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REVIEW ARTICLE

A survey of the demographics of blood use

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SUMMARY. Epidemiological information was obtained by a series of questions to experts in the field of epidemiology of transfusion from the United States, England, Australia and Denmark. Although it became clear that the methods for collecting the data had differed between the countries, useful information was obtained for all questions. The data highlighted some major differences between the countries: the incident rate for red cell transfusion varied from 44·7 to 54·1 units, for platelets from 2·0 to 6·0 units and for plasma from 4·8 to 13·8 units transfused per 1000 population per year. Age and sex distribution of transfused patients was similar in all countries. Most of the red cell products are transfused to older recipients, and the distribution between men and women is approximately equal. The distribution for platelets is over a wider age range, and the difference between men and women is marked, with men predominating in all countries. The distribution for plasma is also directed to the elderly, and there is a predominance of men. The relationship between the disease or surgical procedure and the use of blood products was similar between countries. The use of red cells in cardiovascular surgery predominated. Neoplasms and digestive disorders were also prevalent. Neoplasms, including those relating to haematology, were the main use for platelets, but cardiovascular surgery was also important. In all countries, plasma is largely used in cardiovascular surgery. Two countries provided data relating to the number of units per transfusion episode including information relating to massive transfusion. In Australia, red cell use of $\geq$50 units per episode was largely associated with multiple traumas. In Denmark, it was associated with gastrointestinal bleeding and various medical requests.

Key words: age, epidemiology, per 1000 population, per episode, plasma, platelet dose, platelets, red cells, sex, transfusion.

There is very little literature that summarizes or investigates the epidemiological aspect of recipients and transfusion. Epidemiological information is useful in the planning of production, i.e. the extent, timing and type of production. When used to compare populations, it may also give some insight into the efficiency of product use.

It was therefore decided that a practical way of obtaining epidemiological information may be to ask a series of questions of experts from several countries. The United States, England, Australia and Denmark were selected from the point of view that they could be argued to be representative of the developed world. Moreover, the selected investigators from these countries had published pertinent information in the peer-reviewed literature and were therefore likely to possess the data needed to answer the questions being posed.

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METHOD

To obtain the needed information, the following nine questions were asked of investigators from the United States, England, Australia and Denmark who had published in the field of transfusion epidemiology.

Question 1: What are the details of the population from which the data are acquired? (total number, sample or complete, etc.).

Question 2: What is the number of units of red cells transfused per 1000 population per year?

Question 3: What is the number of platelet doses transfused per 1000 population per year? (one dose of

platelets is one apheresis, one pooled buffy coat or five whole-blood platelets).

Question 4: What is the number of plasma units transfused per 1000 population per year?

Question 5: What is the age and sex distribution for each of these products?

Question 6: If the data are obtained for a specific period (12 months), how does the number of patients relate to the number of units of blood product transfused and the number of transfusion episodes (some patients will be transfused once and some will be transfused many times during a year)?

Question 7: What is the frequency distribution for the number of each blood product transfused/episode and transfused/patient?

Question 8: What are the diseases and the procedures that use the most of each blood product [using major diagnostic category (MDC) or diagnosis-related groups (DRG) if possible]?

Question 9: What are the diseases and procedures that use $\geq$50 units of red cells for one transfusion episode?

Most of the questions were answered by all of the authors. However, as there were several differences in the data provided, it was decided to summarize the responses in consultation with all the authors. There may be some variables that may not be readily identified such as the way in which the data have been collected or the differences in populations or products. Attempts have been made to identify and discuss the situations where it may not be possible to make direct comparisons.

RESULTS

Question 1: What are the details of the population from which the data are acquired (total number, sample or complete, etc.)?

United States (E. C. V.)

The incidence rate (number of units transfused per 1000 population per year) of red cell, platelet or plasma transfusion was presented for each state of the United States in the report of Surgenor & Schnitzer (1985) and subsequently for each census region (Surgenor *et al.*, 1990). Incidence rates were also presented by this team for the entire US population (Surgenor & Schnitzer, 1985; Surgenor *et al.*, 1990; Wallace *et al.*, 1993, 1995, 1998), and later this data collection effort was taken over by the National Blood Data Resource Centre (NBDRC) (NBDRC, 2001, 2003; Sullivan *et al.*, 2002). The latest year for which US data are available from the NBDRC is 2001 (NBDRC, 2003). This is the report that supplies most of the information for the United States.

These reports (Surgenor & Schnitzer, 1985; Surgenor *et al.*, 1990; Wallace *et al.*, 1993, 1995, 1998; NBDRC, 2001, 2003; Sullivan *et al.*, 2002) used standard estimation techniques to arrive at national estimates of the blood transfusion activities in the United States between 1980 (Surgenor & Schnitzer, 1985) and 2001 (NBDRC, 2003). The most recent (2001) survey (NBDRC, 2003) was sent to 2100 hospitals, and 1173 (55·9%) hospitals were responded. The authors demonstrated that gaps in the collected data did not introduce selection (i.e. non-responder) bias into the study, provided that some assumptions held (Surgenor *et al.*, 1990).

The 1-year period prevalence of red cell transfusion equals a random resident's probability to receive a red cell transfusion in the course of a particular year. Vamvakas & Taswell (1994) calculated such probabilities for red cells, platelets and plasma for Olmsted County, Minnesota, residents receiving transfusion in 1989–1992.

Detailed summary

	United States	England	Australia	Denmark
Time period	1980–2001	Red cells: three 14-day periods (October 1999, June 2000 and November 2001). Platelets: All patients transfused in region in June 1994. Plasma: Two 14-day periods (June 2002 and January 2003)	2001/2002	2002
Representation of the country	AABB (American Association of Blood Banks) and non-AABB hospitals (46·6% of all US hospitals)	North of England data from 18 National Health Service (NHS) hospitals (>99%) of this region	All of Western Australia	All transfusions in Funen County (given to citizens of Funen County)

There are several reports on age and sex distribution for red cell, platelet and plasma transfusion in the United States (Friedman *et al.*, 1980, 1982; Cook & Epps, 1991; Vamvakas & Taswell, 1994). The data presented here are from Vamvakas & Taswell (1994). Vamvakas & Taswell (1994) reported on all patients transfused in Olmsted County, Minnesota, over a 4-year period (1989–1992), without recourse to any sampling scheme or estimation technique. In 1990, the population of Olmsted County was 106 473. For this county, the age and sex distribution of the *patients* who received red cell, platelet or plasma transfusion during 1989–1992 and the age and sex distribution for the transfused *units* of red cells, platelets or plasma have been made available (Vamvakas & Taswell, 1994).

The reports shown above (Friedman *et al.*, 1980, 1982; Cook & Epps, 1991; Vamvakas & Taswell, 1994) also presented the transfusion dose (number of units per person) received by each patient or each male or female patient. The most recent study (Vamvakas & Taswell, 1994) calculated the number of units received per person per year. The number of units transfused per transfusion episode was not reported in these studies (Friedman *et al.*, 1980, 1982; Cook & Epps, 1991; Vamvakas & Taswell, 1994), but the latest NBDRC report (NBDRC, 2003) included an average number of allogeneic red cell units transfused per adult recipient.

Listings of blood use by indication for transfusion were presented by International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) principal diagnosis and major disease category in the report of Friedman *et al.* (1980, 1982) by DRG in the study of Cook & Epps (1991) and by clinical specialty group ordering the transfusion in the study of Vamvakas & Taswell (1994).

With regard to the question the diseases and procedures that use $\geq$50 red cell units per transfusion episode, this information has not been captured by any of the listed studies (Friedman *et al.*, 1980, 1982; Surgenor & Schnitzer, 1985; Surgenor *et al.*, 1990; Cook & Epps, 1991; Wallace *et al.*, 1993, 1995, 1998; Vamvakas & Taswell, 1994; NBDRC, 2001, 2003; Sullivan *et al.*, 2002). Individual hospital transfusion services have sometimes provided this information for their own hospital, but such statistics reflect the case-mix of patients treated at a particular hospital. Accordingly, this question is not answered here for the United States.

England (A. W.)

Data are presented from population-based studies of transfusion practice undertaken in the North of England. This geographical area has a population of 2·9 million and is served by a single blood centre. All the studies collected data from the 18 National Health Service hospitals in the region. (Private and military hospitals account for less than 1% of blood use in the region and are not included in our studies). Compared with figures for blood component issues from the blood centre, I believe our studies to be a complete record of transfusion activity within our region during each study period.

Data on red cell use were collected over three periods of 14 days in October 1999, June 2000 and November 2001 (Wells *et al.*, 2002a,b). As described previously, blood bank staff used a preprinted form to record patient demographics and indications for transfusion for all patients transfused in the region. Because this method does not identify patients or transfusion episodes, the results are analysed for blood use by age or indication.

This method has subsequently been developed to collect data on plasma transfusion. Data are presented from two 14-day studies in June 2002 and January 2003 (unpublished data).

Details of platelet use have been extracted from a study of post-transfusion survival, which identified all patients transfused in our region in June 1994 (Wallis *et al.*, 2004).

Estimates of the region's population for 1998 (based on the 1991 national census) were obtained from the Population Estimates Unit of the Office of National Statistics and used to calculate population- and age-adjusted transfusion rates (1994 estimates were used for the survival study data).

Australia (T. J. C.)

Western Australia represents approximately 10% of the Australian population. The Australian Red Cross Blood Service – Enterprise (Western Australia) is unique within Australia in that it receives detailed information on recipients of blood products throughout Western Australia; however, this epidemiological data may be representative of Australia although the proportion of apheresis platelets and leucodepleted blood products may be higher in Western Australia than in some other states and territories. All hospitals, including metropolitan and regional, send monthly reports indicating transfused, unaccounted for and discarded products. Unaccounted for products are further investigated, and for the year of the study, this figure was approximately 2%. The year 2001/2002 was selected for this study. The total number of blood products transfused during 2001/2002 in Western Australia was 71 256. The total number included in the linkage was 69 814. This included 18 070 transfusion episodes and 11 692 different patients.

Denmark (K. T.)

Data are presented for all the transfusions to inhabitants of the county of Funen during 2002. All transfusions can be linked to specific patients. However, 3·5% of the transfusions cannot be linked to the 'diagnosis and procedure register', and these transfusions are excluded as it is not possible to check whether these patients are living in the county of Funen. The county of Funen has one university hospital (services other counties as well) and six local hospitals. The total number of inhabitants in the county during 1 January 2002 was 472 504 (men 49·4%). To calculate transfusions according to the population in Funen, transfusion to patients hospitalized but not living in the county were excluded; this represented 33% of the transfusions given in the county. More detailed explanation of the background and methods have previously been published (Titlestad *et al.*, 2001, 2002).

	Transfusion to inhabitants of the county of Funen in 2002
Plasma	2440
Platelet	2211
Red cell	25 553
Total	30 204

Question 2: What is the number of units of red cells transfused per 1000 population per year?

United States (E. C. V.)

According to the 2001 NBDRC Report (NBDRC, 2003), 13 898 000 red cell units (including allogeneic, autologous and directed units) were transfused, and US population in 2001 was 2 85 094 000.

The incidence rate of red cell transfusion is 48·75 units per 1000 population per year.

England (A. W.)

Red cell use in our region, between 1999 and 2001, is 44·93 units per 1000 population per year. This shows relatively little change from 1994, 44·72 units per 1000 population per year.

Australia (T. J. C.)

The population of Western Australia at 2001 was 1 851 252. The number of red cells transfused per 1000 population per year in Western Australia is 28·00. Additional information is available on the number of red cells issued in Western Australia during 2004/2005. Using a similar calculation to the above data, 31·9 units (data courtesy: Department of Health, Western Australia, Australia, personal communication) are issued per 1000 population per year.

Denmark (K. T.)

The incidence rate of red cell transfusion is 54·08 red cells per 1000 population per year.

Question 3: What is the number of doses of platelets transfused per 1000 population (one dose of platelets is one apheresis, one pooled buffy coat or five whole-blood platelets)?

United States (E. C. V.)

According to 2001 NBDRC Report (NBDRC, 2003), 10 196 000 whole-blood-derived platelet equivalent units [assuming that one apheresis platelet pack equals six platelet concentrate equivalent units, both because this is how the data were published in NBDRC (2003)

Detailed summary

	United States	England	Australia	Denmark
Units of red cells transfused	13 898 000 in 2001	14 794 (during the study)	50 605*	25 553
Population	285 094 000 in 2001	2 900 000	1 851 252 in 2001	472 504
Incidence rate of red cell transfusion	48·75	44·93	28	54·08
Inclusions	Includes allogeneic, autologous and directed		Includes allogeneic, autologous and directed	Only allogeneic as no directed or autologous unit were transfused

*Does not include the red cells that did not link to clinical data.

Detailed summary

	United States	England	Australia	Denmark
Platelets transfused	10 196 000 in 2001	2473 (during the study)	Whole blood, 2734*; apheresis, 5050*	2211
Population	285 094 000 in 2001	2 900 000 in 1994	1 851 252	472 504
Incident rate (doses of platelets per 1000 per year)	5·96	2·03	3·02	4·68
Inclusions	One dose is six whole-blood-derived platelets	One dose is five whole-blood-derived platelets. No apheresis platelets were included	One dose is five whole blood or one apheresis ($3{\cdot}0 \times 10^{11}$ per bag)	One dose is four buffy coat or one apheresis unit

*Does not include the platelets that did not link to clinical data.

and because six whole-blood-derived platelet concentrates as produced in North America would be equivalent (in number of platelets contained in the pool) to five whole-blood-derived platelets produced by the buffy coat method].

US population in 2001 was 285 094 000.

The incidence rate of platelet transfusion is 35·76 units (5·96 doses) per 1000 population per year.

England (A. W.)

In 1994, the standard platelet dose for adults was five whole-blood platelets (apheresis platelets were not issued to local hospitals during the study period). Platelet use was 2·03 platelet doses per 1000 population per year. This figure may underestimate the number of transfusions at that time, as it does not account for children who will have received a smaller number of platelets.

Australia (T. J. C.)

The number of platelet doses transfused per 1000 population per year is 3·02.

In Western Australia, apheresis platelets are predominantly transfused. These components contain at least $3{\cdot}0 \times 10^{11}$ in each bag. The platelets that are produced from whole blood are usually issued as a multiple of five (containing approximately also $3{\cdot}0 \times 10^{11}$ in total). This number per 1000 per year is based on a dose of platelets being one apheresis platelet or five whole-blood platelets.

Denmark (K. T.)

The incidence rate is 4·68 (pool of four buffy coat/equivalent apheresis) per 1000 population per year.

Question 4: What is the number of plasma units transfused per 1000 population per year?

United States (E. C. V.)

According to 2001 NBDRC Report (NBDRC, 2003), 3 926 000 units of donor apheresis plasma and fresh frozen plasma were transfused.

US population in 2001 was 285 094 000.

The incidence rate of platelet transfusion is 13·8 units per 1000 population per year.

Detailed summary

	United States	England	Australia	Denmark
Plasma units transfused	3 926 000	1326 (during the study)	9642*	2440
Population	28 509 400	2 900 000	1 851 252	472 504
Incidence rate of plasma units transfused per 1000 per year	13·8	5·95 during 2002/2003 and 4·83 during 1994	5·33	5·16
Inclusions	Apheresis and fresh frozen plasma (FFP)	FFP	Includes 130 paediatric units during 2001/2002	FFP

*Does not include the plasma that did not link to clinical data.

England (A. W.)

Plasma use is 5·95 units per 1000 population per year. This figure suggests a 23% rise in use from 1994, 4·83 units per 1000 population per year.

Australia (T. J. C.)

The number of plasma units transfused per 1000 population per year in Western Australia is 5·33. This includes a low number of paediatric bags (130 in 2001/2002).

Denmark (K. T.)

The incidence rate of platelet transfusion is 5·16 units of plasma per 1000 population per year.

Question 5: What is the age and sex distribution for each of these products?

United States (E. C. V.)

According to Vamvakas & Taswell (1994), the percentage distribution in Olmsted County, Minnesota, in 1989–1992 is as follows:

	Young patients (<41 years of age)*	Middle-aged patients (41–65 years of age)†	Senior patients (>65 years of age)‡	Male patients§	Female patients¶
Red cell units	18·8	27·8	53·3	48·5	51·5
Patients transfused with red cells	19·6	26·0	54·3	45·3	54·7
Platelets units	30·7	37·8	31·5	57·3	42·7
Patients transfused with platelets	23·1	33·4	43·5	57·3	42·7
Plasma units	19·9	29·5	50·5	55·1	44·9
Patients transfused with plasma	16·2	25·4	58·4	51·2	48·7

*In the 1990 census, 66·9% of Olmsted County residents were younger than 41 years.
†In the 1990 census, 23·8% of Olmsted County residents were 41–65 years of age.
‡In the 1990 census, 9·3% of Olmsted County residents were older than 65 years.
§In the 1990 census, 48·5% of Olmsted County residents were men.
¶In the 1990 census, 51·5% of Olmsted County residents were women.

Detailed summary

	United States	England	Australia	Denmark
Red cell units	<41 years: 18·8%; 41–65 years: 27·8%; >65 years: 53·3%; males: 48·5%; females: 51·5%	<40 years: 14·4%; 40–70 years: 38·4%; >70 years: 47·2%; males: 50·4%; females: 49·6%	<40 years: 15·4%; 40–70 years: 36·7%; >70 years: 47·9%; males: 52·5%; females: 47·5%	<40 years: 6·2%; 40–70 years: 38·4%; >70 years: 55·4%; males: 52·7%; Females: 47·3%
Platelet units	<41 years: 30·7%; 41–65 years: 37·8%; >65 years: 31·5%; males 57·3%; females 42·7%	<40 years: 43·8%; 40–70 years: 43·1%; >70 years: 13·1%; males 66%; females 34%	<40 years: 26·9%; 40–70 years: 47·0%; >70 years: 26·1%; males: 62·4%; females: 37·6%	<40 years: 10·0%; 40–70 years: 63·5%; >70 years: 26·5%; males: 62·4%; females: 37·6%
Plasma units	<41 years: 19·9%; 41–65 years: 29·5%; >65 years: 50·5%; males: 55·1%; females: 44·9%	<40 years: 12·1%; 40–70 years: 49·3%; >70 years: 38·6%; males 59·6%; females: 40·4%	<40 years: 22·5%; 40–70 years: 43·4%; >70 years: 34·1%; males: 57·3%; females: 42·7%	<40 years: 6·6%; 40–70 years: 48·7%; >70 years: 44·7%; males: 63·3%; females: 36·7%

As the proportion of seniors in the US population is increasing, there is evidence that transfused patients in the United States today are older than those who received transfusion in Olmsted County (Vamvakas & Taswell, 1994) in 1989–1992. It is noted that the latest NBDRC report (NBDRC, 2003) stated that the average age of transfusion recipients in the United States in 2001 was 69 years.

England (A. W.)

Age and sex distribution (%)			
Age range (years)	Red cells	Platelets	Plasma
0–9	1·9	11·6	3·1
10–19	2·6	4·0	0·2
20–29	4·1	7·8	2·6
30–39	5·8	20·5	6·2
40–49	6·4	11·5	9·3
50–59	12·0	14·5	12·1
60–69	20·0	17·2	28·0
70–79	28·9	8·5	28·4
80–89	14·7	4·6	8·8
90 and older	3·6	0·0	1·4
Males	50·4	66·0	59·6
Females	49·6	34·0	40·4

Australia (T. J. C.)

It is important to define these parameters carefully. The data given in Fig. 1 relates to the age and sex distribution for red cells, platelets and plasma for the total number of products. In this situation, one patient may be represented several times during the year.

Denmark (K. T.)

Age range (years)	Sex		
	Female, *n* (%)	Male, *n* (%)	Total, *n* (%)
0–9	73 (0·6)	111 (0·8)	184 (0·7)
10–19	46 (0·4)	116 (0·9)	162 (0·6)
20–29	241 (2·0)	200 (1·5)	441 (1·7)
30–39	565 (4·7)	251 (1·9)	816 (3·2)
40–49	779 (6·4)	847 (6·3)	1626 (6·4)
50–59	1297 (10·7)	2228 (16·5)	3525 (13·8)
60–69	1975 (16·3)	2678 (19·9)	4653 (18·2)
70–79	3212 (26·6)	4168 (30·9)	7380 (28·9)
80–89	3053 (25·3)	2467 (18·3)	5520 (21·6)
90 and older	843 (7·0)	403 (3·0)	1246 (4·9)
Total	12 084 (100·0)	13 469 (100·0)	25 553 (100·0)

Age range (years)	Sex		
	Female, *n* (%)	Male, *n* (%)	Total, *n* (%)
0–9	6 (0·7)	2 (0·1)	8 (0·3)
10–19	6 (0·7)	10 (0·6)	16 (0·7)
20–29	17 (1·9)	23 (1·5)	40 (1·6)
30–39	78 (8·7)	19 (1·2)	97 (4·0)
40–49	108 (12·1)	128 (8·3)	236 (9·7)
50–59	127 (14·2)	320 (20·7)	447 (18·3)
60–69	131 (14·6)	374 (24·2)	505 (20·7)
70–79	289 (32·3)	507 (32·8)	796 (32·6)
80–89	109 (12·2)	156 (10·1)	265 (10·9)
90 and older	25 (2·8)	5 (0·3)	30 (1·2)
Total	896 (100·0)	1544 (100·0)	2440 (100·0)

Age range (years)	Sex		
	Female, *n* (%)	Male, *n* (%)	Total, *n* (%)
0–9	29 (3·5)	60 (4·3)	89 (4·0)
10–19	15 (1·8)	23 (1·7)	38 (1·7)
20–29	23 (2·8)	8 (0·6)	31 (1·4)
30–39	12 (1·4)	50 (3·6)	62 (2·8)
40–49	98 (11·8)	155 (11·2)	253 (11·4)
50–59	167 (20·1)	439 (31·8)	606 (27·4)
60–69	252 (30·3)	294 (21·3)	546 (24·7)
70–79	165 (19·9)	252 (18·3)	417 (18·9)
80–89	66 (7·9)	94 (6·8)	160 (7·2)
90 and older	4 (0·5)	5 (0·4)	9 (0·4)
Total	831 (100·0)	1380 (100·0)	2211 (100·0)

Question 6: If the data are obtained for a specific period (12 months), how does the number of patients relate to the number of units of blood product transfused and the number of transfusion episodes (some patients will be transfused once and some will be transfused many times during a year)?

United States (E. C. V.)

A random US resident's probability to receive red cell transfusion in 1980 (i.e. the 1-year period prevalence of red cell transfusion in the United States in 1980) was estimated to be 1·43%. This probability varied from

Detailed summary

	United States	England	Australia	Denmark
Red cells	Not available	Not available	50 605 units red cells, 16 674 transfusion episodes and 11 016 patients	25 553 units of red cells, 7360 transfusion episodes, 4576 patients
Platelets	Not available	Not available	7784 units of platelets (2734 whole blood and 5050 apheresis), 2407 transfusion episodes, 1475 patients	8844 whole blood platelets, 688 transfusion episodes and 377 patients
Plasma	Not available	Not available	9642 units of plasma, 2207 transfusion episodes and 1980 patients	2440 units of plasma, 557 transfusion episodes and 534 patients

1·18% in the Mountain region to 1·53% in the mid-Atlantic region (Surgenor & Schnitzer, 1985).

In Olmsted County, Minnesota, a random resident's probability to receive red cell, platelet or plasma transfusion in 1989–1992 was 0·891%, 0·105%, or 0·142%, respectively. In the case of red cells, this probability was higher for women (0·95%) than for men (0·83%). The probability of transfusion increased by 20-fold from 0·26% for those younger than 41 years to 5·17% for those older than 65 years, and it was 0·97% for middle-aged county residents (see Table) (Vamvakas & Taswell, 1994).

	Probability of receiving transfusion during a year (%)		
	Red cells	Platelets	Plasma
Male	0·83	0·12	0·16
Female	0·95	0·087	0·13
Younger (<40 years)	0·26	0·037	0·034
Middle-aged (40–65 years)	0·97	0·15	0·15
Senior (>65 years)	5·17	0·51	0·88

England (A. W.)

Data not available.

Australia (T. J. C.)

The definition of the transfused population is given in the following Table.

	Total	Transfusion episodes	Number of different patients
Red cells	50 605	16 674	11 016
Total platelets	7784	2407	1475
Apheresis	5050	2170*	1276†
Whole-blood platelets	2734	473*	448†
Plasma	9642	2207	1980

*These numbers include 236 episodes that involve both apheresis and whole-blood platelets.
†These numbers include 249 patients who received both apheresis and whole-blood platelets.

Denmark (K. T.)

This study included inhabitants of the county of Funen, discharged from the university hospital or one of the six local hospitals during 2002. In Denmark, the central authorities provide all inhabitants with a unique and permanent PIN used for all official registrations. Transfused units can thus be related to patients in two ways:

1 Unique patients: each patient is included only once.
2 Transfusion episodes (hospitalization/outpatient visits): each patient may be included more than once.

Question 7: What is the frequency distribution for the number of each blood product transfused per episode and transfused per patient?

United States (E. C. V.)

The latest NBDRC report (NBDRC, 2003) stated that, in 2001, the average number of allogeneic red cells transfused per adult recipient was 2·9.

Detailed summary				
	United States	England	Australia	Denmark
Red cells	4·8 (±0·09) units per person per year in 1989–1992 in one area; 2·9 units per person per year in 2004 across the country	Not available	43·7% of transfusion episodes require 2 units	3·5 unitsper transfusion episode or 5·6 units per patient (mean)
Platelets	20·25 (± 1·14) whole-blood-derived units per person per year in 1989–1992	Not available	49·7% of transfusion episodes required 6 units of whole-blood-derived platelets; 60% of transfusion episodes required 1 unit of apheresis platelets	Equivalent to 12·9 whole-blood-derived single units of platelets per transfusion episode or 23·5 single units per patient (mean)
Plasma	6·11 (±0·36) units per person per year in 1989–1992	Not available	44·3% of transfusion episodes required 2 units of plasma	4·4 units per transfusion episode or 4·6 units per patient (mean)

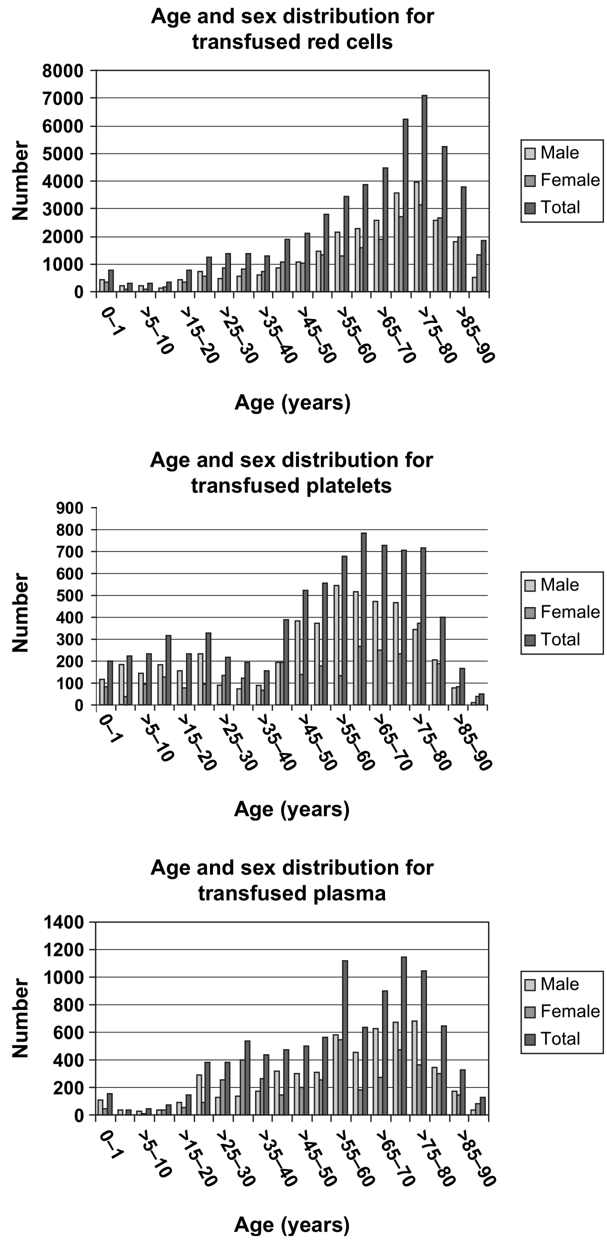

Fig. 1. Age and Sex Frequency Distribution for Red Cell, Platelet and Plasma Recipients in Western Australia.

In the Olmsted County, Minnesota, study (Vamvakas & Taswell, 1994) the mean ± SE dose of red cells, platelets or plasma (number of units transfused per person transfused per year) was 4·80 (±0·09) for red cells, 20·25 (±1·14) for whole-blood-derived platelet concentrate equivalent units and 6·11 (±0·36) for plasma.

England (A. W.)

Data not available.

Australia (T. J. C.)

Number of products transfused per episode	% products transfused			
	Red cells	Plasma	Whole-blood platelets	Apheresis platelets
1	14·4	11·2	7	60
2	43·7	44·3	9·7	18·5
3	18·7	5·2	4·7	7·4
4	11·1	18·2	8	4·1
5	3·4	1·6	6·1	2·5
6	2·7	5·9	49·7	1·8
7	1·4	1·4	0·85	1·2
8	1·4	3·4	2·3	0·74
9	0·8	1	0·85	0·42
10	0·5	1·6	1·1	0·51
11	0·34	0·6	0·63	0·65
12	0·3	1	5·9	0·19
13	0·22	0·5	0	0·28
14	0·2	0·5	0·42	0·18
15	0·1	0·04	0·63	0·09
16	0·09	0·5	0·21	0·09
17	0·09	0·2	0·21	0·19
18	0·06	0·5	0·85	0·19
19	0·09	0·09	0	0·14
20	0·06	0·3	0	0·14
21–30	0·22	1·02	0·85	0·41
31–40	0·08	0·44	0	0·23
41–50	0·03	0·22	0	0·05
51–60	0·005	0·09	0	0
61–70	0	0·04	0	0
71–80	0·01	0·04	0	0
>80	0·005	0·12	0	0
	100	100	100	100

Denmark (K. T.)

	Units	Episodes	Patients	Episodes (mean)	Patient (mean)
Red cells	25 553	7360	4576	3·5	5·6
Plasma	2440	557	534	4·4	4·6
Platelets	2211	688	377	3·2	5·9
Platelets (single)	8844	688	377	12·9	23·5

Question 8: What are the diseases and the procedures that use the most of each blood product? [using major diagnostic category (MDC) or diagnosis-related groups (DRG) if possible]

United States (E. C. V.)

As reported by Cook & Epps (1991) for Central Virginia in 1986, blood use by major DRG is as follows:

Detailed summary

	United States	England	Australia	Denmark
Red cells	Cardiovascular, 24%; digestive, 17%; neoplasm, 16%; injury/poisoning, 14%; musculoskeletal, 6% (data from 1986)	Surgical, 39·7%; orthopaedic surgery, 7·9%; GI surgery, 6·9%; trauma, 5·6. Medical, 53·2%; 16·3%, Haematology; 14%, acute and chronic GI bleeding; 7·2%, other neoplasm; 3·2%, renal failure; 6·2%, obstetrics and gynaecology	Cardiovascular surgery, 10·8%; orthopaedic surgery, 13·8%; GI surgery and medical, 14·05%; Haematology including malignancy, 20·7%; renal disease, 5%; Obstetrics and gynaecology, 5·5%; trauma, 9·5%	Neoplasms, 25·7%; digestive, 15·5%; circulatory, 14·5%; blood and blood-forming organs, 11·1%; injury, etc., 9·7%
Platelets	Neoplasm, 26%; cardiovascular, 20%; digestive, 19%; injury/poisoning, 6%; musculoskeletal, <1% (data from 1986)	Not available	Haematology, 34%; cardiovascular surgery, 21·6%; trauma, 13·0%; bone marrow transplantation, 6·7%	Neoplasms, 66·2%; circulatory, 16·2%; blood and blood-forming organs, 4·9%; digestive, 2·7%
Plasma	Cardiovascular, 34%; digestive, 26%; neoplasm, 12%; injury/poisoning, 10%; musculoskeletal, <1% (data from 1986)	Surgical, 67·2%; Intensive Therapy Unit (ITU), 17·9%; cardiovascular, 13·7%; general, 13·0%; after surgery bleeding or massive transfusion, 42·5%; liver disease, 14·4%. Indication not available for 23·8%	Trauma, 26·6%; cardiovascular surgery, 23·0%; GI surgery, 11·46%; Other orthopaedic surgery, 6·12%; Haematology, 5·2%; hepatic/biliary, 5·18%	Circulatory, 39·2%; digestive; 20·5%; neoplasms, 10·4%; injury/poisoning, 8·3%; infectious and parasitic, 4·9%

	Percentage of all units transfused		
	Red cells	Platelets	Plasma
Cardiovascular	24	20	34
Neoplasm	16	26	12
Digestive	17	19	26
Injury/poisoning	14	6	10
Musculoskeletal	6	<1	<1

The case-mix of transfused patients in the United States today undoubtedly differs from that reported for Central Virginia in 1986 (Cook & Epps, 1991), but – to this author's knowledge – no recent population-based data (reporting information on all patients transfused in an entire area) have been reported.

England (A. W.)

Red cells. Surgical patients account for only 39·7% of red cell transfusion within our region. Patients undergoing orthopaedic surgery (7·9% of all blood), GI surgery (6·9%) and cardiothoracic surgery (5·5%) and patients with trauma (5·6%) were the largest users of blood within this group. Obstetric and gynaecology patients account for 6·2% of blood use.

Only 53·2% of red cells are given for medical indications. The third period of data collection attempted to define medical blood use more closely. During this phase of the study, 16·3% of all blood was given to patients with haematological disorders (5·1% Myelodysplastic Syndrome (MDS), 4·0% lymphoma, 2·7% acute leukaemia and 1·4% myeloma). Other frequent medical indications included acute and chronic GI bleeding (14·0%), non-haematological cancer (7·2%), renal failure (3·2%) and haematinic deficiency (2·9%).

Plasma. In contrast, plasma in our region is mainly given for surgical indications (67·2% of all plasma). The main specialities using plasma were ITU (17·9%), cardiothoracic surgery (13·7%) and general surgery (13·0%). Overall, 42·5% of plasma was given for after surgical bleeding and/or for massive transfusion. Only 14·4% was given for liver disease. The indication for plasma was not available for 23·8% of units used.

Platelets.

Data not available.

Australia (T. J. C.)

Data as in the table.

Denmark (K. T.)

All red cell, plasma and platelet transfusions ranked according to the official ICD10 headlines.

DRG	Red cell numbers	Red cell (%)	Platelet numbers	Platelet (%)	Plasma Numbers	Plasma (%)
Trauma*	4814	9·51	1012	13·00	2560	26·55
Haematology	10 494	20·74	2649	34·03	503	5·22
Gastroenterology	7111	14·05	278	3·57	1105	11·46
Hip replacement	2456	4·85	73	0·94	85	0·88
Cardiovascular	5453	10·78	1679	21·57	2220	23·02
Knee replacement	974	1·93	7	0·09	18	0·19
Other orthopaedics	3561	7·04	150	1·93	590	6·12
Gynaecology/Obstetrics	2760	5·45	111	1·43	338	3·51
Renal	2548	5·04	49	0·63	183	1·90
Medical oncology	668	1·32	62	0·80	8	0·08
Errors and Z's	1719	3·40	130	1·67	246	2·55
Bone marrow transplantation	397	0·78	521	6·69	12	0·12
Respiratory	1622	3·21	179	2·30	290	3·01
Hepatic/biliary	970	1·92	113	1·45	499	5·18
Immunology	442	0·87	0	0·00	5	0·05
Infection	1047	2·07	283	3·64	178	1·85
Burns	522	1·03	20	0·26	135	1·40
Paediatrics	670	1·32	145	1·86	131	1·36
Male pelvic	633	1·25	26	0·33	41	0·43
Other	1735	3·43	297	3·82	495	5·13
	50 596	100·00	7784	100·00	9642	100·00

*Tracheostomy + ventilation/craniotomy.

Red cells	ICD10 First	ICD10 Last	Red cell units	Red cell (%)
Neoplasms	C00	D48	6572	25·7
Diseases of the digestive system	K00	K93	3952	15·5
Diseases of the circulatory system	I00	I99	3693	14·5
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	D50	D89	2826	11·1
Injury, poisoning and certain other consequences of external causes	S00	T98	2483	9·7
Factors influencing health status and contact with health services	Z00	Z99	928	3·6
Diseases of the musculoskeletal system and connective tissue	M00	M99	897	3·5
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	R00	R99	843	3·3
Diseases of the genitourinary system	N00	N99	821	3·2
Diseases of the respiratory system	J00	J99	742	2·9
Certain infectious and parasitic diseases	A00	B99	500	2·0
Endocrine, nutritional and metabolic diseases	E00	E90	450	1·8
Pregnancy, childbirth and the puerperium	O00	O99	371	1·5
Diseases of the skin and subcutaneous tissue	L00	L99	195	0·8
Diseases of the nervous system	G00	G99	93	0·4
Mental and behavioural disorders	F00	F99	79	0·3
Certain conditions originating in the perinatal period	P00	P96	58	0·2
Congenital malformations, deformations and chromosomal abnormalities	Q00	Q99	46	0·2
Diseases of the eye and adnexa	H00	H59	4	0·0
Total			25 553	100·0

Plasma	ICD10 first	ICD10 last	Plasma	Plasma (%)
Diseases of the circulatory system	I00	I99	957	39·2
Diseases of the digestive system	K00	K93	501	20·5
Neoplasms	C00	D48	253	10·4
Injury, poisoning and certain other consequences of external causes	S00	T98	202	8·3
Certain infectious and parasitic diseases	A00	B99	119	4·9
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	R00	R99	102	4·2
Diseases of the musculoskeletal system and connective tissue	M00	M99	86	3·5
Diseases of the genitourinary system	N00	N99	43	1·8
Diseases of the respiratory system	J00	J99	42	1·7
Pregnancy, childbirth and the puerperium	O00	O99	40	1·6
Factors influencing health status and contact with health services	Z00	Z99	32	1·3
Congenital malformations, deformations and chromosomal abnormalities	Q00	Q99	21	0·9
Diseases of the nervous system	G00	G99	18	0·7
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	D50	D89	10	0·4
Certain conditions originating in the perinatal period	P00	P96	6	0·2
Diseases of the skin and subcutaneous tissue	L00	L99	6	0·2
Endocrine, nutritional and metabolic diseases	E00	E90	2	0·1
Diseases of the eye and adnexa	H00	H59		0·0
Mental and behavioural disorders	F00	F99		0·0
Total			2440	100·0

Platelets	ICD10 First	ICD10 Last	Platelets	Platelets (%)
Neoplasms	C00	D48	1464	66·2
Diseases of the circulatory system	I00	I99	359	16·2
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	D50	D89	108	4·9
Diseases of the digestive system	K00	K93	60	2·7
Certain infectious and parasitic diseases	A00	B99	52	2·4
Factors influencing health status and contact with health services	Z00	Z99	49	2·2
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	R00	R99	27	1·2
Injury, poisoning and certain other consequences of external causes	S00	T98	19	0·9
Diseases of the respiratory system	J00	J99	18	0·8
Diseases of the musculoskeletal system and connective tissue	M00	M99	18	0·8
Diseases of the skin and subcutaneous tissue	L00	L99	16	0·7
Certain conditions originating in the perinatal period	P00	P96	7	0·3
Congenital malformations, deformations and chromosomal abnormalities	Q00	Q99	7	0·3
Diseases of the genitourinary system	N00	N99	4	0·2
Mental and behavioural disorders	F00	F99	1	0·0
Pregnancy, childbirth and the puerperium	O00	O99	1	0·0
Diseases of the nervous system	G00	G99	1	0·0
Diseases of the eye and adnexa	H00	H59		0·0
Endocrine, nutritional and metabolic diseases	E00	E90		0·0
Total			2211	100·0

(The first and last ICD10 code for each headline is shown.)

Question 9: What are the diseases and procedures that use ≥50 units of red cells for one transfusion episode?

Detailed summary

	United States	England	Australia	Denmark
Procedure or disease that use ≥50 units red cells/transfusion episode	Not available	Not available	Multiple trauma, 4/5; haematological disease, 1/5	GI bleeding, 3/7; malignancy, 1/7; secondary thrombocytopenia, 1/7; septicaemia, 1/7; coma unspecified, 1/7

United States (E. C. V.)

Data not available.

England (A. W.)

Data not available.

Australia (T. J. C.)

DRG	Greater than or equal to 50 units red cells/episode: Number	Number of units	Age (years)	Sex
Tracheostomy	1	50	75	Male
Tracheostomy	1	82	32	Male
Ventilation or craniotomy	1	72	37	Male
Lymphoma and leukaemia	1	73	43	Female
Multitrauma	1	51	24	Male
Total	5			

Denmark (K. T.)

Diseases using >49 red cell units transfusions, all at the university hospital.

ICD10		ICD10 detail		Red cell	Plasma	Platelets single unit	Sex	Age (years)
C67	Malignant neoplasm of bladder	C679	Bladder, unspecified	58	14		Male	74
K26	Duodenal ulcer	K260	Duodenal ulcer, acute with haemorrhage	57	44	19	Male	58
K26	Duodenal ulcer	K261	Duodenal ulcer, acute with perforation	66	29	3	Male	62
K62	Other diseases of anus and rectum	K625	Haemorrhage of anus and rectum	60	18	6	Male	75
D69	Purpura and other haemorrhagic conditions	D695	Secondary thrombocytopenia	70	10	7	Male	47
A40	Streptococcal septicaemia	A400	Septicaemia due to streptococcus, group A	74	17	3	Male	64
R40	Somnolence, stupor and coma	R402	Coma, unspecified	50	15	5	Female	75

CONCLUSIONS

This exercise has been very useful and has given some of the first comparative epidemiological data between countries with comparable levels of health provision. There are many similarities between countries, particularly in the data relating to the age and sex distribution. However, the study has emphasized the differences that exist between the countries. Some of these differences may be related to the type of products transfused and also by the way in which the data have been collected. Possible differences in the prevalence of diseases have not been addressed at this time. Some participants used apheresis platelets and others used whole-blood-derived platelets, and it is difficult to be sure that it is reasonable to compare these two products even if the number of platelets is similar.

How to 'convert' an apheresis dose to similar whole-blood platelet doses is still uncertain.

In the case of the Western Australian data, the number of red cells transfused per 1000 population was much lower than that in other countries. The number of red cells transfused, 28 per 1000 population per year, was based on an expectation that >95% of red cell transfusions were included in the study. In Western Australia, there is some autologous blood that is produced by laboratories other than the Australian Red Cross Blood Service. This blood was not included in the study but is not of sufficient magnitude to explain the difference seen between Australia and the other countries. The process of obtaining transfusion details in Western Australia relied heavily on hospitals returning these data after transfusion but unaccounted for units of red cells was rigorously investigated. The additional data that have been provided by the Department of Health, Western Australia, was calculated on a different year, and the process for obtaining the data was not directly related to the procedure given here. The fact that the numerical value was slightly increased compared with the number of red cells transfused was to be expected as it is likely that that some of the issued red cells were not transfused. The fact that the data are very similar may be evidence that the difference between the Western Australia data and the other countries is reliable. However, the difference between Western Australian and the other country participants, needs to be investigated further. It should also be considered that Western Australia provided a large proportion of leucodepleted red cells, unrefrigerated whole-blood and apheresis platelets during the time that these data were collected. It could be argued that at least some of these blood products may have reduced the total use of red cells in this region of Australia.

The most striking difference between the four countries surveyed in our study was the difference in the number of plasma units transfused per 1000 population per year. The United States uses more than twice the volume of plasma used in England, Australia or Denmark. This difference in plasma use has been previously commented on by Wallis & Dzik (2004) who compared FFP use between the United States, Norway, New Zealand, the United Kingdom and France. Their data (Wallis & Dzik, 2004) showed that relative to red cell use, plasma use in the United States has doubled since 1979. It is possible that some countries with a level of health-care provision similar to that in the United States under use plasma transfusions or that the case-mix of transfused patients in the United States may be weighted towards surgical procedures that use more FFP. Alternatively, the

United States may be overusing plasma transfusions and/or different population demographics may be affecting rates of use (Wallis & Dzik, 2004). Our study did not support any of these explanations, as the age and sex distribution of transfused patients was similar between countries and use of blood products by disease or surgical procedure also did not differ. However, our comparisons were based on broad diagnostic categories for transfusion indications (e.g. MDC or DRG), rather than on individual procedures or diagnoses. Such detailed data will have to be collected to examine whether plasma is overused in the United States or underused in other countries with similar levels of health-care provision or whether differences in the methods used previously for data collection account, in part, for the differences in plasma use observed by Wallis & Dzik (2004) and by us.

These types of data can be used for production planning, for judging the efficiency of product use and, to some extent, also as a measure of the quality of a significant section of the health system. Therefore, it may be appropriate to undertake an International Study of Blood Product Use in a co-ordinated manner to minimize the variability of data collection and product quality so that more definitive conclusions can be drawn from comparisons between countries.

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