hill *et al.*) suggested that restricting the use of RBC to patients with serum haemoglobin levels below 7.0 g/dL did not have adverse effects on outcomes. The review also found evidence that restrictive triggers reduced the use of red cells, reduced patients' length of hospital stay, and, in some circumstances, reduced patient mortality.

In this study ten major metropolitan Sydney hospitals were randomly allocated to two groups of five hospitals each. There were interventions for both groups, but these varied in intensity. At the pre-test (audit 1) information on up to 60 consecutive patients receiving RBC transfusion at each hospital was collected. The less intensive intervention consisted of feedback by post, of the results of the first audit, together with a summary of the systematic review and recommendations for actions to improve RBC transfusion practice. The more intensive intervention included these components plus a verbal presentation by the study group of the results of the first audit at a meeting with hospital clinical leaders at each of the five hospitals. The post-test data (audit 2) from up to 60 consecutive records were then collected.

Transfusions were assessed for appropriateness using two criteria:

- The first assessed an RBC transfusion as inappropriate if the haemoglobin (Hb) level before transfusion was 10 g/dL or more, and there was no indication of continuing, excessive or abnormal bleeding.
- The second assessed the transfusion as inappropriate if the haemoglobin level before transfusion was 7 g/dL or more (≥ 8 g/dL if pre- or peri-operative) and less than 10 g/dL, with no clinical signs, symptoms or evidence that the patient was at increased medical risk, and no continuing, excessive or abnormal bleeding.

Of 1117 patients included in the study, we found that 35% of blood transfusions were potentially inappropriate. The results for surgical patients was 42%; for medical patients 32%, and for obstetrics and gynaecology patients 16% (38%, 26% and 15% respectively when only considering the first unit transfused). A small percentage of transfusions (9% overall) could not be classified as appropriate or inappropriate because information needed - usually haemoglobin level - was omitted from patient records. Some of these will have been appropriate and some inappropriate. If they all were classed as appropriate then, the overall percentage inappropriate would be reduced from 35% to 32%.

There was an apparent reduction in inappropriate transfusion rates between the first and second audits for both intervention groups. This was greatest for the group with the less intensive intervention (29% first audit, 21% second audit) and for this group the reduction was significant. The reduction for the more intensive intervention was from 41% to 35% and was not significant. There was a lack of comparability between the groups in that they differed in inappropriateness at the first audit, before the intervention, despite the random allocation of hospitals to groups.

From the literature review and the study results emerge the following recommendations:

1. That NSW Health, The Australian Red Cross Blood Service - NSW and relevant Colleges develop RBC transfusion policies with criteria for use as soon as possible. These policies should include guideline triggers for RBC transfusion, and should provide recommended formats for hospital blood request forms. All RBC requests should include information permitting assessment of adherence to the guidelines.
2. The RBC transfusion guidelines should be prescribed for use in all hospitals where blood transfusions are conducted and their implementation should be monitored as part of the hospital's ongoing safety and quality monitoring processes. Guideline adherence should be benchmarked against comparable hospitals. All hospitals should be required to demonstrate improvement in the level of inappropriate transfusions over time.

3. NSW Health and the Australian Red Cross Blood Service – NSW should devise an education strategy to inform clinicians and managers working with blood transfusion services of the results of the systematic review and the newly developed transfusion policies and practices. These efforts should be targeted on a group and individual basis to all clinicians who request blood products.

RED BLOOD CELL TRANSFUSION PRACTICES IN NEW SOUTH WALES

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BACKGROUND

On 19 November 1998, the Australian Centre for Effective Healthcare signed an agreement with the NSW Health Department to conduct a project on the appropriateness of red blood cell transfusion in NSW hospitals. The objectives of the project were to:

1. Survey the existence and use of transfusion policies by NSW hospitals;
2. Review the available evidence for the appropriate use of red blood cells (RBC);
3. Develop indicators of the appropriateness for use of RBC;
4. Measure the indications for and appropriateness of use of RBC in a selection of hospitals;
5. Assess the effect of implementation of these policies;
6. Develop a prototype for improving the appropriate use of RBC; and
7. Make recommendations for appropriate use of RBC.

This is the final report on the project. It has been prepared for the Chief Health Officer and Deputy Director General, Public Health, NSW Health Department, and the Chairman of the NSW Ministerial Advisory Committee on Quality in Healthcare.

A report on the existence and use of transfusion policies by NSW hospitals has been provided separately (Dean & Vincent, 1999). A systematic review on methods for improving the appropriateness of RBC transfusion, conducted for this project on a sub-contracted basis by the Newcastle Systematic Review Group (Hill *et al*, 1999), is also available and is summarised in Append 2.

What follows is the first report of our study:

1. To determine the level of inappropriate RBC transfusion practice in Sydney metropolitan hospitals, and
2. To test the effectiveness of interventions to improve transfusion practices.

The study was a collaborative effort by the participating hospitals, the Australian Red Cross Blood Service - NSW, and the Effective Healthcare Consortium (comprising the Australian

Centre for Effective Healthcare and the Westmead Hospital Department of Public Health and Community Medicine).

INTRODUCTION

Estimates of inappropriate RBC use range from 16% (Metz *et al*, 1995) to 67% (Hebert *et al*, 1997; Ghali *et al*, 1994) (Dietrich, 1965; Reece and Beckett, 1966; Mozes *et al*, 1989; Coffin *et al*, 1989). Potential problems attributed to the unnecessary use of blood products are well known. They include unnecessary patient exposure to health risks (Bove, 1987; Welch *et al*, 1992; Soumerai *et al*, 1993; Ghali *et al*, 1994); unnecessary costs (Goodnough *et al*, 1993; Rosen *et al*, 1993); unnecessary pressure on the supply of blood products (Thomson *et al*, 1991; Welch *et al*, 1992); and greater likelihood of clinician exposure to medico-legal action (Metz *et al*, 1995; Grainger *et al*, 1997). Moreover, transfusion practices have been shown to vary substantially between hospitals, within clinical settings, within specific disease categories and surgical procedures independent of patient characteristics (Baele P *et al*, 1998; Hebert 1997).

A systematic review commissioned as part of the study (Hill *et al*, 1999) suggested that restricting the use of RBC to patients with serum haemoglobin levels below 7.0 g/dL did not appear to have adverse effects on outcomes. The term *restrictive trigger* refers to a threshold haemoglobin level below which RBC transfusion is indicated. The review produced evidence that use of appropriate restrictive triggers reduced patients' length of hospital stay and, in some circumstances, mortality. Moreover the introduction of restrictive triggers was associated with significant reductions in RBC transfusions in most studies.

The first objective of the present study was to obtain information on current transfusion practice in NSW hospitals, and to estimate the level of potentially inappropriate transfusions. There are major gaps in our knowledge of the effect of restrictive triggers in particular sub-groups of patients. In many sub-groups the effect of restrictive triggers either has not been studied (eg. patients with haematological disorders) or has been studied only in small numbers of patients (eg. those with renal disease). There is some evidence that, in patients with vascular disease, in some circumstances, a trigger of 8.0gm/dL may be appropriate, but there is also evidence that increasing the trigger to 10.0gm/dL in these patients may have adverse effects (Hebert *et al*, 1999).

For this study, based on the systematic review and the work of Metz (1995), we assessed an RBC transfusion as inappropriate if:

1. the haemoglobin (Hb) level before transfusion was 10g/dL or more, and there was no indication of continuing, excessive or abnormal bleeding.
2. The haemoglobin (Hb) level before transfusion was 7g/dL more more (≥ 8 g/dL if pre- or peri-operative) and less than 10 g/dL, with no clinical signs, symptoms or evidence that the patient was at increased medical risk, and no continuing, excessive or abnormal bleeding.

The second objective of the present study was to test the effect of two fairly simple interventions aimed at reducing the level of inappropriate transfusions. Ten major Sydney metropolitan hospitals were randomly allocated to two groups. The first group received a less intensive intervention after baseline data had been collected and analysed, each hospital in this group was sent a letter containing its own results and advice on steps which might reduce the number of inappropriate transfusions. They were also sent a summary of the systematic review.

The second group received a more intensive intervention. This contained the same components as for the first group, but in addition, a meeting was organised at each of the five hospitals, at which members of the project team presented the baseline results and discussed them with staff attending the meeting. Offers were made to provide help and collaboration with any steps which might be taken to reduce inappropriateness.

Relatively few studies examine strategies for changing transfusion practices, and most of these have been observational studies. These studies suggest that 'complex' interventions constitute the most effective methods of changing clinical practice in relation to transfusions. We know of one study which examined the change in costs in relation to the use of a restrictive transfusion strategy. This showed a reduction in the use of blood and an associated reduction in costs (Hill, 1999). Our intervention was to provide further information relevant to estimating possible savings in RBC transfusion costs.

It has been shown that unnecessary use of blood products can be reduced (Hebert, 1997). In Australia, for example, modification of a request form for transfusion of blood with restricted

indications for transfusion and clinical and laboratory data included on the form, led to a reduction in the rate of inappropriate RBC transfusions (Tuckfield, 1997).

Several comprehensive guidelines have been developed for RBC transfusion in recent years (Canadian Medical Association 1997; Gunter P (American Society of Anesthesiologists) 1996; Polk HC American College of Surgeons 1995).

METHODS

Study design

The study utilised a pre-test/post-test design, with random allocation to two intervention groups (one receiving a more intensive intervention than the other). The terms pre- and post- test signify hospitals and not patients, and will be referred to in this report as the first and second audits (audit 1 and audit 2).

In the first audit , medical records of patients who received an RBC transfusion in the participating hospitals were sampled. At this pre-intervention audit, the records were examined by trained observers who extracted information on the transfusion and the indications for it. The participating hospitals were then randomly allocated to receive one of the two interventions as described below.

Six weeks after the interventions were conducted, the medical records on another sample of patients were audited using the same procedure as for the first audit. Pre and post-intervention transfusion practices were then compared in the two intervention groups.

Ethical approval for the study was given by each Area Health Service and by hospital Chief Executive Officers. The study was also endorsed by the NSW Statewide Ethics Confidentiality Committee. Researchers collecting data from the patients' medical records had no information on the purpose of the study, or on allocation of hospitals to interventions.

Sample

Hospitals

Participants in the study were ten of the 11 major metropolitan hospitals in Sydney, New South Wales as defined by the NSW Health Department (*NSW Public Hospitals Comparison Data – 1996/97*). These hospitals had a mean of 209.5 available beds. The one hospital which did not participate was excluded because it had disproportionately more beds than the others (404 available beds). Five hospitals were randomly allocated to the more intensive intervention, and five to the less intensive intervention. The interventions are described below.

Sample size

We calculated that a sample of 550 medical records at the pre- and post-intervention stages respectively (1100 records in all) would provide power of 89% to detect a 33% reduction in inappropriate RBC transfusions at $P < 0.01$ (two-tailed). A reduction of this size would be consistent with other comparable Australian studies (Brandis, 1994; Tuckfield, 1997). As some medical records were likely to lack the information necessary for determining appropriateness (Wilson, 1995), we increased sample size by approximately 10%. This gave an intended sample of $N=1200$, containing 60 medical records from each hospital at each audit.

Procedures

At the outset of the study an external academic unit was contracted to conduct a systematic review of the literature on triggers for RBC transfusion. This review was conducted using methods specified by the International Cochrane Collaboration (<http://www.update-software.com/ccweb/cochrane/revabstr/ccabout.htm>) and produced a report which will be added to the Cochrane Database of Systematic Reviews. A summary is given in Appendix 2.

Each participating hospital nominated a contact person for liaison with the study team.

Medical records of patients who received a RBC transfusion after 1 October 1998 (audit 1) or 1 September 1999 (audit 2) were identified by the Medical Records Manager at each hospital, in conjunction with the hospital's blood bank service. All medical records which contained references to transfusions after those dates were included in chronological order of admission.

Records of patients transfused in Emergency Departments or Intensive Care Units were excluded because of the greater difficulty of defining an appropriate transfusion. Patient records were consecutively introduced into the study until a maximum of 60 per hospital had been accumulated, or three months had elapsed (whichever occurred first). Every record identified by this process was included in the sample. In audit 1 the accumulation of medical records covered a mean of 63 days with a range of 55 to 90 days. The mean for the post-intervention audit was 78 days with a range of 51 to 118 days.

In both audits the data collection was undertaken by hospital staff who were instructed in standard procedures by members of the project team. The data-collection form was prepared for the study in collaboration with the Australian Red Cross Blood Service – NSW, and is given in Appendix 1. Hospitals were paid a fee to cover the cost of providing staff to undertake the audits.

After data collection was completed a research nurse with extensive experience of medical record audits contacted staff responsible for the auditing and visited hospitals, as necessary, to confirm accuracy of the information provided and to obtain missing items. This was undertaken separately for each audit and immediately after supply and checking of the data. The research nurse and hospital personnel were blind to the intervention status of the hospital.

The period between the presentation of first audit results to hospital staff and the commencement of the second audit varied from hospital to hospital. The time ranged from six to ten weeks. This variation was a consequence of considerable differences in the return of data for the first audit, reportedly due to pressure of work on hospital records staff. For this reason, with the agreement of the hospitals concerned, second audit data at four hospitals were collected by trained research nurses employed specifically for the project. Similar steps were taken as at the first audit, and by the same research nurse, to maintain accuracy of data and to trace missing items.

Interventions

The interventions comprised the following:

(1) Less intensive intervention. A letter was sent to the Chief Executive Officer (CEO) and to contact persons of each of the 10 hospitals. This letter expressed thanks for the hospital's participation, and gave the results of the pre-intervention audit for that hospital only (the percentage of inappropriate transfusions, and details of admission categories, medical risk factors and reasons for transfusion). A summary of the systematic review was enclosed. The hospitals which received this intervention are referred to as the letter only group.

(2) More intensive intervention. In addition to the letter, a meeting was organised at the five hospitals in this group by the hospital's contact person and on behalf of the project team. At this meeting, the results of the pre-test audit for that hospital were presented by at least two of the authors of this report, using visual aids of identical format at all five hospitals. The intention was that staff attending the meetings would include clinicians from departments primarily responsible for ordering and performing RBC transfusions: Medicine, Surgery, Anaesthetics, and Obstetrics and Gynaecology. In addition, the Director of Medical Services was asked to encourage the attendance of resident medical staff. Presentations at these meetings comprised an introduction and overview of the study (five minutes); a summary of the systematic review (five minutes); the results of the first audit conducted at that hospital (10 minutes); and discussion among all attendees about the results and how to improve RBC transfusion practice (approximately 40 minutes). The meetings took place before the letters (described above) were delivered. The hospitals which received this intervention are referred to as the visit plus letter group.

Measures

Data were collected in three domains:

1. *Demographic factors* - age and sex.
2. *Hospital stay details* - admission date, time, assigned specialty, specific reason for admission, and discharge date and time.
3. *RBC transfusion details* – total number of units ordered, number of units transfused, date and time each unit was transfused (first four units only), whether transfusion was autologous, evidence of health-risk factors which may have been exacerbated by anaemia (myocardial or cerebral ischaemia; coronary, valvular, or congestive heart disease; carotid artery occlusion; and respiratory impairment). In addition, for first four units only - associated clinical factors (haemoglobin, haematocrit, blood pressure, pulse), reason for transfusion, associated signs or symptoms (syncope, dyspnoea, angina, drowsiness), evidence that transfusion supplements were considered (erythropoietin, clear fluids, iron, vitamin B12, folate), blood type and documentation (intravenous fluid sheet and blood request form).

For the first four units transfused, date and time of haemoglobin, haematocrit, clinical factors, and giving of transfusions supplements were used to match these measures to the date and time of the units transfused. When this information was present for a unit transfused (always at least the first), but not for a subsequent unit, then the available data was applied to the subsequent unit(s) provided that units were transfused within the same episode¹. Other than this, if no haemoglobin level was available then the unit was included in the category: ‘insufficient information’ and not evaluated for inappropriateness.

The inappropriateness criteria

Each RBC transfusion was considered inappropriate if:

- Haemoglobin (Hb) level before transfusion was ≥ 10 g/dL or more, and there was no indication of continuing, excessive or abnormal bleeding.
- Hb level before transfusion was ≥ 7 g/dL or more (≥ 8 g/dL if pre- or peri-operative) and less than 10 g/dL, with no clinical signs, symptoms or evidence that the patient was at increased medical risk, and no continuing, excessive or abnormal bleeding.

This formulation, following that of Metz can be expressed in terms of appropriate transfusion with 3 criteria as follows. 1) continuing, excessive or abnormal bleeding; 2) pre- or peri-operative Hb less than 8 g/dL, or less than 7 g/dL for all others; 3) Hb less than 10 g/dL where there were clinical signs, symptoms or evidence that the patient was at increased medical risk. If any one of these criteria were met, then transfusion would be appropriate. This re-formulation, which in clinical use might be more readily applicable, would produce exactly the same results in determination of inappropriateness as would the Metz et al criteria, although for consistency the Metz formulation is used in this report.

Statistical analyses

Initially all data were screened for clerical errors and omissions. When errors and omissions were identified, they were checked against source material and corrected. The most commonly omitted items were haemoglobin levels. In most cases these were subsequently found and added to the data. The appropriateness criteria were applied to the data by a computer program written for that purpose. The validity of this program was established by comparison of results from it with those from an independent manual application of the criteria to two samples of $N=60$ each. Both methods agreed 100%. Information on inappropriate transfusions was analysed overall; by sequence of unit transfused; by audit (pre- or post-test); by intervention group (less intensive, i.e. letter only, or more intensive, i.e. visit plus letter; and by patient characteristics.

Categorical analysis techniques were used, including chi-squared and exact probability tests and, for the multi-way tables, log-linear modelling. This latter technique is an hypothesis-testing method analogous to analysis of variance in circumstances where the dependent variable is

¹ This report follows the Australian Red Cross Blood Service definition of a transfusion episode as including all units transfused within a 24 hour period.

categorical rather than continuous and when interactions between factors may be of interest. Logistic regression was used in analyses for controlling differences between hospitals. Simple contrasts of patient and medical characteristics were made using Student's 't' test or chi-squared tests as appropriate for the scale of measurement used. In all cases test assumptions were met. All data screening and analysis was conducted using SPSS (SPSS Inc 1999) and SAS (SAS Institute, 1997) computer programs.

RESULTS

Sample

At the first audit information was abstracted from 543 medical records at the 10 hospitals, with a mean of 54 records per hospital. At the second audit 574 medical records were audited and the mean per hospital was 57 records. This gave a total achieved sample of 1117 which was 93% of the planned sample size. Of these, 105 lacked information necessary for determination of transfusion appropriateness (9% of achieved sample). Thus the sample used for most tests was N=1012. This was further reduced in analyses where patient and medical characteristics were introduced because values for individual variables were sometimes missing. Each analysis in this report uses all available data, as can be seen by the differing N values for some of the tables. Table 1 shows the distribution of the sample by audit and intervention groups.

Table 1. Distribution of sample by audit and treatment group

Group	1 st Audit	2 nd Audit	Total
Letter only	276	275	551
Letter + visit	267	299	566
Total	543	574	1117

Patient characteristics

Characteristics of patients separately for audit 1 and 2 are given in Table 2 and separately for the two intervention groups in Table 3, together with significance test results. From these it can be seen that there were statistically significant differences between first and second audit and also between intervention groups. Inspection of the mean values and standard errors established that these differences, although significant, were small in practical terms and were a consequence of the comparatively large sample.

Table 2. Patient characteristics at first unit for audit 1 and audit 2

	Audit	N	Mean	SE	P
Age	1	521	69.4	.811	.374
	2	573	70.3	.730	
Haemoglobin	1	476	8.9	.990	.002
	2	515	8.5	0.99	
Haematocrit	1	429	.272	0.84	.009
	2	438	.261	.003	
Systolic BP	1	481	125.5	1.000	.042
	2	484	122.5	1.000	
Diastolic BP	1	479	67.3	.610	.001
	2	480	64.3	.590	
Pulse	1	476	84.0	.740	.040
	2	490	86.2	.780	

Note. Probability by Student's 't' test, two-tailed, independent samples.

Table 3: Patient characteristics at first unit by intervention (1=letter only; 2=letter+visit)

	Intervention	N	Mean	S.E.	P
Age	1	547	67.8	.810	.001
	2	547	71.9	.720	
Haemoglobin	1	483	8.6	.095	.068
	2	508	8.8	.088	
Haematocrit	1	464	.264	.003	.207
	2	403	.269	.003	
Systolic BP	1	471	121.7	.990	.002
	2	494	126.2	1.080	
Diastolic BP	1	468	65.1	.590	.082
	2	491	66.6	.620	
Pulse	1	463	86.5	.800	.018
	2	503	83.9	.730	

Note. Probability by Student's 't' test, two-tailed, independent samples.

There were more females in the sample (59%) than males (41%).

Medical speciality at admission

The majority of study patients were admitted to medical (47%) or surgical wards (43%) These results are in Table 4. The small number of Accident and Emergency and Intensive care patients were initially admitted to those units, but were transferred before the transfusion episode.

Table 4. Speciality assigned at admission

Speciality	N	%
Surgical	484	43
Medical	530	47
Obstetrics & Gynaecology	67	6
Intensive Care	18	2
Accident & Emergency	8	.7
Other	10	.9
Total	1117	100

Number of units transfused

The mean number of RBC units ordered was 3.4 (SE 0.09) and the mean number transfused was 2.9 (SE 0.08). A total of 3484 units were ordered (by the clinician) and 3225 of these were transfused (93%). Ninety percent of patients received 4 or less and 10% received more than four (Table 5). Less than 1% of patients received more than 10 units.

Table 5. Number of RBC units transfused

	N	%	Valid %
One	95	9	9
Two	521	47	48
Three	198	18	18
Four	165	15	15
Five or more	115	10	10
Valid total	1094	98	100
Not recorded	23	2	
Total	1117	100	

The total number of units transfused was 2966. The total number of units transfused limiting to the first four was 2391. The total for which a transfusion date was available was 2806. The total with haemoglobin level was 2570. All 1117 patients included in the appropriateness assessment had complete data for the first unit transfused.

There were 89 units of autologous blood provided by 40 patients (mean 2.2 units per patient) and 81 of these units were transfused.

Transfusion reason

The overall most common reason given for commencing transfusion was anaemia, followed by pre- or peri-operative and abnormal or excessive or continued bleeding (Table 6). There were significant differences between the two audits and between the two intervention groups. These were tested after the reasons listed in Table 6 had been merged to give five categories: anaemia plus anaemia with sepsis; anaemia with symptoms plus bone marrow failure; continuing, excessive or abnormal bleeding; pre- or peri-operative; other. At audit 1 the two intervention groups differed significantly (Chi-squared=66.97, Df=4, P<0.001) and this was the case also at audit 2 (Chi-squared=50.38, Df=4, P<0.001). Both the letter only (Chi-squared =60.21, Df=4, P=0.001) and the letter+visit (Chi-squared =46.25, Df=4, P=0.001) groups differed significantly between audit 1 and audit 2 for transfusion reason.

Table 6. Reasons for transfusion by audit and intervention group

Intervention	Transfusion reason	1 st Audit	2 nd Audit	Both audits
		%	%	%
Letter only	Anaemia	35	33	34
	Anaemia with symptoms	20	11	16
	Bone marrow Failure	0	0	0
	Anaemia with sepsis	1	5	3
	Abnormal or excessive bleeding	14	29	21
	Continued bleeding	3	5	4
	Pre-operative	12	2	7
	Other	5	15	10
	None stated	8		4
	Total	100	100	100
Letter+visit	Anaemia	30	50	40
	Anaemia with Symptoms	5	13	9
	Bone marrow failure		0	0
	Anaemia with sepsis		1	1
	Abnormal or excessive bleeding	13	9	11
	Continued Bleeding	2	3	2
	Pre- operative	34	11	22
	Other	17	13	15
	None stated			
	Total	100	100	100

Note - zeros in this table represent small values less than 0.5; blanks indicate nil occurrence

Medical risk factors, signs and symptoms

Medical risks relevant to transfusion decisions are given in Table 7. More risk factors were recorded for patients in the second audit than for the first audit. This was the case both for the letter only group (Chi-squared=17.49, Df=5, P=0.004) and for the letter+visit group (Chi-squared=14.62, Df=6, P=0.023). In addition there was a significant difference between the intervention groups at the second audit (Chi-squared =13.11, Df=5, P=0.022), but not at the first audit (Chi-squared=8.99, Df=6,P=0.175). More risk factors were present for the letter only group at the second audit, and these were mostly coronary heart disease.

Table 8 shows signs and symptoms potentially related to anaemia. There were no significant differences by intervention or audit for any of the conditions in this table.

Table 7. Medical risk factors by intervention and audit (%)

Intervention	Risk factor	1 st Audit	2 nd Audit	Both audits
		%	%	%
Letter only	Coronary heart disease	20	28	24
	Valvular heart disease	3	01	02
	Cerebral ischaemia	3	05	04
	Carotid artery occlusion			
	Congestive heart disease	4	8	6
	Respiratory impairment	4	7	5
	None stated	66	51	58
	Total	100	100	100
Letter+visit	Coronary heart disease	11	19	16
	Valvular heart disease	2	5	4
	Cerebral ischaemia	3	5	4
	Carotid artery occlusion	0		0
	Congestive heart disease	6	5	6
	Respiratory impairment	4	6	5
	None stated	72	60	66
	Total	100	100	100

Note - zeros in this table represent small values less than 0.5; blanks indicate nil occurrence

Table 8. Signs and symptoms relevant to transfusion by intervention and audit (%)

Intervention	Sign or symptom	1 st Audit	2 nd Audit	Both Audits
		%	%	%
Letter only	Syncope	4	1	2
	Dyspnoea	2	3	2
	Angina	1	0	1
	Drowsiness		2	1
	Other	81	94	87
	None stated	12		6
	Total	100	100	100
Letter+visit	Syncope	1	3	2
	Dyspnoea	3	4	3
	Angina	2	1	1
	Drowsiness	2	1	2
	Other	92	91	92
	None stated			
	Total	100	100	100

Note - zeros in this table represent small values less than 0.5; blanks indicate nil occurrence

Assessment of the appropriateness of RBC transfusions

The results of applying the two appropriateness criteria to the data from the 10 hospitals with both audit and intervention groups pooled are given in Table 9a. From the table it can be seen that 35% of transfusion episodes included inappropriate RBC units. If it is assumed that the 105 (9%) episodes which could not be assessed, because medical records lacked necessary information, were all appropriate, then the percentage inappropriate is 32%. As some of the 9% are likely to have been inappropriate, this is a conservative estimate.

Table 9b presents the same results separately by admission speciality. Here it can be seen that 38% of surgical transfusions were inappropriate compared to 29% of medical transfusions. These results refer to the full transfusion episode up to the fourth unit transfused.

Table 9a. The overall assessment of appropriateness including all patients in both audits

Did patient receive any inappropriate units?	N	% of all Patients	% of with information
No	659	59	65
Yes	353	32	35
Total with sufficient information	1012	91	100
Insufficient information*	105	9	
Total	1117	100	

* medical record lacked information necessary for assessing appropriateness.

Table 9b Overall inappropriateness by speciality

Did patient receive any inappropriate units ?	Surgical	Medical	Obstetrics & gynaecology	Other	All	N
	%	%	%	%	%	
No	52	63	78	56	59	659
Yes	38	29	15	14	32	353
Insufficient information*	10	8	7	31	9	105
N	484	530	67	36		1117

* medical record lacked information necessary for assessing appropriateness

The same results are given by audit and treatment groups in Table 10.

The percentage inappropriate for the letter only group at the first audit was 29% and this was reduced to 21% at the second audit. For the letter+visit group the percentage inappropriate at first audit was 41% reducing to 35% at the second audit. These percentages included in the denominator the 105 transfusion episodes which could not be assessed because of lack of information on medical records. The effect of this is to treat them as if they were all appropriate. Thus the percentages inappropriate in Table 10 are conservative estimates.

When these percentages were recalculated using only data where appropriateness could be assessed, those for the letter only group were 33% and 24% and for the letter+visit group 45% and 38%. Thus it can be seen that the two intervention groups differed in the pre-test measurement (Fisher's exact test, $P=0.007$). They also differed significantly at post-test (Fisher's exact test, $P=0.0002$). In addition there was a reduction in inappropriate transfusions between pre- and post test. This was significant for letter only group (Fisher's exact test, $P=0.028$), but not for the group receiving the more intensive letter+visit intervention (Fisher's exact test, $P=0.129$). At the pre-test an inappropriate RBC unit was 1.7 times more likely for the letter+visit group than for the letter only group ($P<0.01$, z test on log odds ratio), and at the post-test it was twice as likely ($P<0.001$, same test).

Table 10. Inappropriate transfusions by audit and intervention group

Intervention	Inappropriate ?	1 st Audit		2 nd Audit		Both Audits	
		N	%	N	%	N	%
Letter only	No	163	59	191	69	354	64
	Yes	79	29	59	21	138	25
	Insufficient information	34	12	25	9	59	11
	Total	276	100	275	100	551	100
Letter+visit	No	133	50	172	58	305	54
	Yes	109	41	106	35	215	38
	Insufficient information	25	9	21	7	46	8
	Total	267	100	299	100	566	100
Both	No	296	55	363	63	659	59
	Yes	188	35	165	29	353	32
	Insufficient information	59	11	46	8	105	9
	Total	543	100	574	100	1117	100

Of the 353 patients who received inappropriate RBC units 29% were given one unit inappropriate, 50% received two, 14% received three and 8% received four inappropriate units. This was 10%, 18%, 5% and 3% of patients (in the same order). The counts on which these percentages are based are given in Table 11.

Table 11. Number of inappropriate units transfused per patient

Number of units	N	%	% with
		all patients	information
None	659	59	65
One	101	9	10
Two	177	16	18
Three	48	4	5
Four	27	2	3
Total units classified	1012	91	100
Insufficient information	105	9	
Total patients	1117	100	

The two inappropriateness criteria

Separate results are given for each of the inappropriateness criteria in Table 12 and Table 13. More units were found to be inappropriate by the first criterion (18%) than by the second (15%). This difference was not significant (Fisher's exact test, $P=0.1860$, $OR=0.85$, $z=1.38$).

There was a greater proportion of inappropriate determinations for the letter+visit group than for the letter only group both for the first criterion (Fisher's exact test, $P=0.0007$, $OR=1.7$, $z=3.32$ $P<0.001$) and for the second criterion (Fisher's exact test, $P=0.0031$, $OR=1.6$, $z=2.86$, $P<0.005$).

Table 12. Appropriateness classification of transfusion episode by 1st criterion*

	Letter only		Letter+visit		Both	
	N	%	N	%	N	%
Appropriate	429	78	409	72	838	75
Inappropriate	75	14	121	21	196	18
Insufficient information	47	9	36	6	83	7
Total	551	100	566	100	1117	100

*see page 14

Table 13. Appropriateness classification of transfusion episode by 2nd criterion*

	Letter only		Letter+visit		Both	
	N	%	N	%	N	%
Appropriate	437	79	425	75	862	77
Inappropriate	67	12	105	19	172	15
Insufficient information	47	9	36	6	83	7
Total	551	100	566	100	1117	100

*see page 14

The first unit transfused

Result tables in this section are for the first unit transfused. These are included separately because this is the stage at which the initial decision whether to transfuse or not may have been made. From Table 14 it can be seen that 30% of assessable first unit transfusions were inappropriate. This compares to 35% (Table 9) when the first four units transfused were taken into account, showing that the decisions which led to an inappropriate transfusion episode were largely taken before the first unit was transfused.

Table 14. First unit transfused: inappropriateness at start of transfusion episode

Was 1 st unit inappropriate ?	N	% all 1 st units	% assessable 1 st units
No	691	62	70
Yes	300	27	30
Total assessable	991	89	100
No information	126	11	
Total	1117	100	

Speciality at admission was significantly related to the likelihood of an inappropriate first RBC unit (Chi-square =23.97, Df=3, P<0.0001). A greater proportion of surgical patients receiving transfusions were given an inappropriate first unit than was the case for other admissions (Table 15). Surgical admission were 1.7 times more likely to receive an inappropriate first unit than were medical admissions ($z=3.663$, $P<0.001$, test on log odds ratio).

Table 15 Inappropriate first unit: medical speciality at admission

Medical speciality	First unit inappropriate ?		N
	No (%)	Yes (%)	
Surgical	62	38	424
Medical	74	26	481
Obstetrics & Gynaecology	85	15	61
Other	84	16	25
All	70	30	991

Table 16, Table 17 and Table 18 contain results for transfusion reason, medical risk factors and signs and symptoms related to appropriateness of the first unit transfused. The transfusion reason with the highest level of inappropriate first units were anaemia without symptoms (42%) or pre- or peri-operative (36%).

Table 16. Inappropriate first unit: reason given for transfusion

Transfusion reason	First unit inappropriate ?		N
	No (%)	Yes (%)	
Anaemia	58	42	383
Anaemia with symptoms	95	5	120
Continued, excessive or abnormal bleeding	100		174
Pre- or peri op	64	36	140
Other	40	60	116
Total	69	31	933

(The percentages inappropriate associated with medical risk factors in Table 17 were a consequence of failure to meet the first criterion – haemoglobin 10g/dL or over and no continuing, excessive or abnormal bleeding. This was most likely to have taken place when the risk factor was heart disease. Failure to meet criterion 1 will also be the case for the percentages inappropriate by signs and symptoms given in Table 18.)

Table 17. Inappropriate first unit: medical risk factors

Medical risk factors	First unit inappropriate ?		N
	No (%)	Yes (%)	
Coronary heart disease	89	11	201
Valvular heart disease	80	20	30
Cerebral ischaemia	93	7	41
Carotid artery occlusion	100		1
Congestive heart disease	86	14	63
Respiratory impairment	92	8	60
None stated	57	43	595
Total	70	30	991

Table 18. Inappropriate first unit: signs and symptoms recorded

Sign or symptom	First unit inappropriate ?		N
	No (%)	Yes (%)	
Syncope	91	9	22
Dyspnoea	87	13	31
Angina	88	13	8
Drowsiness	92	8	12
Other	68	32	869
None stated	68	32	27
Total	69	31	969

Table 19 lists frequencies for units transfused subsequent to an inappropriate first unit. A total of 744 units were given subsequent to an inappropriate first unit.

Table 19. Inappropriate first units: count of further units transfused

Number of units transfused:	One	Two	Three	Four	Five	Six or more	Total	
	%	%	%	%	%	%	%	N
Was 1 st unit inappropriate ?								
No	7	45	20	17	4	7	100	2085
Yes	12	52	15	11	3	7	100	846
All	10	47	19	15	4	7	100	2931

Single unit transfusions

For 5% of patients the transfusion given was a single unit of RBC blood. For 44% of patients who received a single unit that was the total amount of blood ordered² for that patient. Results for the appropriateness of single unit transfusions are given in Table 20. When data for both intervention groups were pooled, 45% of single unit transfusions were inappropriate at the first audit and 37% at the second audit. From Table 20 it can be seen that for the letter+visit group inappropriate single unit transfusions appeared to increase substantially between audits, whereas for the letter only group there appeared to be an equally substantial decrease.

² ordered refers to the number of units which the attending clinician ordered be given to the patient.

Counts for these contrasts are small, and the differences were not significant. The same results are presented separately by the two inappropriateness criteria in Table 21 and Table 22. There were no significant contrasts in these tables.

Table 20 . Inappropriateness for single unit transfusions

Intervention	Audit	Appropriate		Inappropriate	
		N	%	N	%
Letter	1	11	58	8	42
	2	23	79	6	21
Letter+visit	1	11	52	10	48
	2	6	35	11	65
Both	1	22	55	18	45
	2	29	63	17	37

Table 21. Inappropriateness for single unit transfusions by the 1st criterion

Intervention	Audit	No		Yes		Insufficient information	
		N	%	N	%	N	%
Letter	1	15	60	4	16	6	24
	2	26	87	3	10	1	3
Letter+visit	1	15	71	6	29		
	2	12	63	6	32	1	5
Both	1	30	65	10	22	6	13
	2	38	78	9	18	2	4

Table 22. Inappropriateness for single unit transfusions by 2nd criterion

Intervention	Audit	Appropriate		Inappropriate		Insufficient information	
		N	%	N	%	N	%
Letter	1	15	60	4	16	6	24
	2	26	87	3	10	1	3
Letter+visit	1	17	81	4	19		
	2	13	68	5	26	1	5
Both	1	32	70	8	17	6	13
	2	39	80	8	16	2	4

Inclusion of information on blood loss not coded as continuing, excessive or abnormal

An open-ended question on the survey sheet asked for information on 'cause' of the transfusion need. Varied and incomplete comments were provided by hospital staff completing the form, but it was noted that these included references to bleeding or used terms implying blood loss although without any indication that the bleeding was abnormal, excessive or continued. This was as expected since this question followed the specific and numerically coded question on continuing, excessive or abnormal bleeding which was incorporated in the application of both inappropriateness criteria. Although it seemed likely that these comments referred to lesser episodes of bleeding, there was a possibility that some of these may have rendered a transfusion appropriate when in fact the rules had classed it as inappropriate. For this reason the inappropriate assessment was remade including all textual information referring to or implying blood loss, irrespective of extent. These results are given in Table 23. This had very little effect on the proportion of inappropriate transfusions (Table 23) with a reduction in the overall inappropriate (Table 9) from 35% to 34%.

Table 23. Percentage inappropriate if transfusions with lesser blood loss are accepted as an appropriate (see text)

Intervention	Audit	Appropriate	Inappropriate	Insufficient Information
(i) Including all transfusions				
Letter	1	63	24	12
	2	70	21	9
Letter+visit	1	51	40	9
	2	61	32	7
Both	1	57	32	11
	2	66	26	8
(ii) Including only transfusions with sufficient information				
Non-intervention	1	72	28	
	2	77	23	
Intervention	1	56	44	
	2	66	34	
All	1	64	36	
	2	71	29	

Validity of risk information

The second criterion concerned transfusions in the range 7- 10 g/dL (8 – 10 g/dL pre- or peri-operative) and the presence of signs, symptoms and risk factors. When these were present the transfusion was classed as appropriate. It seemed possible that in some cases the decision to transfuse may have been based on the presence of these factors, but that information on this may have been omitted from the patients medical records. For this reason an experienced haematologist was asked to examine 60 survey forms from a single hospital with a high inappropriateness rate and to judge from other information (included textual responses to open-ended questions) whether or not there was a possibility of an unstated risk or symptom which if taken into account would reclassify an inappropriate transfusion as appropriate. A small number of such cases were found. The effect of taking these into account was to reduce the inappropriate rate at that hospital by 6%.

Results for individual hospitals

Confidentiality of results for individual hospitals was assured, however the variability between hospitals in transfusion practice is a matter of interest. For this reason results are given separately for each hospital and the numbering used merely indicates sequence in the table and in no way identifies the hospital supplying the data. Inappropriate RBC transfusion results are given for the individual hospitals in Table 24 and are illustrated in Figure 1. Interpretation of the variability between hospitals has to take into account the differences on all major variables found in the first audit, including differences in medical speciality at admission. Characteristics of the hospitals are shown in Tables 25-27. Tables 28 and 29 provide separate results by hospital by inappropriateness criterion. Although the hospitals cannot be identified in these tables, the numbering of hospitals from table to table is consistent.

The apparent differences between hospitals in the measures relevant to inappropriate transfusions were not statistically tested as this level of detail was not relevant to the study. There was in any case a lack of statistical power. Instead an overall test of hospital effect was made. Logistic regression was used to predict inappropriate transfusion episodes from dummy variables representing hospitals. Highly significant prediction was achieved (Chi-squared=40.48, Df=9, $P<0.001$, 64% successful prediction). Age and sex were tested as covariates in this analysis but did not contribute significantly ($P=0.079$ and $P=0.4721$ respectively). Further dummy variables representing the measures shown in Tables 25-27 were then offered in a stepwise procedure whilst hospital was retained in the equation as a covariate entered at the first step. This achieved 80% successful prediction (Chi-squared=378.21, Df=9, $P<0.001$). Finally haemoglobin level (at unit 1) was entered into the equation achieving over 90% successful prediction (Chi-squared=656.74, df=8, $P<0.001$). This high level of success was a consequence of predicting inappropriate transfusions from the measures used to determine inappropriateness. However the procedure also established the independent contribution of the measures used to determine appropriateness, on which hospitals did differ, after any other effects attributable to hospitals had been taken into account.

Table 24. Appropriateness of transfusion by hospital (%)

Hospital	Appropriate	Inappropriate	Insufficient information
(i) Including all transfusions			
1.00	77	20	3
2.00	52	47	1
3.00	53	39	7
4.00	53	34	13
5.00	56	32	12
6.00	63	24	13
7.00	64	24	12
8.00	44	48	8
9.00	66	23	11
10.00	64	24	12
All	659	353	105
(ii) Including only transfusions with sufficient information			
	%	%	
1.00	79	21	
2.00	52	48	
3.00	57	43	
4.00	61	39	
5.00	63	37	
6.00	72	28	
7.00	72	28	
8.00	48	52	
9.00	75	25	
10.00	73	27	
All	659	353	

Note. The numbers given to hospitals are consistent but do not identify hospital.

Figure 1. Inappropriate transfusions at 10 hospitals (% of transfusions classified)

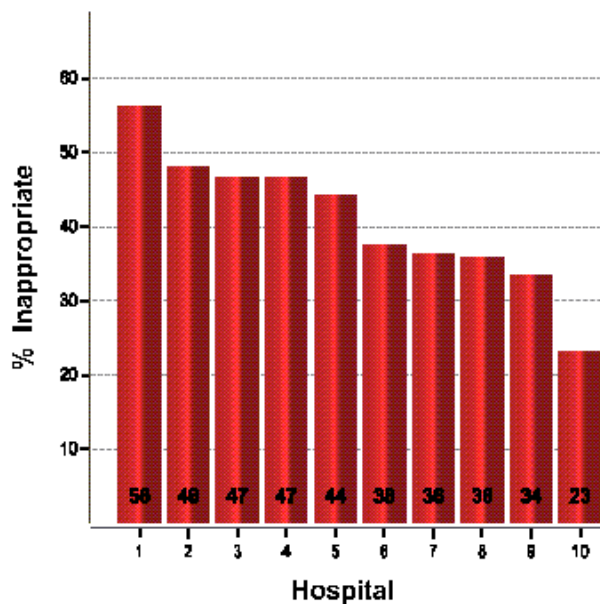


Table 25. Medical speciality at admission by hospital (%)

	Surgical	Medical	Obstetrics & gynaecology	Other
1	36	43	17	4
2	32	57	5	5
3	43	48	9	
4	52	44	3	2
5	38	54	5	3
6	51	43	3	3
7	36	55	3	6
8	65	26	7	1
9	50	46	1	3
10	28	59	8	5
N	484	530	67	36

Note. Numbers given to hospitals consistent with Table 24, but do not identify hospitals.

Table 26. Reason given for transfusion, by hospital (%)

	Anaemia	Anaemia with Symptoms	Excessive Bleeding	Pre- or peri operative	Other
Hospital					
1	34	8	37	15	6
2	46	25	8	14	7
3	44	2	16	19	19
4	40	7	18	27	7
5	57	5	22	12	4
6	29	11	38	9	14
7	40	34	17	1	8
8	34	1	7	25	34
9	41	11	15	23	9
10	28	27	22	1	22
N	408	132	197	154	130

Note. The numbers given to hospitals are consistent but do not identify hospital.

Table 27. Factors indicating increased medical risk, by hospital (%)

	Coronary Heart disease	Valvular Heart disease	Cerebral ischaemia	Carotid artery occlusion	Congestive Heart disease	Respiratory impairment	None stated
Hospital							
1	36	1	6		6	8	44
2	16	5	4	1	4	4	66
3	9	2			12	6	71
4	11	4	3		3	7	71
5	23	3	8		3	3	61
6	14	2	2		13	1	68
7	21	5	4		5	9	56
8	13	2	1		4	1	80
9	28		3		4	8	61
10	25		3		4	8	61
N	218	31	47	1	66	61	693

Note. The numbers given to hospitals are consistent but do not identify hospital.

Table 28. Inappropriate transfusions by criterion 1, by hospital

Hospital	Appropriate %	Inappropriate %	Insufficient Information %
1	84	15	1
2	75	25	1
3	80	17	3
4	65	26	8
5	82	11	7
6	69	18	13
7	80	11	9
8	67	25	8
9	75	14	11
10	75	12	12
N	838	196	83

Table 29. Inappropriate transfusions by criterion 2, by hospital

Hospital	Appropriate %	Inappropriate %	Insufficient Information %
1	93	6	1
2	73	26	1
3	72	26	3
4	83	8	8
5	70	23	7
6	82	6	13
7	78	13	9
8	66	25	8
9	81	8	11
10	75	13	12
N	838	172	83

Transfusions with haemoglobin $\geq 10\text{g/dL}$ without continued, excessive or abnormal bleeding

When haemoglobin was 10g/dL or more the unit transfused was classified as inappropriate unless there was continuing, excessive or abnormal bleeding. However although at this haemoglobin level the assigned speciality, reasons given for transfusion, medical risk factors and signs or symptoms were not taken into account by the criteria, they may have influenced the clinical decision to transfuse. If so then information on this might aid development of appropriateness protocols.

Table 30 to Table 34 present results relating inappropriate transfusion of the first unit when haemoglobin was ≥ 10 g/dL to medical speciality, reasons for transfusion, risk factors and signs and symptoms. The letter only and letter + visit groups did not differ significantly in the number of transfusions with haemoglobin ≥ 10 g/dl (Table 30).

Table 30. Number of inappropriate first units with haemoglobin ≥ 10 g/dL

Intervention	1 st Audit	2 nd Audit	Both Audits
	N	N	N
Letter only	35	19	54
Letter+visit	49	38	87
Total	84	57	141

Fisher's exact test P=0.3786).

Table 31. Percentage of first units inappropriate when haemoglobin ≤ 10 g/dL by medical speciality

Medical speciality	Letter only			Letter+visit		
	1 st Audit %	2 nd Audit %	Both %	1 st Audit %	2 nd Audit %	Both %
Surgical	60	68	63	88	66	78
Medical	26	21	24	12	34	22
Obstetrics & gynaecology	14	5	11			
Other		5	2			
Total	100	100	100	100	100	100

From Table 31 it can be seen that most first unit transfusions ≤ 10 g/dL were for surgical admissions. This was the case both at first and second audit and for both treatment groups. Loglinear modeling established significant effects for the surgical ($z=8.91$, $P<0.0001$) and medical ($z=8.38$, $P<0.0001$) categories, but with no significant differences for audit, treatment or for interaction terms.

Table 32. Percentage of first units inappropriate when ≤ 10 g/dL (criterion 1) by transfusion reason

Transfusion reason	Letter only			Letter+visit		
	1 st Audit %	2 nd Audit %	Both %	1 st Audit %	2 nd Audit %	Both %
Anaemia	39	36	38	14	37	24
Anaemia with	7	7	7	2	5	3
Pre-or peri-op	32	26	21	59	32	47
Other	21	57	33	24	26	25
Total	100	100	100	100	100	100

The reasons given for transfusion ≤ 10 g/dL overall were pre- or peri-operative (39%), anaemia without symptoms (29%) or other (28%). Less than 5% were for anaemia with symptoms. These percentages are given separately by intervention group in Table 32. The treatment groups differed significantly at both audits and overall (chi squared = 15.81, $df = 3$, $P<0.001$).

Table 33. Percentage of first units inappropriate when $\leq 10\text{g/dL}$ (criterion 1) by risk factor

Increased Medical risk factor	Letter only			Letter+visit		
	1 st Audit	2 nd Audit	Both	1 st Audit	2 nd Audit	Both
	%	%	%	%	%	%
Coronary heart disease	20	26	22	6	21	13
Valvular heart disease	6	5	6		8	3
Cerebral ischaemia		11	4	2		1
Congestive heart disease		11	4	6	11	8
Respiratory impairment		5	2	4	5	5
None stated	74	42	63	82	55	70
Total	100	100	100	100	100	100

The most common risk factor reported when inappropriate transfusion had been made at $\leq 10\text{g/dL}$ was heart disease at 29% for both treatment groups pooled, but for 67% of these transfusions, again overall, no risk factor was given on patients medical record. For both treatment groups significantly more risk factors were recorded at the second audit (Fisher's exact test, letter only group $P=0.021$; letter+visit group $P=0.027$). These results are given in Table 33.

Table 34. Percentage of first units inappropriate when $\leq 10\text{g/dL}$ (criterion 1) by sign or symptom (%)

Sign or symptom	Letter only			Letter+visit		
	1 st Audit	2 nd Audit	Total	1 st Audit	2 nd Audit	Total
Syncope	3	5	4			
Dyspnoea		5	2	4	3	3
Angina	3		2			
Drowsiness					3	1
Other	76	89	81	96	95	95
Not Stated	18		11			
Total	100	100	100	100	100	100

There were very few relevant signs or symptoms in cases where the transfusions were inappropriate because haemoglobin level was $\leq 10\text{g/dL}$ (less than 6% overall). Further there were no significant differences between audits or treatment. These results are given in Table 34.

Varying the lower cutpoint for inappropriate transfusion

The second criterion used for determining inappropriateness used a lower cutpoint of 8g/dL for pre- and peri-operative transfusions and 7g/dL for all other transfusions. Results for applying an identical cutpoint to all transfusions irrespective of speciality are shown in this section. For these the cutpoint was varied across the range 6g/dL to 10g/dL. The first value provided a start below recommendations. The last value in effect turned criterion 2 off, leaving as inappropriate only transfusions where haemoglobin was 10g/dl or over with no continued, excessive or abnormal bleeding. These results are shown in Figure 2 with the percentages expressed as percent of transfusions with sufficient information for determining appropriateness. They are also shown as percent of all transformations providing a conservative, under-estimate, of inappropriateness (Figure 3).

Figure 2. Effect on inappropriateness of varying criterion 2 cutpoints (% of classified)

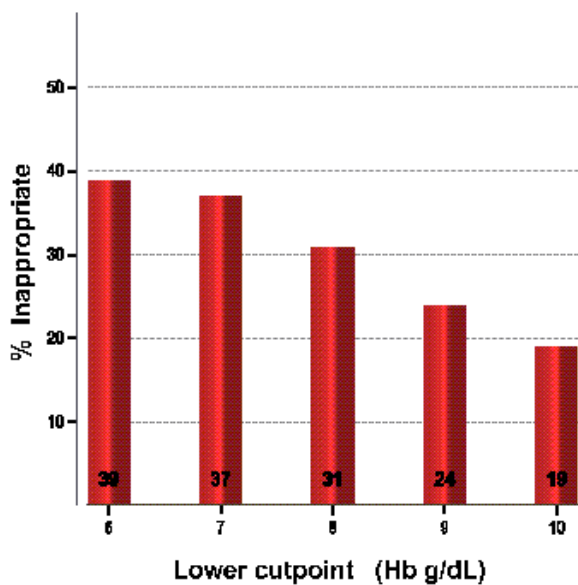
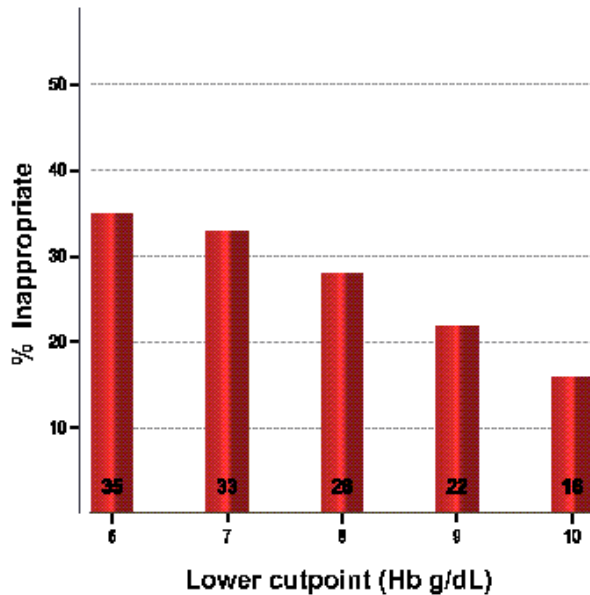


Figure 3. Effect on inappropriateness of varying criterion 2 cutpoints (% of all transfusions)



Blood and treatment characteristics

Table 35 contains appropriateness results by blood type. Table 36 contains appropriateness results by treatment given immediately after transfusion.

Table 35. Blood type by appropriateness categories

	% of appropriate transfusions	% of inappropriate transfusions	Probability*
O-negative	6	6	.931
O-negative to O-negative	55	76	.273
Percent autologous ?	1	6	.003

*Probability for difference between appropriate and inappropriate transfusions on the item listed.

Table 36. Post transfusion treatment[°] by appropriateness categories

	% of appropriate transfusions	% of inappropriate transfusions	Probability*
Clear fluids ♦	36	32	.324
Iron ♦	18	14	.001
B12 ♦	11	8	.001
Folate ♦	14	9	.001

*Probability for difference between appropriate and inappropriate transfusions on the item listed.

~ Patient was given transfusion prior to being given this item.

° Not included in table – ‘Did patient receive erythropoietin ? ‘ There were only 4 positive responses to this question.

Documentation

Information was collected on IV fluid sheet documentation and also on whether or not the cross-match (request for blood) form was correctly signed. These results are given in Table 37. These results are given separately for the first unit transfused (all cases in study received a first unit), and then for the first four units. Documentation information for units transfused after the fourth was not collected.

Table 37. Documentation of the transfusion

	Yes		No		No information or not found		Total units*	
	N	%	N	%	N	%	N	%
<u>First transfused unit:</u>								
Correctly documented on IV fluid sheet	939	84	118	11	60	5	1117	100
Cross-match request form correctly signed	819	73	46	4	252	23	1117	100
<u>First four units transfused:</u>								
Correctly documented on IV fluid sheet	2409	89	246	9	46	2	2701	100
Cross-match request form correctly signed	2079	80	89	3	436	17	2604	100

*Some units included in the total for first 4 transfused were not included in earlier tables because missing values prevented classification. The missing item was usually Hb level.

Pre-test differences between the intervention groups

It was clear from the analyses presented in sections 1 to 4 of these results that there were significant differences between the audit and treatment groups which had not been controlled by the random allocation of hospitals to group. Possible reasons for this will be considered in the Discussion section of this report. The present section considers solely their likely effect on the estimates of inappropriateness.

The use of logistic regression, or a similar method, to remove the unwanted effects statistically would be unsound, although it has been shown above that the influence of differences between hospitals other than from these sources can be controlled by that method. This is because the variables concerned - medical speciality, presence of risk factors, transfusion reason, signs and symptoms - would contribute to both sides of the regression equation, i.e. in the determination of inappropriateness and to the prediction (as covariates) of inappropriateness. This would not be the case if analysis were restricted to inappropriateness solely as judged using the first rule, haemoglobin ≤ 10 g/dL, but this would involve omitting a major component of the assessment of inappropriateness (criterion 2). For these reasons attempts to remove pre-intervention differences between the groups were not made. These problems in no way effect the overall estimates of inappropriateness where any audit and intervention group differences and hospital differences are pooled.

DISCUSSION

This study has found that 35% of blood transfusions in major metropolitan hospitals in Sydney in 1998-99 were potentially inappropriate. The results for surgical patients was 42%; for medical patients 32%, and for obstetrics and gynaecology 16%. When we considered the appropriateness of only the first unit transfused, the results were 30% and 38% and 26% and 15% for the same specialities respectively. A small percentage of transfusions (9% overall) could not be classified as appropriate or inappropriate because information needed - usually haemoglobin level - was omitted from patient records. Some of these will have been appropriate and some inappropriate, but if all were classed as appropriate then the overall percentage inappropriate would be reduced from 35% to 32%.

There was an apparent reduction in inappropriate transfusion rates between the first and second audits for both intervention groups. This was greatest for the group with the less intensive intervention (29% first audit, 21% second audit) and for this group the reduction was significant. The reduction for the more intensive intervention was from 41% to 35% and was not significant. There was a lack of comparability between these groups in that they differed in inappropriate rates at the first audit, before the intervention, despite the random allocation of hospitals to groups. This does not effect the overall estimates of inappropriateness, but does cast doubt on the adequacy of the sample size to randomise hospital differences at the level of testing the intervention effect.

All hospitals sampled agreed to participate in the study, negating the possibility of hospital selection bias. The inclusion of all but one of the major metropolitan hospitals increased the likelihood that results are generalisable to comparable hospitals in NSW and Australia. There were no selection criteria for individual medical records within the time period sampled. The period of review for the first audit was conducted retrospectively to ensure its conduct did not influence clinician behaviour and to avoid the summer period in which many usual hospital staff were likely to be on holiday.

Measures

Potential problems of reliability of the data collected were reduced by the following methods. First, coders were merely required to extract specific data from the medical record using a standardised and piloted at a hospital not involved in the study. Second, instructions were provided on how to complete the form and a member of the project team visited hospitals to provide hands-on instruction. Third, research staff experienced in auditing medical records checked the data once it had been collected and telephoned, or visited as necessary, hospitals to correct missing or inconsistent items. Fourth, as the appropriateness of the transfusions rested in part on clinical indicators, which may inadvertently have been omitted from medical records, steps were taken to estimate the likely extent of any effect from such omission. Finally, it was reasonable to assume that any remaining differences would be distributed evenly between both intervention groups and would cancel when comparisons were made between them.

Classification criteria

Our classification criteria were based on the systematic review of the literature and are directly comparable to the criteria used by other Australian investigators, Metz, (1995) and Tuckfield, (1997). Our results indicate levels of inappropriate RBC transfusion higher than those recorded in the latter studies (16%). These were both conducted at a large Melbourne tertiary referral teaching hospital with a haematology unit actively engaged in blood transfusion research. To enable some comparison with their data, we abstracted records from a large Sydney tertiary referral teaching hospital with a haematology unit which reportedly promotes good blood transfusion policy and practice. Of 60 records taken from the same time period as the first audit, we classified 20% as potentially inappropriate. This figure reasonably approximated that of the Melbourne group.

While our levels of inappropriate RBC transfusion are in line with the very broad range derived from the literature review (Hebert 1997), there are a number of factors which could influence our classification. There may have been errors linking particular haemoglobin results with specific transfusion units given.

We recorded separately and checked date and time of each unit transfused, up to the fourth, and also the date and time of each haemoglobin measurement immediately before and during the transfusion episode. We have no reason to believe that there would be a systematic error in recording these, or in utilising them to assess appropriateness.

Medical risk factors or signs and symptoms present may not have been recorded in the medical record. If this were the case then we would expect any effect to be randomly distributed in the first and second audits at the same hospital and thus to be balanced in comparisons between the two intervention groups. Even so the effect of missing risk factors, signs or symptoms would be to increase inappropriate transfusion classifications. Inappropriateness in terms of the first criterion, haemoglobin of 10 g/dL or over, would be overstated if information on continuing, excessive or abnormal bleeding were not recorded. Inappropriateness in terms of the second criterion, haemoglobin of 7 g/dL (8 g/dL pre- or peri-operative) or over and less than 10 g/dL plus risk factors or signs and symptoms, would be overstated if information on these were not recorded. We dealt with these potential problems in a number of ways. An experienced haematologist examined every data form from one hospital (N=60) and took into account every item of patient information and made a judgment as to whether or not a relevant risk factor, sign or symptom may possibly have been present but was unrecorded. The effect of this was to reduce inappropriate transfusion at that hospital by 6%. An analysis was made in which every transfusion where there was a reference to blood loss, either directly or indirectly, in answer to open-ended questions was reclassified as appropriate, even if this was not said to have been 'continuing, excessive or abnormal'. This very conservative reassessment of inappropriateness reduced the overall rate from 35% to 29%.

Quality of the interventions

Both interventions were comparatively weak. The letter only group were sent their audit results, together with the systematic review, and recommendations for potential hospital action and an offer of assistance if required. This offer was not taken up by any hospital in this group. It is possible that as the results were taken as an audit, there may have been little incentive or motivation to take subsequent remedial action. We do not have information on whether or not the results were presented to or discussed with relevant clinical staff in these hospitals.

Moreover, if they were, clinicians on learning the results may have disregarded them as they had not yet been subject to peer review.

Our visits to the letter + visit group of hospitals consisted of a once only visit with a maximum one hour session with management and clinicians. The meetings were invariably difficult to set up and at three of five of the hospitals, poorly attended by important specialty groups. At two of the hospitals the meeting coincided with the medical staff meeting with absence of surgical, anaesthetic and obstetric specialists. Some of the staff at these meetings may have paid less attention to the results as they had not been subject to peer review. Indeed the results we presented were repeatedly challenged (without supporting data) at two of the letter + visit hospitals. At other hospitals, staff attending the meeting were receptive of the results and enthusiastic for action to reduce inappropriateness levels. None of the staff of hospitals visited contacted us for further information or assistance in devising procedures that might help reduce inappropriate transfusions. None of the hospitals visited had transfusion policies that were clearly in place. Finally, we allowed a relatively short period for any policy changes that might have been made to be implemented. Our second audit commenced after as short as six weeks from the intervention visit or letter. All things considered however, our results remain disappointing in the light of previous investigations with interventions that have reduced inappropriate RBC transfusion levels from 16% to 3% (Tuckfield 1997) through specifically designed blood request forms for transfusion of blood with restricted indications for transfusion and clinical laboratory data included in the form.

A further possible aspect of the interventions, which cannot be isolated, was the effect of the first audit not only on the hospital clinical staff where it was made, but also on the performance of staff abstracting the data. Control of this effect was beyond our resources as it would have necessitated a group of hospitals tested only at first audit and another group tested only at second audit. There was, however, some unmeasured evidence that at hospitals where return of first audit data was slow there was reactivity with responsible staff since pressure was applied to speed up procedures.

Fortuitously, this was more the case for hospitals in the less intensive intervention group, who will have consequently been more familiar with project staff than was intended. Although the

extent of influence from this source, if any, cannot be tested, it could possibly account for the greater reduction in inappropriateness rates for hospitals in this group.

Modification of appropriateness criteria

The second inappropriateness criterion used a more lenient lower cutpoint for pre- and peri-operative (8 g/dL) than for other patients (7 g/dL). When the 8 g/dL cutpoint was applied to all transfusions, irrespective of speciality, the inappropriateness rate was still over 30%. Even when the lower cutpoint for the second criterion was raised to 9 g/dL for all specialities inappropriate transfusion remained close to 25%. These results suggest that a substantial proportion of clinicians transfusing their patients may be unaware of the risks of transfusing at higher haemoglobin levels (Hill 1999).

In the financial year 1998/99, 211,170 units of RBC were issued by the Australian Red Cross Blood Service – NSW (Dr Mark Dean, personal communication 24 March 2000). Extrapolating our results would suggest that up to 72,000 units may have been inappropriately used with attendant costs and morbidity risks. Reducing inappropriate transfusions from 34% to 10% could potentially save \$8.362m ($\$165 \times 211,170 \times 0.24$) per year for more productive use in the health system.

Conclusions

Over 30% of RBC transfusions in Sydney major metropolitan hospitals were judged potentially inappropriate by criteria previously used in Australian hospital settings. Interventions to reduce the number of inappropriate transfusions comprising feedback of audit results and educational visits appeared to have only a modest effect and may have reduced the level of inappropriate RBC transfusions by 5-10%. There was substantial variation in inappropriate practice across study hospitals. Reducing inappropriate RBC transfusions in NSW from 32% to 10% could potentially save more than \$7m per year and free these resources for other more effective interventions.

Recommendations

1. That NSW Health, The Australian Red Cross Blood Service - NSW and relevant Colleges develop RBC transfusion policies with criteria for use as soon as possible. These policies should include guideline triggers for RBC transfusion and recommended hospital blood request form formats with these guidelines. All RBC requests should include information permitting assessment of adherence to the guidelines.
2. The RBC transfusion guidelines should be prescribed for use in all hospitals where blood transfusion are conducted and their implementation should be monitored as part of the hospital's ongoing safety and quality monitoring processes. Guideline adherence should be benchmarked against comparable hospitals. All hospitals should be required to demonstrate improvement in the level of inappropriate transfusions over time.
3. NSW Health and the Australian Red Cross Blood Service – NSW should devise an education strategy to inform clinicians and managers working with blood transfusion services of the results of the systematic review and the newly developed transfusion policies and practices. These efforts should be targeted on a group and individual basis to all clinicians who request blood products.

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APPENDIX 1:
Data Collection Form

APPENDIX 2:

Summary of Systematic Review

From: Hill, SR, Carless, PA, Henderson, K, Henry, DA (1999). Improving the Appropriateness of Red Blood Cell Tranfusion in New South Wales Hospitals

**APPENDIX 3:
Letter to Hospitals**

