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ORIGINAL ARTICLE

The EASTR Study: indications for transfusion and estimates of transfusion recipient numbers in hospitals supplied by the National Blood Service

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SUMMARY. This study provides data on National Blood Service (NBS) red blood cell (RBC, $n = 9142$), platelet (PLT, $n = 4232$) and fresh frozen plasma (FFP, $n = 3584$) recipients independently sampled by monthly quota from 29 representative hospitals over 12 months in 2001–2002. Hospitals were stratified by size according to total yearly RBC issues. Transfusion indications were chosen from diagnostic and procedural codes, and recipients grouped into Epidemiology and Survival of Transfusion Recipients Case-mix Groups (E-CMGs). The main E-CMGs were digestive [19% of RBC recipients; including 5% gastrointestinal (GI) bleeds and 3% colorectal surgery], musculoskeletal (15%; 12% hip and knee replacement), haematology (13%) and obstetrics and gynaecology (10%). Renal failure, fractured neck of femur, cardiac artery by-pass grafting (CABG) and paediatrics, each accounted for 3–4% recipients. FFP recipients: the main E-CMGs were digestive (21% of FFP recipients; including 7% GI bleeds and 3% colorectal surgery), hepatobiliary (15%; 7% liver disease and 2% liver transplant), cardiac (12%) and paediatrics (9%) The renal, paediatrics, vascular and haematology E-CMGs each had 6–7% of recipients. PLT recipients: the main E-CMGs were haematology (27% of PLT recipients; including 9% lymphoma and 8% acute leukaemia), cardiac (17%), paediatrics (13%), hepatobiliary (10%) and digestive (9%). Back-weighting gave national estimates of 433 000 RBC, 57 500 FFP and 41 500 PLT recipients/year in England and North Wales, median age 69, 64 and 59 years, respectively. Digestive and hepatobiliary indications emerged as the top reason for transfusion in RBC and FFP recipients, and was also a frequent indication in PLT recipients.

Key words: blood transfusion, FFP, ICD-10, OPCS-4, platelets, red cell transfusion, transfusion recipients.

INTRODUCTION

Blood services throughout the world aim to provide a safe and reliable supply of blood components for all patients who need them. Although good internal management data are generally available, there has been a lack of information on blood component usage in hospitals. In recent years there have been a number of studies that have aimed to provide these data. These studies have usually presented results for all transfusion recipients or for red cell recipients alone (Mathoulin-Pelissier *et al.*, 2000; Tynell *et al.*, 2001; Stanworth *et al.*, 2002; Wells *et al.*, 2002; Tynell *et al.*, 2005; Palo *et al.*, 2006a). Falling donor numbers, increasing demands for blood safety and economic

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restrictions mean that such information is increasingly important for policy making. In the UK, the assessment of risk reduction steps for prevention of transfusion-transmitted vCJD required risk–benefit and cost–benefit analyses (Ludlam & Turner, 2006). When such work was begun in the late 1990s, there were no national data on basic parameters such as the number of individuals transfused each year. To ensure effective use of resources, information is required to provide an accurate understanding of transfusion recipients, the components they receive, the reasons they are transfused and their survival after transfusion.

The Epidemiology and Survival of Transfusion Recipients (EASTR) study has gathered data on transfusion recipients treated in hospitals supplied by the National Blood Service (NBS). The objectives of the study were to identify a representative dataset of red cell, fresh frozen plasma (FFP) and platelet (PLT) recipients, to document their age, gender and the components they received, and to establish the indications for which they were transfused, using information extracted from hospital records including diagnostic and procedural codes. The study will also follow the survival of recipients for 10 years after transfusion.

Before undertaking this survey, a pilot study was performed to inform calculation of the number of recipients required and to develop a data collection and analysis method suitable for a national study (Llewelyn *et al.* 2009). Previous studies of transfusion have mostly used the diagnostic codes recorded for hospital admissions and day cases to classify indications for transfusion e.g. International Statistical Classification of Disease and Related Health Problems 10th Revision (ICD-10) (World Health Organisation, 2005). Alternatively, procedure codes such as the UK Office of Population, Censuses and Surveys –Classification of Surgical Operations and Procedures –4th Revision (OPCS-4) have been used to identify a sub-set of recipients who have undergone surgery and to examine the types of operations being performed (NHS Connecting for Health, 2006). Using both these sources of information as a starting point, we developed a novel algorithm to select the appropriate indication for transfusion and collate these into a unified set of clinically relevant EASTR Case-mix Groups (E-CMG). Although these were devised especially for the EASTR study, they could be applied to other surveys of the use of blood components (Llewelyn *et al.* 2009). We have now applied this methodology to three independently selected cross-sectional samples of red blood cells (RBC), FFP and PLT recipients from 29 representative hospitals supplied by the NBS. This paper presents demographic details of these recipients and an analysis of their indications for transfusion. Information on repeat transfusions and donor exposure rates, post transfusion survival and paediatric usage are not given in this paper.

METHODS

Study design

EASTR was designed as a retrospective multi-centre epidemiological study, with cross-sectional sampling of transfusion recipients over a period of 1 year, and prospective survival monitoring for over 10 years (ongoing). The study includes three separate groups of patients transfused with red cells (RBC), FFP and PLTs over a 12-month period (1st October 2001 to 30th September 2002). On the basis of the pilot study data obtained in early 2001, sufficient patients were chosen to allow characterization of the most frequent indications for RBC, FFP and PLT transfusion. The sample size allowed for adequate representation from hospitals of all sizes supplied by the NBS, with seasonal variation taken into account by monthly sampling across the year.

Ethics approval

The study was approved by the Eastern Multi-Centre Research Ethics Committee, and further approval was obtained as necessary from each of the participating hospitals. It was not practical to obtain individual informed consent from transfusion recipients, therefore permission was obtained in 2003 from the Patient Information Advisory Group for the collection of patient-identifiable data under Section 60 of the Health and Social Care Act, 2001 (Malfroy *et al.*, 2004).

Selection of study hospitals

The NBS is the sole supplier of blood components to hospitals in England and North Wales. Data on total RBC issues to all hospitals during 2001 were collected and used to stratify hospitals into large, medium and small according to red cell usage (>9500 RBC units, 5000–9500 RBC units and <5000 RBC units issued per year, respectively). Twenty-nine representative hospitals (14 large, 9 medium and 6 small) were selected from across the three main geographical regions supplied by the NBS: North England and North Wales, Midlands and South-West England, and London and South-East England (Fig. 1). These regions accounted for 37, 27 and 37% of total RBC units issued by the NBS during the study year. The higher proportion of large hospitals sampled (Table 1) reflected the higher use of NBS blood components by these hospitals. No independent specialist hospitals, such as a

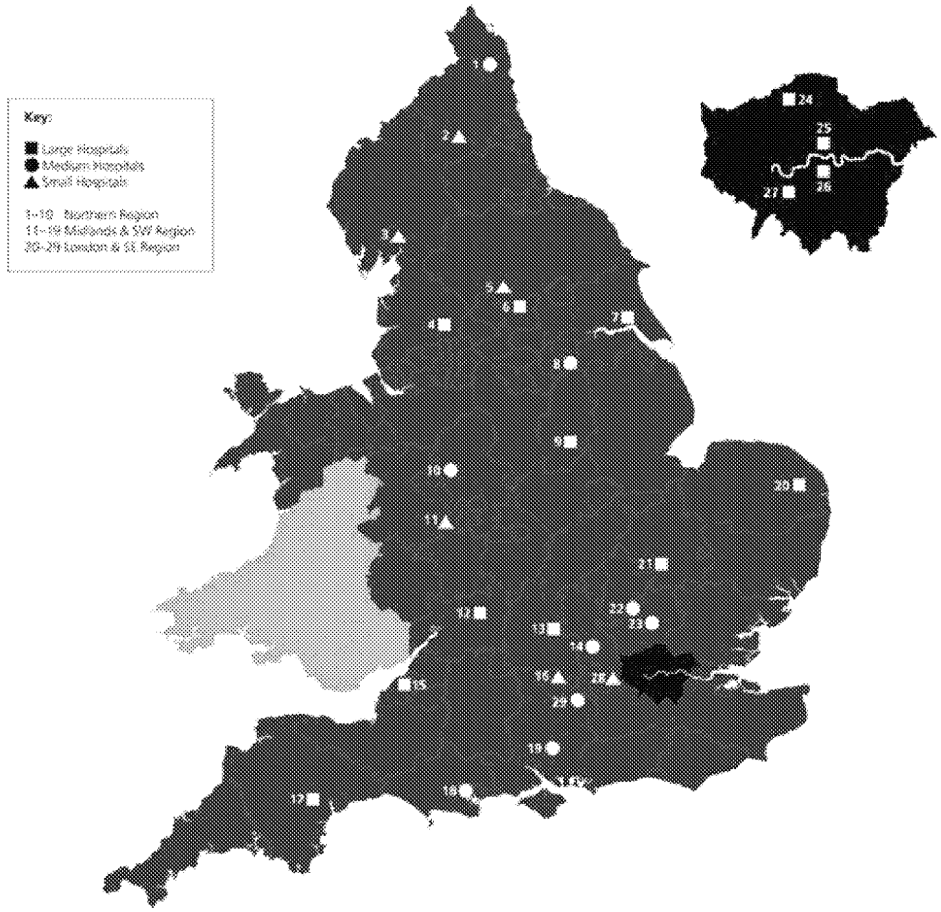

Fig. 1. Map of England and North Wales showing hospitals participating in EASTR.

children's hospital, were selected. Although study hospitals should ideally have been chosen randomly, the final choice was influenced by practical issues such as the availability of hospital staff, the suitability of hospital computer systems to extract study data and willingness of hospitals to participate in the study.

Sampling strategy for selection of recipients

The transfusion laboratory computer system at each study hospital provided details of all transfusion episodes for the 12-month study period. For the purposes of patient selection a transfusion episode was defined as a calendar day during which one or more blood components were issued for a patient. All units issued and not recorded as returned to the laboratory or wasted were included in the study. The actual dates of transfusion were not recorded by any of the participating hospitals and therefore the dates of issue from the hospital blood bank have been used as surrogates. It was not feasible to check hospital notes for confirmation of transfusion.

Transfusion episodes within the 12-month study period were ordered by date, before applying a monthly sampling quota to select independently RBC, FFP and PLT recipients for inclusion in the study. The quotas for each recipient group were based on the product distribution observed in the pilot study and differed according to hospital size (Table 1). Transfusion recipients were selected from the first day of each calendar month until either the monthly quota was completed or until all available recipients for that month were used up. A transfusion recipient could only be selected once *within* each component group. However, a transfusion recipient could be selected for inclusion in one, two or all three component groups.

Allocation of the indication for transfusion

Information on hospital admissions for selected transfusion recipients, including day case attendances, throughout the study year was obtained from each participating hospital's Patient Administration System (PAS). Data extracted included primary and secondary

Table 1. Sampling scheme and units transfused to selected recipients by hospital size

Hospital size	Small	Medium	Large	Total
All hospitals supplied by NBS	125	110	81	316
Hospitals selected for inclusion in study	6	9	14	29
RBC recipients				
Number of RBC recipients transfused during year at participating hospitals	3664	13 831	48 335	65 830
Monthly sampling scheme for selection of RBC recipients*	8	18	38	64
Total number of RBC recipients sampled across year	576	2184	6382	9142
FFP recipients				
Number of FFP recipients transfused during year at participating hospitals	170	1615	8595	10 380
Monthly sampling scheme for selection of FFP recipients*	4	9	19	32
Total number of FFP recipients sampled across year	133	1021	3078	4232
PLT recipients				
Number of PLT recipients transfused during year at participating hospitals	97	786	7476	8359
Monthly sampling scheme for selection of PLT recipients*	4	9	19	32
Total number of PLT recipients sampled across year	92	728	2764	3584

*Number of recipients sampled at each hospital every month. Sampling of recipients was carried out independently for each component by monthly quota according to hospital size.

diagnoses recorded as ICD-10 codes, and primary codes for any operations or procedures performed recorded as OPCS-4 codes. Transfusion episodes were matched to hospital admissions by date as described in the accompanying paper except that in EASTR we included blood bank issues that occurred up to 5 days before a hospital admission or day case, instead of 3 days to improve matching between the two data sets. The method developed to select transfusion indications from coding data is explained in greater detail in the accompanying paper (Llewelyn *et al.* 2009).

Analysis

The hospital admission which included the transfusion episode used to select a recipient for inclusion in the study was defined as the index admission. All units transfused during an index admission were recorded. For each recipient group (RBC, FFP and PLT), the transfusion indication selected for the index admission was collated into E-CMGs, which combined both medical and surgical patients into clinically relevant groups (Llewelyn *et al.* 2009), with all patients aged less than 16 years at the index transfusion assigned to the paediatric group.

Information on indications for transfusion (RBC, FFP, and PLT) was available only on the recipients sampled within each hospital (the E-CMG). To produce national estimates of the numbers of patients transfused for each indication, we needed to combine the estimates from each hospital using the two-stage stratified study design, a process known as back-weighting. The first stage was to back-weight the patient numbers for a specific indication in a specific hospital by the ratio of the number of patients transfused in that hospital divided by the number of patients sampled in that hospital; the second stage was to back-weight by the ratio of the national number of hospitals in the appropriate stratum (small, medium or large) divided by the number of hospitals of each size that were sampled. The back-weighted patient numbers for each indication were then summed across the sampled hospitals to produce national estimates with 95% confidence intervals (CIs) using the survey procedure in STATA (Version 9.1, Stata Corp LP, Lakeway Drive, College Station, TX, USA). Besides estimating the total number of recipients for each procedure, we can also estimate the total number of units issued for each E-CMG, and by summing, the total number of units issued to hospitals nationally. Our estimates of the latter considerably exceeded the actual number of units issued by the NBS. Further investigation revealed that by chance that our sampled hospitals within each stratum (small, medium and large) used more components than the national average for each stratum. Consequently, we replaced the second-stage back-weighting ratios (national number of hospitals in each stratum divided by the number of sampled hospitals in each stratum) by the ratios of the total number of national issues divided by the number of issues within each hospital size stratum to produce the estimates reproduced in Tables 2–4 (together with their 95% CI). Throughout the back-weighting procedure, paediatric split packs were converted to adult units using fractions of 1/6 for RBC, and 1/4 for both FFP and PLT.

Data on all units issued to selected recipients over the entire study year are not presented. EASTR data were held in a computer database (Microsoft Access 97, Microsoft Corporation, Redmond, WA, USA) and analysed using Access, Microsoft Excel 97 and STATA.

Table 2. E-CMGs for sampled RBC recipients, estimated national totals and mean units transfused in Index Admission

	RBC recipients sampled			Estimated NBS annual number of RBC recipients†			Percentage of recipients within E-CMG			RBC units transfused	
E-CMG and sub-group*	Median age	(IQR)	Number	Total	95% CI	Percentage‡	Male	Surgery	Cancer	Mean	95% CI
Digestive	74	(62–82)	1480	73 036	66 337–79 735	19	49	34	36	4.8	4.5–5.0
GI bleed			366	19 143	15 857–22 430						
Colorectal surgery			246	12 617	9640–15 594						
Peptic ulcer disease			199	9818	7338–12 299						
Stomach & duodenum			132	6282	4128–8435						
Inflammatory bowel disease			98	4690	3103–6278						
Colon cancer			96	4399	3240–5557						
Musculoskeletal	73	(64–81)	1069	58 856	53 628–64 085	15	31	93	8	3.0	2.9–3.2
Total hip replacement			616	35 678	31 627–39 728						
Total knee replacement			224	13 061	10 480–15 643						
Haematology	72	(55–82)	1107	52 613	47 998–57 228	13	46	0	41	3.6	3.5–3.8
Anaemia –cause unknown			272	14 746	12 500–16 992						
Lymphoma			240	10 691	8680–12 702						
Iron deficiency			149	7654	6113–9195						
Myeloma			91	4496	3001–5991						
Myelodysplastic syndrome			88	4035	2827–5242						
Acute leukaemia			96	3829	2571–5088						
O&G	36	(29–48)	768	38 329	30 773–45 885	10	0	46	20	3.9	3.4–4.4
Obstetrics			386	19 426	13 015–25 838						
Gynaecology			382	18 903	16 059–21 747						
Renal	73	(62–81)	696	32 041	28 008–36 074	8	68	23	45	4.0	3.7–4.3
Renal failure			285	12 780	10 309–15 250						
Prostate cancer			105	4773	3369–6176						
Other disease groups	61	(49–75)	534	24 261	20 843–27 680	6	37	32	49	3.6	3.4–3.9
Breast			119	5809	4410–7207						
Mouth, head, neck, ears			116	4902	3435–6369						
Infection			82	4022	2381–5664						

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Table 2. continued

E-CMG and sub-group*	RBC recipients sampled			Estimated NBS annual number of RBC recipients†			Percentage of recipients within E-CMG			RBC units transfused	
	Median age	(IQR)	Number	Total	95% CI	Percentage‡	Male	Surgery	Cancer	Mean	95% CI
Trauma	80	(58–88)	538	25 306	20 427–30 185	6	37	75	3	4.1	3.6–4.6
Fractured neck of femur			291	14 192	11 898–16 487						
Cardiac	69	(62–75)	581	20 447	17 405–23 489	5	68	99	2	4.8	4.4–5.2
Coronary artery by-pass			406	14 312	11 649–16 975						
Valve surgery			132	4607	3448–5767						
Paediatrics	<1	(<1–7)	409	16 350	11 595–21 105	4	58	26	15	2.0	1.6–2.4
Hepatobiliary	60	(48–71)	341	15 601	12 264–18 939	4	54	33	33	5.8	5.1–6.6
Liver disease			139	6656	4574–8739						
Respiratory	71	(59–78)	336	15 559	11 884–19 234	4	52	14	52	3.7	3.2–4.3
Unassignable	67	(51–80)	212	11 439	8578–14 300	3	42	0	0	3.3	2.8–3.7
Vascular	74	(65–80)	229	10 003	7665–12 342	3	63	93	6	6.7	5.8–7.6
Unavailable	75	(62–84)	842	38 840	33 518–44 161		46	n/a	n/a	4.1	3.8–4.4
Total	69	(51–79)	9142	432 682	417 442–447 921		44%	40%	24%	4.0	3.9–4.1

*Data shown for sub-groups where national estimate is approximately 4000 recipients and above.
†Back-weighted estimate for total number of RBC recipients across England and North Wales.
‡% given is total number within E-CMG divided by total number of recipients with available data (432 682 –38 840 = 393 842).

Table 3. E-CMGs for sampled FFP recipients, estimated national totals and FFP units transfused in Index Admission

E-CMG and sub-group*	FFP recipients sampled			Estimated NBS annual number of FFP recipients†			Percentage of recipients within each E-CMG				FFP units transfused	
	Median age	IQR	Number	Total	95% CI	Percentage‡	Male	Surgery	Cancer	Cryo§	Mean	95% CI
Digestive	72	(61–81)	839	11 398	10 019–12 778	21	53	47	26	6	5.3	5.0–5.7
GI bleed			272	3740	3024–4456							
Colorectal surgery			147	1997	1414–2579							
Peptic ulcer disease			85	1118	795–1581							
Stomach & duodenum			70	975	533–1417							
Small intestine			45	675	283–1068							
Hepatobiliary	55	(46–67)	571	7836	6576–9097	15	58	32	20	14	7.6	6.8–8.3
Liver disease			284	3883	2899–4866							
Liver transplant			71	955	632–1278							
Cardiac	69	(60–75)	471	6421	5603–7239	12	71	98	3	10	5.1	4.7–5.4
Coronary artery by-pass			262	3776	3146–4407							
Valve surgery			150	1913	1441–2385							
Other disease groups	65	(50–75)	338	4670	3885–5455	9	52	40	26	4	3.7	3.4–4.0
Mouth, head, neck, ears			84	1073	593–1552							
Nervous system			69	986	687–1285							
Infection			62	865	565–1166							
Renal	68	(57–77)	272	3653	2342–4965	7	68	32	35	6	5.6	4.3–6.9
Renal failure			143	1969	915–3023							
Paediatrics	<1	(<1–5)	332	4896	3187–6605	9	60	36	6	12	2.0	1.5–2.5
Vascular	74	(67–79)	253	3397	2614–4180	6	73	92	8	17	6.6	5.7–7.4
Emergency aortic surgery			76	1063	658–1469							
Haematology	61	(45–76)	231	3120	962–5279	6	56	0	56	9	21.1	10.9–31.2
Lymphoma			57	768	348–1188							
Acute leukaemia			47	661	138–1183							
O & G	36	(30–47)	171	2369	1806–2932	4	0	52	19	19	4.6	4.0–5.1
Obstetrics			93	1335	910–1761							
Gynaecology			78	1033	670–1396							
Respiratory	69	(56–75)	128	1572	1034–2109	3	62	34	35	6	5.1	4.1–6.2
Trauma	55	(33–79)	126	1661	1096–2225	3	63	49	5	12	5.5	4.4–6.7
Musculoskeletal	70	(49–80)	111	1407	952–1862	3	47	85	11	7	4.4	3.6–5.2
Total hip replacement			45	583	364–803							
Unassignable	69	(61–82)	82	1238	884–1592	2	56	0	0	2	3.5	3.1–4.0
Unavailable	67	(53–79)	307	3843	2716–4971		54	n/a	n/a	11	4.9	3.9–5.8
Total	64	(46–75)	4232	57 480	49 438–65 522		57%	45%	19%	10%	6.0	5.4–6.6

*Data shown for sub-groups where national estimate is >500 recipients.
†Back-weighted estimate for total number of FFP recipients across England and North Wales.
‡% given is total number within E-CMG divided by total number of recipients with available data (57480 − 3843 = 53637)
§ % of recipients receiving Cryo in addition to FFP.

Table 4. E-CMGs for sampled PLT recipients, estimated national totals and units transfused in Index Admission

E-CMG and sub-group*	PLT recipients sampled			Estimated NBS annual number of PLT recipients†			Percentage of recipients within each E-CMG			PLT units transfused	
	Median age	IQR	Number	Total	95% CI	Percentage‡	Male	Surgery	Cancer	Mean	95% CI
Haematology	60	(47–72)	981	10 539	8664–12 414	27	55	0	77	4.8	4.3–5.4
Lymphoma			315	3272	2447–4097						
Acute leukaemia			290	3212	2251–4174						
Myeloma			108	1061	563–1559						
Myelodysplastic syndrome			91	941	488–1394						
Myeloproliferative disorders			53	579	321–837						
Aplastic anaemia			48	536	63–1008						
Cardiac	69	(59–75)	479	6702	5819–7586	17	72	99	2	2.1	1.9–2.2
Coronary artery by-pass			301	4375	3633–5116						
Valve surgery			127	1745	1285–2205						
Paediatrics	3	(<1–9)	426	5049	3188–6911	13	52	17	36	2.6	1.9–3.2
Hepatobiliary	53	(45–63)	339	3928	3102–4754	10	56	39	15	3.8	3.3–4.3
Liver disease			177	2078	1486–2669						
Liver transplant			72	838	473–1202						
Digestive	69	(57–77)	315	3293	2523–4064	9	57	55	33	2.7	2.3–3.1
GI bleed			82	855	361–1350						
Colorectal surgery			60	590	346–834						
Other disease group	58	(43–70)	160	1783	1223–2343	5	55	29	32	2.5	2.0–2.9
Infection			46	502	285–719						
Vascular	73	(66–79)	158	1709	1160–2258	4	75	95	2	2.6	2.1–3.0
Emergency aortic surgery			77	760	393–1127						
Renal	65	(47–75)	117	1463	969–1958	4	81	25	51	2.9	2.3–3.4
O & G	34	(29–42)	90	1046	723–1368	3	0	46	26	1.9	1.6–2.2
Obstetrics			57	681	415–947						
Respiratory	61	(45–70)	77	1001	349–1653	3	66	35	61	3.5	2.0–4.9
Musculoskeletal	63	(35–77)	79	850	544–1157	2	53	68	39	1.8	1.5–2.1
Trauma	50	(30–61)	71	818	473–1163	2	63	66	11	2.9	2.2–3.5
Unassignable	59	(39–67)	40	514	215–812	1	58	0	0	2.2	1.5–2.9
Unavailable	62	(46–74)	252	2767	1657–3877		58	n/a	n/a	3.5	2.6–4.4
Total	59	(39–71)	3584	41 462	37 841–45 084		58%	35%	36%	3.2	3.0–3.4

*Data shown for Case-Mix sub-groups where national estimated total is >500 recipients.

†Back-weighted estimate for total number of PLT recipients across England and North Wales.

‡% given is total number within E-CMG divided by total number of recipients with available data (41 462 −2767 = 38 695).

RESULTS

Overview

The NBS provides blood components to all hospitals in England and North Wales and served an estimated population of 50.1 million in mid-2001 (http://www.statistics.gov.uk). During the study period the NBS issued approximately 2.1 million RBC, 0.3 million FFP and 0.2 million PLT. At the 29 hospitals participating in the study, a total of 68 600 transfusion recipients (65 830 RBC, 10 380 FFP and 8359 PLT recipients) were identified during the 12 months of the study (Table 1). After application of the sampling strategy, 9142 RBC, 4232 FFP and 3584 PLT recipients were selected for inclusion in the study (representing 14, 41 and 42% of RBC, FFP and PLT recipients at the participating hospitals). Despite independent selection of the RBC, FFP and PLT recipient samples, 15% of transfusion recipients belonged to more than one recipient group. However, within each group all recipients were selected only once.

Figure 2 presents the gender and age distribution of recipients in each component group. All recipient groups showed a peak of transfusion activity in patients aged 0–4 years; this was mainly due to transfusion of neonates and infants under 6 months of age. The higher proportion of female RBC recipients is explained by the larger number of women aged 20–50 years receiving transfusion, and the greater proportion of women in the very elderly (over 80 years) population as a whole. FFP and PLT use was higher in men aged 40–84 years. 4% of RBC, 9% of FFP and 13% of PLT recipients were younger than 16 years.

RBC recipients

As shown in Table 2, our data suggest that approximately 433 000 patients were transfused with red cells in NBS hospitals during the study period. The top three E-CMGs were digestive, musculoskeletal and haematology (19, 15 and 13% of recipients, respectively). The recipients in these groups were elderly, with median ages around 73 years. Obstetrics and gynaecology (O&G) was the fourth largest E-CMG (10% of recipients), median age 36 years. Table 2 also shows other important sub-groups of RBC recipients (each with 3–4% of recipients) were renal failure, fractured neck of femur, cardiac artery by-pass grafting (CABG) and paediatrics, of whom 50% were under 1 year of age at the time of transfusion.

Gastrointestinal (GI) bleeding (5% of recipients) and colorectal surgery (3% of recipients) were the most frequent sub-groups in the digestive E-CMG. Approximately two-thirds of the latter operations were undertaken for cancer. Few patients with GI bleeds underwent surgery, with most undergoing upper GI endoscopy or colonoscopy. A further 3% of recipients had peptic ulcer disease, including patients with ulcers that have perforated or whose records excluded current bleeding.

Within the musculoskeletal E-CMG, total hip replacement and total knee replacement were the commonest sub-groups (12% of RBC recipients). The remaining patients in this disease group were a mixture of those undergoing other orthopaedic operations and patients with chronic diseases such as rheumatoid arthritis.

The third most frequent E-CMG for RBC recipients was haematology (13% of recipients). The largest subgroup within this category was anaemia of unknown cause (4% of recipients) where coding staff at the hospital did not have enough information to classify the anaemia and hence the reason for transfusion. Many of these patients were elderly and may have had non-haematological diagnoses leading to the anaemia of chronic disease. Other patients in the haematology category had iron deficiency anaemia (2% of recipients), for which the underlying cause would rarely be a primary haematological disorder. The remaining 7% of recipients in the haematology E-CMG include the common diseases of clinical haematology practice such as lymphoma, myeloma, myelodysplastic syndrome and acute leukaemia (Table 2). Myeloproliferative diseases, aplastic anaemia, inherited anaemias (such as thalassaemia and sickle cell disease) and vitamin B12 and folate deficiency were less frequent transfusion indications.

FFP recipients

During the study year it is estimated that approximately 57 500 patients were transfused with FFP in hospitals receiving blood components from the NBS (Table 3). Overall, FFP recipients were more commonly transfused in relation to surgery (45%) than RBC recipients (40%). Most E-CMGs showed an excess of male recipients, which was particularly marked in the cardiac, renal and vascular groups where approximately 70% of recipients were male.

The largest E-CMGs for FFP recipients were digestive, hepatobiliary and cardiac (21, 15 and 12% of recipients, respectively). The breakdown of sub-groups within the digestive E-CMG was very similar to red cell recipients, with GI bleeding (7% of recipients) and colorectal surgery (4% of recipients) emerging as the most frequent transfusion indications for FFP. Liver disease was the most important indication for FFP transfusion in the hepatobiliary E-CMG, and these patients

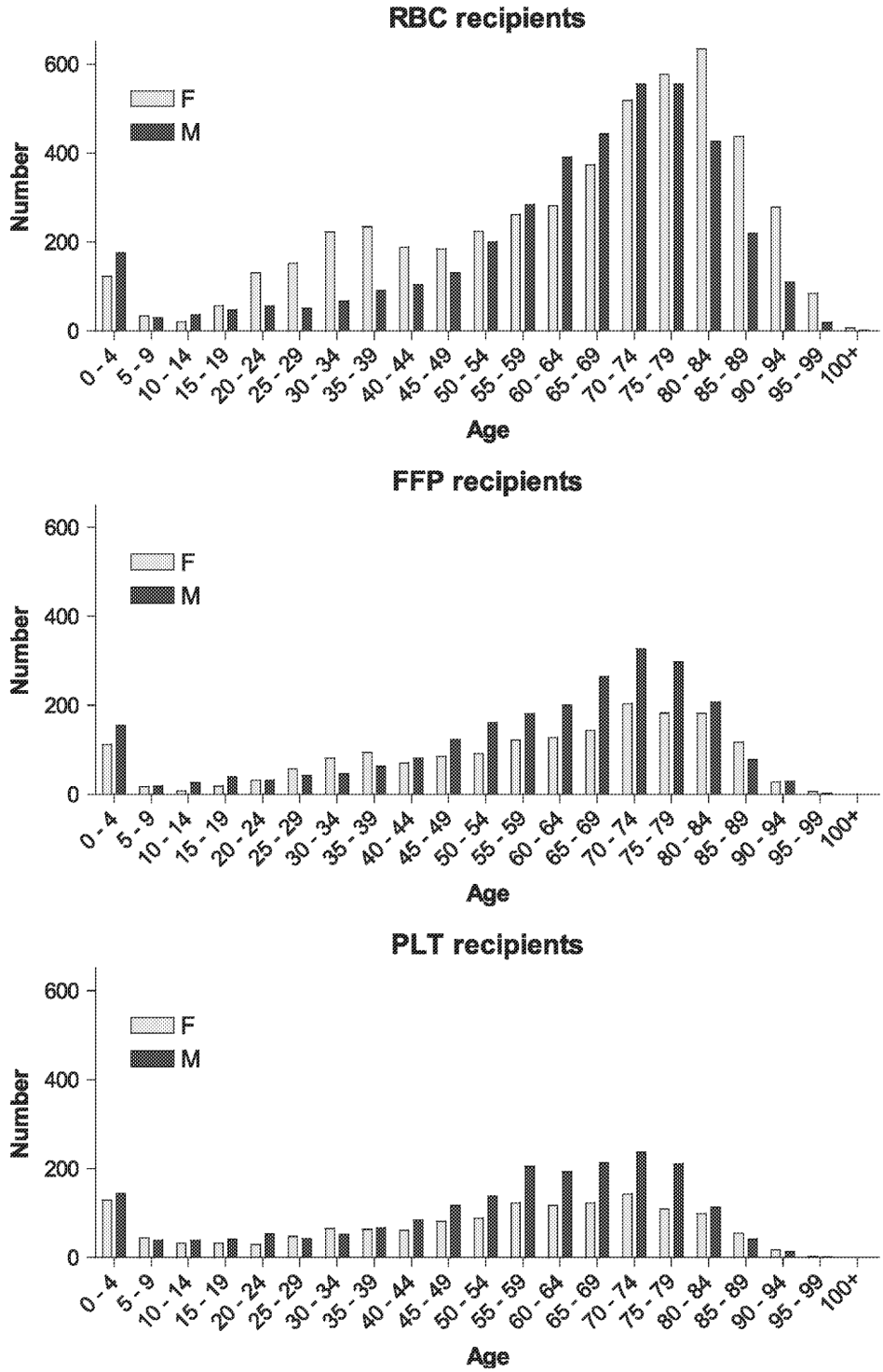

Fig. 2. Gender and age distribution of selected recipients.

(7% of recipients) probably received FFP either for bleeding complicating their liver disease or as prophylaxis prior to procedures such as liver biopsy. The hepatobiliary E-CMG includes patients undergoing liver transplantation (2% of all recipients), with the remaining recipients in this group receiving transfusions for a range of pancreatic, gall bladder and bile duct disorders.

The majority of cardiac FFP recipients underwent CABG and valve surgery (Table 3), which together accounted for 11% of all FFP recipients, with the remainder transfused for other cardiac procedures. Haematology patients comprised 6% of all FFP recipients and received a mean of 21 units per index admission. This is skewed by 12 patients with Thrombotic Thrombocytopenic Purpura (TTP) or Haemolytic Uraemic Syndrome (HUS) who received a median of 125 units per recipient (IQR 57 –355). This contrasts with the median number of FFP units transfused to all FFP recipients which was four units. Details of cryoprecipitate (cryo) use for FFP recipients are also presented in Table 3. Ten percent of FFP recipients received cryo, and a total 4606 units of cryo were transfused.

PLT recipients

It is estimated that during the study year approximately 41 500 patients received PLTs across England and North Wales (Table 4). PLT recipients, median age 59 years, were younger than RBC or FFP recipients, with only 35% undergoing surgery. The top three transfusion indications for PLT recipients were haematology, cardiac and paediatrics (27, 17 and 13% of recipients, respectively), followed by hepatobiliary and digestive indications which together accounted for 19% of PLT recipients.

The most frequent sub-groups in haematology were lymphoma, acute leukaemia and myeloma (9, 8 and 3% of recipients, respectively) where PLTs would commonly be required to support intensive chemotherapy treatment. Virtually all cardiac PLT recipients underwent CABG (11% of recipients) and valve surgery (5% of recipients).

For PLT recipients in the hepatobiliary and digestive E-CMGs, the major indications for transfusion were liver disease, liver transplantation, GI bleeds and colorectal surgery (Table 4). In contrast to RBC and FFP recipients, fewer PLT recipients were transfused for digestive system disorders, but when PLTs were given, they were more likely to be related to surgery. Around a third of the PLT recipients in the digestive E-CMG had been diagnosed with cancer.

DISCUSSION

The study used blood bank data from 29 hospitals to identify representative samples of RBC, FFP and PLT recipients transfused over a 12-month period and estimated total numbers of recipients supplied by the NBS. These three cohorts have been sampled and analysed separately, with minimal overlap between the groups allowing separate identification of the clinical scenarios associated with RBC, FFP and PLT transfusion. Coding information (both diagnostic and procedural) recorded for the hospital admission associated with each transfusion was reviewed in a novel way to determine and group together the probable transfusion indications (Llewelyn *et al.* 2009). This approach allowed assignment of a 'reason for transfusion' in over 97% of patients for whom coding data were available. A further development from previous studies has been the collation of the transfusion indications into our own clinically relevant case-mix groups.

Our sampling scheme was designed to ensure that the proportion of recipients within each E-CMG provided a realistic picture of transfusion indications for hospitals supplied by the NBS. We used back-weighting to correct for the sampling scheme, adjusting for the proportion of NBS issues that went to study hospitals over the year. The precision of our estimates, expressed as 95% confidence limits, reflects variation among hospitals within and between strata (small, medium or large). Comparison with Hospital Episode Statistics (HES, www.hesonline.nhs.uk) for procedures that are frequently associated with transfusion provides evidence that these estimates are representative of transfusion practice in England and North Wales at the time of the study. HES reports that 1791 emergency aneurysm repairs were performed in the financial year 2001/2002; our estimates were 1489 patients based on RBC use and 1063 based on FFP use. Similarly, HES reports that approximately 23 000 coronary artery by-pass grafts were performed, during this period. At the time of data collection between 60 and 80% of CABG patients were transfused with red cells perioperatively (Williamson et al., 2002). Therefore, our estimate of 14 300 patients based on RBC use seems believable.

We found that transfusion recipients tend to be elderly, as documented by previous studies conducted between 1993 and 2003 in France, Sweden and Finland in which 52–64% of recipients were reported as being over 64–65 years old (Mathoulin-Pelissier *et al.*, 2000; Tynell *et al.*, 2005; Palo *et al.*, 2006a). In our study, the age distribution varied between the three groups of recipients, with a median age for RBC recipients of 69 years, 64 years for FFP recipients and 59 years for PLT recipients. Such differences between recipient groups are of practical importance when considering blood safety initiatives which are usually component specific. For example, the UK now imports clinical FFP for patients under the age of 16 years. Our results suggest that if this age limit were raised, the requirement for imported FFP units would rise dramatically; for example, twice as many units would be required if the age limit was raised to 25 years.

In this study, the digestive E-CMG has, perhaps unexpectedly, emerged as a frequent indication for transfusion of all components, with national estimates of 19, 21 and 9% of independently selected RBC, FFP and PLT recipients. These figures are higher than previously reported in studies using primary diagnostic codes alone to classify recipients with digestive disorders. For example, 9% of Canadian RBC recipients and 11% of French transfusion recipients had digestive system disorders (Chiavetta *et al.*, 1996; Mathoulin-Pelissier *et al.*, 2000). These figures would have excluded patients with GI cancer classified separately under 'neoplasms' whereas these patients are included in our digestive E-CMG. The disparity between our results and those reported previously could be even greater because we have reported liver disease and liver transplantation separately within the hepatobiliary E-CMG; if added to the digestive E-CMG, these patients together account for 23, 36 and 19% of RBC, FFP and PLT recipients, respectively.

In our study, GI bleeding was the largest sub-group of patients within the digestive E-CMG, accounting for 5, 7 and 2% of RBC, FFP and PLT recipients, respectively. Repeat studies from the North of England looking at usage by components issued have also reported GI bleeding as a common indication for red cell transfusion (Wells *et al.*, 2002; Wallis *et al.*, 2006). At the time of writing a National Comparative Audit of transfusion practice in GI haemorrhage is being analysed, the aims of which include a reduction in the variation of blood use for this condition (National Blood Service, 2007).

There are few published studies that specifically identify FFP recipients (Wallis & Dzik, 2004; Palo *et al.*, 2006b). In our study, 36% of FFP recipients were in the digestive and hepatobiliary E-CMG, with GI bleeds (7%) and liver disease (7%) the most frequent single indications for FFP along with CABG (7%). Liver disease is increasing in the UK, with a 67% rise in mortality from cirrhosis in England and Wales between 1987–1991 and 1997–2001, a 10% rise in confirmed Hepatitis C cases from 2005 to 2006 and hospital admissions in England for alcoholic liver disease have more than doubled between 1995/1996 and 2005/2006 (Leon *et al.*, 2006; Health Protection Agency, 2007; The Information Centre, 2007). Therefore it is likely that the current use of FFP for this patient group is higher than that reported in this study, and will continue to rise.

The overall proportion of FFP recipients undergoing surgery in our study was 45% compared to 67% observed in Finland (Palo *et al.*, 2006b). This may be due to a difference in case-mix between countries and/or differences in methodology; in our study 12% of FFP recipients had cardiac surgery, compared to 25% in Finland (Palo *et al.*, 2006b). In Finland, 20% of FFP recipients underwent operations on the digestive tract and spleen. In our study, combining the number of surgical patients in the digestive and hepatobiliary E-CMGs, gives a comparable figure of 15%. FFP transfusion is a topic that needs further study and it is well recognized that the evidence for benefit from FFP transfusion is poor (Stanworth, 2007).

In our study we estimated that 13% of RBC, 27% of PLT and 6% of FFP recipients were in the haematology E-CMG. In contrast studies from France and Finland reported that 7% and 22% of all transfusion recipients had a diagnostic code for a blood disorder or haematological malignancy (Mathoulin-Pelissier *et al.*, 2000; Palo *et al.*, 2006b). Studies reporting units used by indication may give higher figures because haematology patients are often transfused repeatedly. For example, Wallis *et al.* found 18% of red cell units were given to haematology patients and a further 28% were transfused for anaemia (Wallis *et al.*, 2006).

The monthly sampling strategy we used did not always result in a full quota of FFP or PLT recipients being identified at the small and some of the medium-sized hospitals. It was not appreciated how relatively infrequently FFP is given in these hospitals. This is consistent with the fact that many of the disease groups and surgical procedures associated with FFP transfusion are typically treated or performed in large hospitals. At smaller hospitals PLTs tended to be administered to the same patients over several admissions during the year, commonly for long-term support of patients with chronic thrombocytopenia rather than during acute episodes of surgery. We did not collect the details of the total number of admissions at participating hospitals during the study and as a result we cannot report the percentage of admitted patients or the proportion of patients with a given diagnosis or procedure that are transfused. Direct clinical or laboratory data were not collected and therefore we cannot comment on the appropriateness or timing of administration of transfusions given during an admission. It has been noted previously that 48% transfusions given 'perioperatively' were actually administered post-operatively (Cook & Epps, 1991).

A final point concerns the timeliness of the data. Since the study period, there has been a significant reduction in RBC use in the UK, although this has not been seen to the same extent for FFP and PLT. Influences include the Better Blood Transfusion Health Circulars, the establishment of hospital transfusion teams and evolving best practice guidelines (Department of Health, 2007). One hospital in this study repeated data collection using the same methodology over

a further 12 months in 2003–2004. In line with national reports, overall red cell use fell by 14%, but this hid an absolute increase in blood use for medical patients of 12% (Ballard et al., 2007). Similar findings have been reported from the North of England (Wallis *et al.*, 2006). A challenge for further studies will therefore be to collect and report data in a timelier manner. To meet this need, large national or regional databases of transfusion recipients have been set up in Scotland and Scandinavia (Stewart & McClelland, 2006; Titlestad *et al.*, 2006; Palo *et al.*, 2006a). It remains to be seen whether such a database can be established in the context of the Connecting for Health project in England (www.connectingforhealth.nhs.uk).

In conclusion, the EASTR study has provided national estimates for the numbers of RBC, FFP and PLT recipients supplied by the NBS and the indications they are transfused for. This information will be useful for future planning and targeting major users for appropriate blood-saving strategies.

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