THE 2009 NATIONAL BLOOD COLLECTION AND UTILIZATION SURVEY

REPORT

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1. Executive Summary

The Assistant Secretary for Health, along with the Department of Health and Human Services (DHHS) operating divisions [Centers for Disease Control and Prevention (CDC), Centers for Medicare and Medicaid Services (CMS), Food and Drug Administration (FDA), and the National Institutes of Health (NIH)] sponsored the 2009 National Blood Collection and Utilization Survey (NBCUS), which was conducted under contract to AABB.

The DHHS 2009 NBCUS continues to be the major mechanism for assessing blood collections and utilization in the United States and follows previous national blood surveys conducted in 2007, 2005, 2002, 2000, and 1998 for the survey years 2008 (current), 2006, 2004, 2001, 1999, and 1997. Data from earlier assessments conducted by the National Heart, Lung, and Blood Institute and the Center for Blood Research are included where they are comparable to recent questions.

The objectives of the survey were to generate national estimates for blood collection and utilization activities in the United States in 2008; provide comparisons with previous years; provide data for national biovigilance safety monitoring; and characterize business practices in the blood collection, transfusion medicine, and cellular therapies communities.

The facilities surveyed included all non-hospital-based blood collection centers (blood centers), a sample of hospitals from the American Hospital Association (AHA) database, AABB member hospitals not in the AHA database, and a sample of cord blood banks. Hospitals reporting fewer than 100 inpatient surgeries per year were not included. Hospitals with annual surgical volumes between 100 and 999 were stratified and randomly sampled at a rate of 33.3%, while all hospitals reporting 1,000 or more surgeries were included in the sample.

The overall response rate for the 2009 NBCUS was 53.1% (1,660/3,129). For blood centers the response rate was 93.3% (126/135); for hospitals, 51.5% (1,529/2,970); and for cord blood banks 20.8% (5/24). Statistical procedures were used to verify that the sample was representative of the study universe and to develop sample weights to produce national estimates. Results from the cellular therapies survey are presented in a supplement to this report.

Important Trends in the US Blood Supply

The supply of available Whole Blood (WB) and Red Blood Cell (RBC) units after accounting for infectious disease testing was 17,159,000. This number exceeds transfusions of allogeneic WB/RBCs (14,855,000) by a margin of 2,304,000 units—13% of available supply. These high numbers of available non-transfused units indicate the beginning of a

blood surplus, which may be of a local nature, as 13.2% of hospitals have reported some challenges to supply.

The blood supply was provided by 10,877,000 allogeneic donors who successfully gave blood—3,165,000 (29%) of whom were first-time donors and 7,640,000 (71%) of whom were donors who had donated previously. Repeat donors, as defined by the reporting facility, provided a total of 11,461,000 donations, the equivalent of 1.5 donations per donor. The allogeneic blood collection rate was 85.2 units per thousand population of donor age (16-64) in 2008 compared to 84.1 units per thousand (donor age 18-64) in 2006. Donors aged 16-24 contributed 19% of the units collected in 2008. The rate of donations in the population aged 16-24 was 84.8 units per thousand persons in 2008, nearly as high as the rate for the eligible population overall.

The US WB/RBC allogeneic transfusion rate in 2008 was 48.8 units per thousand persons in the overall US population; this was not a significant change from the 48.3 units per thousand persons in 2006.

Blood Collection

The 2009 NBCUS estimates that a total of 17,286,000 units were collected, an increase of 6.9% over 2006 total collections. Blood centers were responsible for the collection of 16,212,000 units or 93.8% of the supply; hospitals collected 1,074,000 units or 6.2%.

RBC apheresis collections (allogeneic, including directed, and autologous, combined) accounted for 1,926,000 units collected. This was an increase of 18.9% over RBC apheresis collections in 2006 (**Figure 1-1**).

Blood Transfusion

The total number of WB/RBCs transfused in 2008 equaled 15,014,000 units. This was not statistically different from overall utilization in 2006. However, there were significantly more non-directed allogeneic units transfused, including pediatric transfusions expressed as adult equivalents ($p<0.05$). Significantly fewer directed units (intended for a specific patient) were transfused (73,000 units compared with 126,000 units in 2006; $p<0.05$).

The total number of platelets transfused in 2008 was 2,021,000 apheresis-equivalent units, a statistically significant increase of 16.7% ($p<0.001$). In a change from previous reports, platelets are reported as apheresis-equivalent units [one apheresis platelet = five whole-blood-derived (WBD) platelet concentrates], reflecting the predominant source of platelets in 2008. Apheresis platelets represent the bulk of the increase (16.2%, $p<0.001$), while transfusion of WBD platelets also increased but not significantly.

Biovigilance

The 2009 NBCUS allowed a second opportunity for an evaluation of the baseline of adverse events associated with blood collection and transfusion (both donor and recipient hemovigilance) in the United States. At the time data were collected for this survey, preparations were being concluded to pilot the Hemovigilance Module of the National Healthcare Safety Network (NHSN) and the Donor Hemovigilance System was being developed.

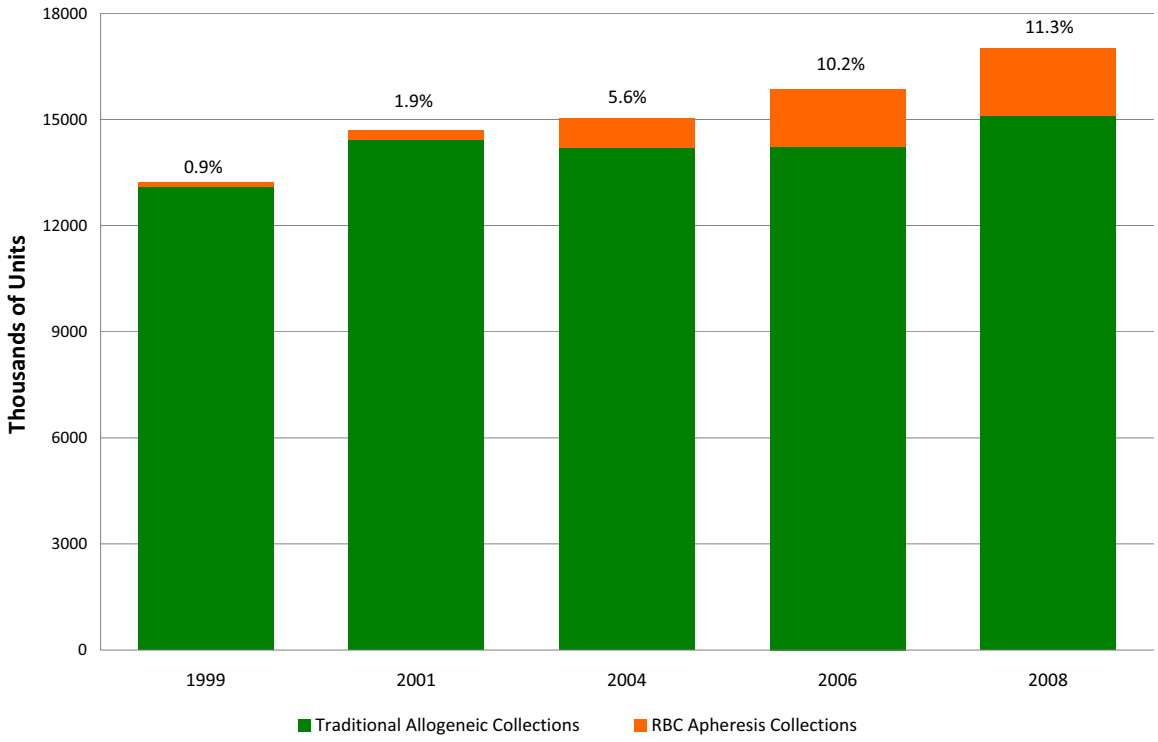

Figure 1-1. Use of RBC apheresis technology.

An estimated total of 60,000 transfusion-related adverse reactions were reported for 2008, not significantly different than reported in 2006.* The adverse reaction rate (events/total components transfused) was 0.25% compared to 0.26% in 2006.

Approximately 16,000 severe adverse donor reactions were reported by blood collectors in 2008, a rate of 0.09% of collection procedures, a significant increase ($p<0.05$) in the reported adverse reaction rates among donors from 2006 (11,000 reactions; 0.07% of procedures). This increase may be an artifact of better reporting due to enhanced focus on biovigilance, rather than an actual increase.

**See text box on page 35 for explanation of change in 2006 data.*

2. Key Findings

The results of the 2009 NBCUS provide an update of US blood collection and transfusion services and related activities in the 2008 survey year to the analyses made by the five previous nationwide surveys conducted in 2007, 2005, 2002, 2000, and 1998 (see references, page 47). Notable findings from the 2009 NBCUS and comparisons with the 2007 survey results are listed below.

New Findings

Collection

- There was a surplus of 2,043,000 available, test-negative, allogeneic WB/RBC units collected over those transfused in the United States in 2008 (12%). This is a 67% increase over the surplus reported in 2006 (1,227,000).
- Autologous collections declined significantly by 24.5% to 253,000 units ($p<0.001$).
- The donation rate for repeat donors was 1.5 donations per donor in 2008, compared with 1.7 donations per repeat donor in 2006.
- The rate of severe donor reactions was 0.09% ($p<0.05$).
- The WB/RBC collection rate per thousand US donor population (aged 16-64) was 85.2 units per thousand in 2008.

Transfusion

- Allogeneic (non-directed) WB/RBC transfusions increased significantly by 5.8% ($p = 0.023$) in 2008 to 14.8 million units; however, the total number of WB/RBC transfusions (15.0 million units) remained statistically unchanged.
- The number of transfusions that were from collections directed to a specific person decreased significantly to 73,000 units ($p = 0.032$; –42%).
- WBD platelets were transfused most often in pools of five or fewer concentrates.
- The transfusion of apheresis platelets increased significantly in 2008 by 16% ($p<0.001$). The number of WBD platelet concentrates transfused did not change when compared with 2006 figures.
- The total number of all components transfused in 2008 was 23,668,000, based on the use of an apheresis platelet as the basis for counting platelets instead of the platelet concentrate equivalent used for counting platelets in 2006 and previous reports.
- Compared to 2006, preparation of leukocyte-reduced (LR) components increased by 9.2%.
- The total number of transfused components that were irradiated increased by 14.8% while the number of transfused components that were leukocyte reduced increased by 20.1%.

- A total of 62 hospitals (4.4%) reported postponing elective surgery for one or more days due to blood inventory shortages. Comparison of weighted data shows that this affected 325 patients nationwide, compared to 721 in 2006 ($p<0.001$).
- The mean age of RBC units at transfusion was 18.2 days.
- The mean age of WBD platelet units was 3.7 days at transfusion vs 3.2 days for apheresis platelet units, compared with 2.1 and 3.2 days, respectively, reported in 2006.
- The average hospital cost of a unit of leukocyte-reduced RBCs increased significantly by 5.5% to $223.09 between 2006 and 2008. CMS covers approximately 83% of this cost.

Interesting But Statistically Unchanged Findings

Collection

- Total WB/RBC collections in 2008 increased from 2006 by 6.9% to 17.3 million units, but the difference was not statistically significant.
- Allogeneic collections remained statistically the same at 17.0 million units.
- The number of RBC apheresis units collected was 1.9 million.
- Of the 10,877,000 allogeneic donors who successfully gave blood in 2008, 29% were first-time donors and 71% were repeat donors; 0.6% were directed donors.
- Test losses declined 15.9% to 127,000 units from the 151,000 units reported in 2006.

Transfusion

- The rate of adverse transfusion reactions reported to hospital transfusion services was 0.25%, the same as the corrected rate from 2006.*
- The rate of allogeneic WB/RBC transfusions remained nearly the same at 48.8 units per thousand overall US population, compared to 48.3 units per thousand persons in 2006.

**See text box on page 35 for explanation of change in 2006 data.*

3. Blood Collected and Processed in the United States

Trends in Collection

Whole blood and RBC collections for the survey years 1989 through 2008 are illustrated in **Figure 3-1**. Total collections, which dropped to a low of 12.6 million units in 1997, reached a high of 17.3 million units reported in the 2009 NBCUS for the year 2008. New questions aimed at better accounting for RBC apheresis collections helped to add precision to these collection elements.

Autologous donations, **Figure 3-2,** continue to decline significantly from 2006 to 2008. Autologous collections included 253,000 manual WB collections and 8,000 RBC apheresis collections (included in the RBC apheresis totals), or 1.5% of total collections. The practice of donating for the use of a designated patient has also continued to decline to a small fraction of overall collections, only 61,000 units in 2008.

Total WB/RBC Collections

The total WBD and apheresis RBCs collected in the United States in 2008 were 17,286,000 (±1,890,000) units, before laboratory testing (**Table 3-1**). Blood centers collected 16,212,000 units, or 93.8% of the total. The remaining 1,074,000 ± 243,000 units (6.2%) were collected by hospitals. Compared to total collections from 2006, 2008 collections increased 6.9%.

The increase can be attributed to an 18.9% increase in RBC apheresis and a 6.3% increase in manual WB allogeneic (excluding directed) collections, which collectively accounted for 98.2% of total blood collections for 2008. The total units rejected on testing decreased by 15.9% in 2008 compared to 2006. There were 17,159,000 usable (available) units, 99.3% of units collected.

Whole Blood Collections

Donations of WB in 2008 totaled 15,361,000. These collections, reported according to the type of donation, are shown in **Table 3-1**. Community donations, excluding directed donations, accounted for 98% of total WB collections; directed donations totaled 0.4%; and autologous donations contributed 1.6%.

Allogeneic donations (nondirected) totaled 15,047,000 (±1,659,000) of which 93.8% were collected by blood centers and 6.2% by hospitals. The percentage increase in allogeneic donations (nondirected) between 2006 and 2008 was 6.3%, which was not statistically significant. Also not significant was the 12.8% decline in

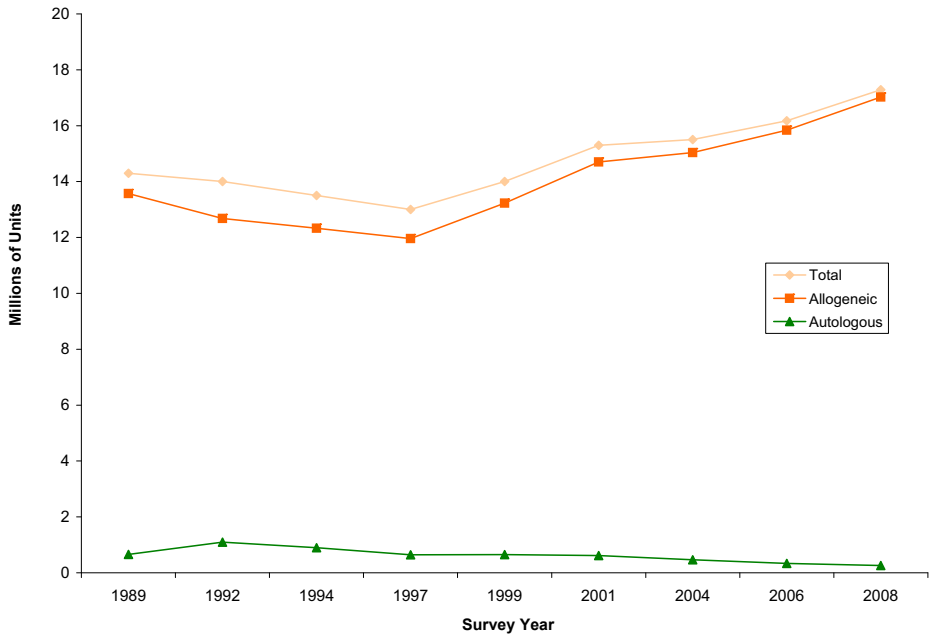

Figure 3-1. Allogeneic, autologous, and total whole blood and red cell collections, 1989-2008.

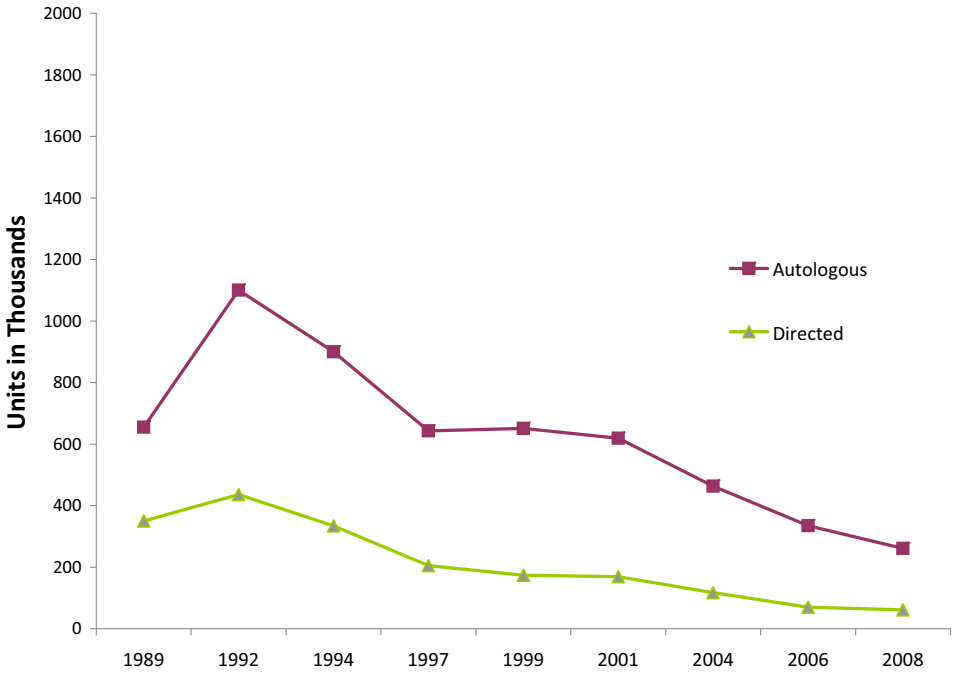

Figure 3-2. Autologous and directed whole blood and red cell collections, 1989-2008.

Table 3-1. Estimated 2008 Collection and Transfusion by US (50 States and DC) Blood Centers and Hospitals for Whole Blood (WB) and Red Blood Cells (RBCs) (expressed in thousands of units)

Activity	Blood Centers	Hospitals		2008 Combined Total	% of Total Collections/ Transfusions	2006 Total	% Change 2006-2008
		Total	±95% CI				
Collections							
WB Allogeneic (excluding directed)	14,120	927	224	15,047	87.0	14,151	6.3
WB Autologous	172	81	13	253 *	1.5	335	–24.5
WB Directed (fewer collected than transfused)	35	26	8	61 *	0.4	70	–12.8
RBC Apheresis	1,884	41	22	1,926	11.1	1,619	18.9
Total Supply	16,212	1,074	243	17,286	100.0	16,174	6.9
Rejected on Testing	116	11	3	127	0.7	151	–15.9
Available Supply	16,096	1,063	240	17,159	99.3	16,023	7.1
Transfusions							
Allogeneic (excluding directed)	654	14,127	404	14,782 *†	98.4	13,978	5.8
Autologous	5	154	25	159	1.1	189	–15.8
Directed (to designated patient)	0	73	36	73 *	0.5	126	–41.7
Total Transfusions	660	14,355	411	15,014	100.0	14,650 †	2.5
Outdated WB/RBCs	219	228	20	447	2.7	400	11.7

*Significantly different from 2006 data.
†Total includes pediatric transfusions.

directed allogeneic donations to 61,000 (±16,000) units. Of these, 36.9% were eventually used as part of the community supply.

Autologous, or self-directed units totaled 253,000 (±41,000), a decrease of 24.5% compared to 2006 ($p<0.001$). Hospitals collected 32% of all autologous units.

RBC Apheresis

In addition to WB collections, 1,926,000 (±328,000) RBC units were collected by apheresis. Most apheresis RBC collections yielded a double volume (ie, 2 units) of RBCs. RBC apheresis collections in 2008 increased by 18.9%, which was not statistically significant in comparison to 2006, when 1,619,000 RBC units were collected. There were 1,022,000 RBC apheresis collection procedures. RBCs collected by apheresis constituted 11.3% of the total WB/RBC supply in 2008 **(Figure 1-1).**

While 99.5% of the RBC apheresis collections were allogeneic, non-directed units, a small number of units collected by RBC apheresis were either for autologous use (8,000 units) or directed for the use of a specific patient (2,000 units).

The growth of reported RBC apheresis collections occurred largely in blood centers that accounted for 97.8% of such units. In 2006, 118 blood centers and 33 hospitals reported RBC apheresis collections. In 2008, 115 blood centers reported employing this technology, and 46 hospitals reported collecting RBCs by apheresis. Among the institutions that reported RBC apheresis collections (unweighted data), the mean number of units collected by blood centers was 15,188 (vs 12,419 in 2006) and by hospitals was 529 (vs 284 in 2006). The minimum number of units collected by any facility reporting apheresis collections was 4 and the maximum was 83,111.

Non-RBC Components Produced

Non-RBC component units collected or processed include apheresis platelets, plasma, and granulocytes as well as platelets, cryoprecipitate, and granulocytes from whole blood. The total number of non-RBC components produced for transfusion in 2008 was 11,152,000 (WBD platelets counted as individual concentrates, not as apheresis-equivalent units).

Platelets

An estimated 1,352,000 plateletpheresis procedures were completed, yielding 2,024,000 apheresis platelet components for an overall split rate of 1.5. The number of products increased 11% from 2006 (**Table 3-2**). Blood centers collected 94.1% of apheresis platelets while hospitals were responsible for 5.9%.

Platelet concentrates were derived from 1,964,000 units of WB, a decrease of 18% ($p = 0.21$) from the 2006 volume (2,396,000 units). Platelets were prepared from 13.9% of all allogeneic WB collected, down from the 16.9% (NS) from total whole blood collections in 2006. Blood centers produced 1,789,000 units (91.1%) while hospitals produced 175,000 (8.9%).

In 2008 the most common number of platelet concentrates reported to be pooled together for transfusion was 5 units. This is a change from past surveys (2006, 2004, and 2001) where the

Table 3-2. Estimated 2008 Collection and Transfusion by US (50 States and DC) Blood Centers and Hospitals for Non-Red Blood Cell (non-RBC) Components (expressed in thousands of units)

		Hospitals				
Activity	**Blood Centers**	**Total**	**±95% CI**	**2008 Total**	**2006 Total**	**% Change 2006-2008**
Components Collected/Produced						
Apheresis Platelets	1,906	119	34	2,024	1,823	11.0
WBD Platelet Concentrates†	358	35	13	393 (1,964)	399 (2,396)	–1.6 (–18)
Total Platelets	2,263	154	37	2,417	2,222	8.8
Plasma‡	5,305	395	85	5,700	5,684	0.3
Cryoprecipitate	1,425	37	18	1,462	1,197	22.2
Components Transfused						
Apheresis Platelets	60	1,701	93	1,761*	1,515	16.2
WBD Platelet Concentrates†	38	222	46	260 (1,300)	216 (1,296)	20.3 (0.3)
Total Platelets	98	1,923	116	2,021*	1,731	16.7
Plasma‡	222	4,263	231	4,484*	4,010	11.8
Cryoprecipitate	42	1,068	131	1,109	993	11.7
Non-WB/RBC Components Outdated	385	514	54	900	875	2.8

*Significantly different from 2006 data.
†Apheresis-equivalent units; numbers in parenthesis represent individual platelet concentrates produced from whole blood collections.
‡Plasma for transfusion including apheresis and pediatric plasma.
WBD = whole-blood-derived.

most common number was 6 platelet concentrates. For comparison with the production of apheresis platelets, it is assumed that five platelet concentrates are equivalent to one unit of apheresis platelets. Thus 1,964,000 units of WB platelets equal 392,800 apheresis-equivalent units.

Total apheresis-equivalent units collected in 2008 were 2,417,000, an increase of 8.8% from 2006; this was composed of 83.7% apheresis collections and 16.3% platelet concentrates from WB (**Table 3-2**).

Plasma

A total of 5,700,000 (± 559,000) units of plasma were produced for transfusion. This includes WBD Fresh Frozen Plasma (FFP), Plasma Frozen Within 24 Hours After Phlebotomy (PF24), Plasma Cryoprecipitate Reduced, and plasma from apheresis collections. This amount is an increase of 0.3% from 2006 (NS). Blood centers produced 93.1% of the plasma (5,305,000 units), and hospitals produced the remaining 6.9% (395,000 units). A total of 65,000 plasmapheresis procedures were reported, generating 125,000 units of apheresis plasma for transfusion. Other apheresis procedures produced 260,000 units. The remaining 5,315,000 units of plasma were derived from whole blood (**Figure 3-3**). In addition, 8,850,000 units of plasma were produced as recovered plasma for further manufacture, with 96% coming from blood centers—overall, a 1.4% increase from 2006 levels.

Cryoprecipitate

A total of 1,462,000 (± 307,000) units of cryoprecipitate were prepared. This increase of 22.2% over 2006 was not statistically significant, due to the large standard error of the 2008 estimate. Blood centers accounted for 97.4% of cryoprecipitate produced.

Granulocytes

Granulocytes, which are prepared from both apheresis and WB units, totaled 2,258 units produced. This is a 60.9% decrease from the amount produced in 2006. Blood centers reported producing 77% of this total.

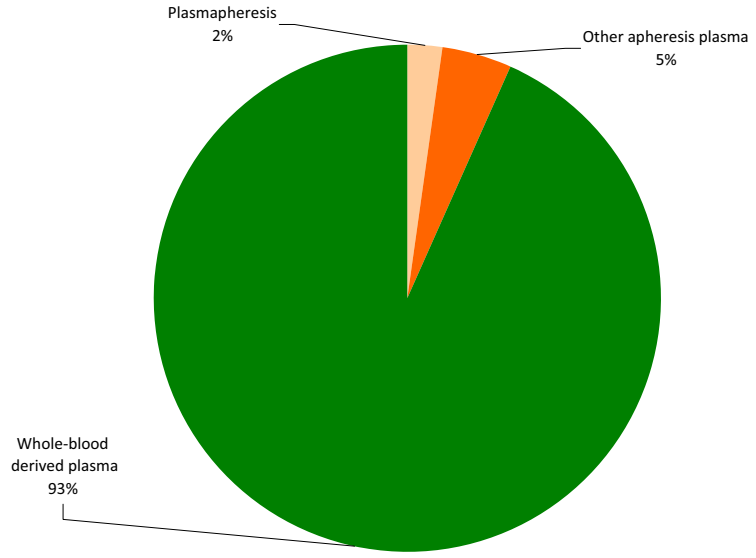

Figure 3-3. Sources of plasma for transfusion.

4. Blood Transfused in the United States

Whole Blood and Red Blood Cells Transfused

Transfusions of WB and RBCs of all donation types including pediatric transfusions totaled 15,014,000 units. The number of allogeneic, non-directed units transfused was significantly greater than that reported in 2006 ($p = 0.023$; **Table 3-1**). Whole blood transfusions accounted for 0.03% of total transfusions (approximately 5,000 units). Allogeneic units transfused, including directed units and pediatric units expressed as adult-equivalent units, accounted for 98.9% of units transfused or 14,855,000 units. Of the available allogeneic units, 87.9% were used in allogeneic transfusions, compared with 93.4% and 95.5% in 2006 and 2004, respectively, suggesting an oversupply.

Autologous transfusions continued to decline, as has been the trend in previous surveys. There were 15.8% fewer units transfused (159,000 units) than in 2006, although this decline was not statistically significant. The number of autologous units transfused represented 62.9% of the 253,000 units donated preoperatively by patients in 2008. Only a very small number, approximately 3,000 units (1.4% of the autologous units collected) were reported to have been crossed over to the community supply in 2008, while more than one in three units were not used.

Directed donations, the donation of allogeneic blood for a designated patient other than the donor, accounted for 73,000 units transfused; this was a significant decrease from the 126,000 reported in 2006 ($p = 0.032$). Another 17,000 units were reported to have crossed over to be transfused to non-designated patients. Although the number reported to have been collected was only 63,000 (manual and apheresis collections combined), many hospitals reported that they were unable to retrospectively distinguish between non-directed and directed allogeneic units.

Pediatric Transfusions

There was a small increase in pediatric WB/RBC transfusions reported in 2008, 7.3% more than in 2006 (**Table 4-1**). This represents 2.6% of all transfused RBCs. Pediatric transfusions are included in the totals reported in **Table 3-1**. In 2008, hospitals reported the number of pediatric transfusions of adult-equivalent units used in whole or in part by component type, for a total of 654,000 units transfused to the pediatric population. Pediatric components transfused included WB/RBCs (58.6%), platelets (26.0%), and plasma (15.4%).

Transfusion Recipients

The 2009 NBCUS captured the number of recipients of transfused RBCs of each

Table 4-1. Pediatric Transfusions by US (50 States and DC) Blood Centers and Hospitals in 2008 (expressed in thousands of units)

Pediatric Transfusions	2008 Total	2006 Total	% Change 2006-2008
WB/RBCs	383	357	7.3%
Platelets	170	NA	NA
Plasma	101	NA	NA

NA = Pediatric component transfusions were not reported separately in the 2007 NBCUS.

donation type. Based on unweighted data, the reported number of recipients of allogeneic RBC units was 1,679,000 per 4,379,000 units transfused by the 1,018 facilities reporting numbers of recipients, or 2.6 units per recipient, a decrease from 3.0 units per recipient per year. This may represent more than one transfusion episode per recipient. Autologous recipients received an average of 1.4 units per transfusion (1.6 in 2006). Recipients of directed units received an average of 1.7 units per transfusion in 2008. Finally, for recipients of pediatric RBC units, the ratio was 2.0 units per recipient, a decrease from the reported rate of 2.7 per recipient in 2006.

Extrapolating the ratios of units per recipient population proportionally to the numbers of WB/RBCs transfused yields a national estimate of 5.8 million total WB/RBC recipients in 2008. This represents a 16% increase in the number of transfusion recipients in comparison with the estimated 5.0 million recipients of 2006.

Non-RBC Components Transfused

National estimates for non-RBC components transfused in 2008 (including transfusions to pediatric patients) are presented in **Table 3-2.**

An estimated total of 2,021,000 platelet units were transfused to US patients in 2008, an increase of 16.7% in comparison with 2006 ($p = 0.001$; **Figure 4-1**). The transfusion of apheresis platelets increased by 16.2% from 1,515,000 to 1,761,000 units ($p<0.001$).

In this report, as described in Chapter 4, platelets are reported using apheresis equivalents. For comparison with the transfusion of apheresis platelets, it is assumed that five WBD platelet concentrates are equivalent to one unit of apheresis platelets. Thus, the 1,300,000 units of WBD platelets are reported as 260,000 apheresis-equivalent units.

The decline in the transfusion of WBD platelet concentrates, first observed in 1999, was actually reversed, albeit not significantly, between 2006 and 2008, increasing 20.3% ($p = 0.24$), with 260,000 apheresis-equivalent units transfused in 2008 compared with 216,000 from the 2006 survey. Although there was no statistical difference between 2006 and 2008 in platelet concentrates transfused, the trend toward smaller pool size (average size is 5 or fewer) in 2008 allows more patients to receive platelet transfusions using WBD platelets than was indicated by the number of transfused

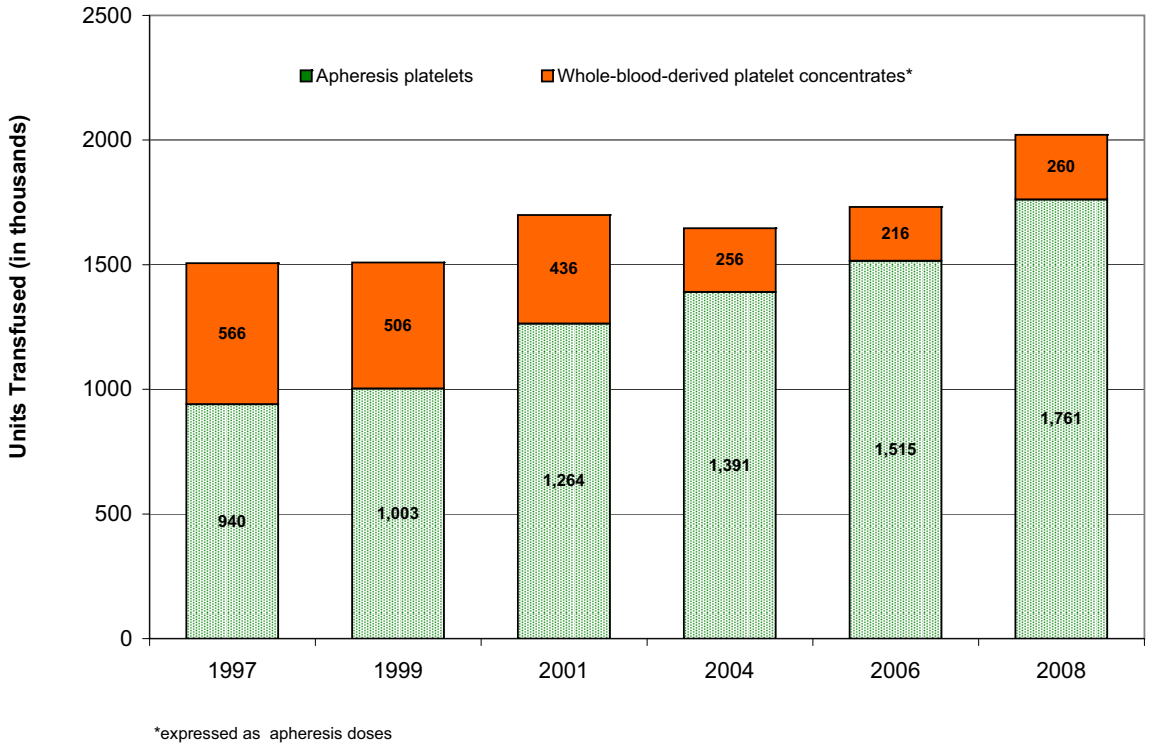

Figure 4-1. Trends in platelet transfusion, 1997-2008.

concentrate units. The ratio of apheresis concentrates to WBD platelet concentrates used has decreased slightly from 2006 (7 apheresis units: 1 pool of WBD concentrates) to 6.8:1 in 2008. The platelet dose calculation affects this ratio as expected.

The combined total of WBD plasma and apheresis plasma resulted in 4,484,000 units transfused, significantly more ($p<0.001$) than the number transfused in 2006 (4,010,000 units). Reporting institutions indicated the amounts of the various types of plasma transfused as shown in **Figure 4-2**. The results, for which overlap is possible, are as follows:

- FFP represented only 53.8% of plasma transfused (2,411,000 units). This is a significantly smaller proportion ($p<0.001$) of all transfused plasma compared with 2006, when 77.2% of the plasma transfused was FFP (3,109,000 units).
- Transfusion of PF24 increased significantly ($p<0.001$) to make up 38.8% of the transfused plasma in 2008, (1,742,000 units), compared with only 15.3% in 2006 (613,000 units).
- Jumbo plasma accounted for 1.1% (51,000 units) of plasma transfused.
- Cryoprecipitate-reduced plasma accounted for 4.0% of the total plasma transfused (180,000 units), comparable in proportion and amount

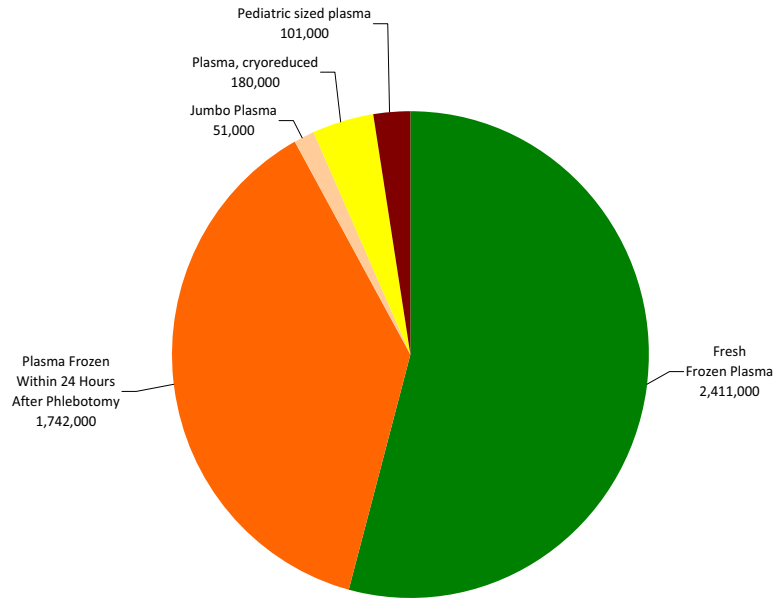

Figure 4-2. Types of plasma transfused in 2008.

to 2006 (4.7%, 188,000 units).

- Plasma transfused to pediatric patients, whether pediatric FFP (100-mL size) or plasma of other types, accounted for 2.3% (101,000 units) of the total plasma transfused.

In 67% of transfusing facilities, plasma was routinely transfused to non-pediatric patients based on unit volume; it was transfused based on patient size in 33% of transfusing facilities.

The reported median volume of plasma transfused during a single transfusion episode was 300 mL (n = 1,288), the same as reported on previous surveys.

The mean volume transfused was 363 mL.

Cryoprecipitate use was reported as 1,109,000 units or unit equivalents. In 2006, data on cryoprecipitate use were collected as separately reported numbers for Cryoprecipitated AHF transfusion and for use in fibrin sealant (993,000 and 10,000, respectively); in this survey a single figure for all uses of the component was reported.

There was an overproduction of cryoprecipitate by approximately 24.1%; only 3.1% of the total was accounted for by reported outdates.

Transfusion of granulocytes, prepared from both apheresis and WB units, decreased significantly (38.7%; $p<0.01$). A total of 1,013 units were transfused, compared with 1,652 reported to be used in 2006.

Total Components Transfused

The total number of units of all components transfused in the United States in 2008, both RBC and non-RBC components, was 23,669,000, an increase of 1,203,000 (5%) in comparison with 2006.*

Hospitals also reported on the use of Intravenous Immune Globulin by their institution. Most hospitals were required to obtain this information through the hospital pharmacy. A total of 5,101,000 g (an increase of 4% from 4,905,000 g in 2006) were reported to have been used.

**Data reported in the 2007 NBCUS was recalculated without converting apheresis platelets to concentrate equivalents in order to perform a meaningful comparison.*

Platelet Dosage

Institutions reporting platelet transfusions were requested to indicate the number of therapeutic doses of each type of platelets. Hospitals reported the transfusion of 1,399,000 doses of plateletpheresis products and 195,000 doses of WBD platelet concentrates (see **Figure 4-3**). Blood centers reported the transfusion of 34,000 plateletpheresis doses and 38,000 doses of WBD platelet concentrates. In 2008, the ratio of apheresis platelet concentrate doses transfused to WBD doses transfused was 6.2:1, compared with 4.8:1 in 2006 and 3.7:1 in 2004.

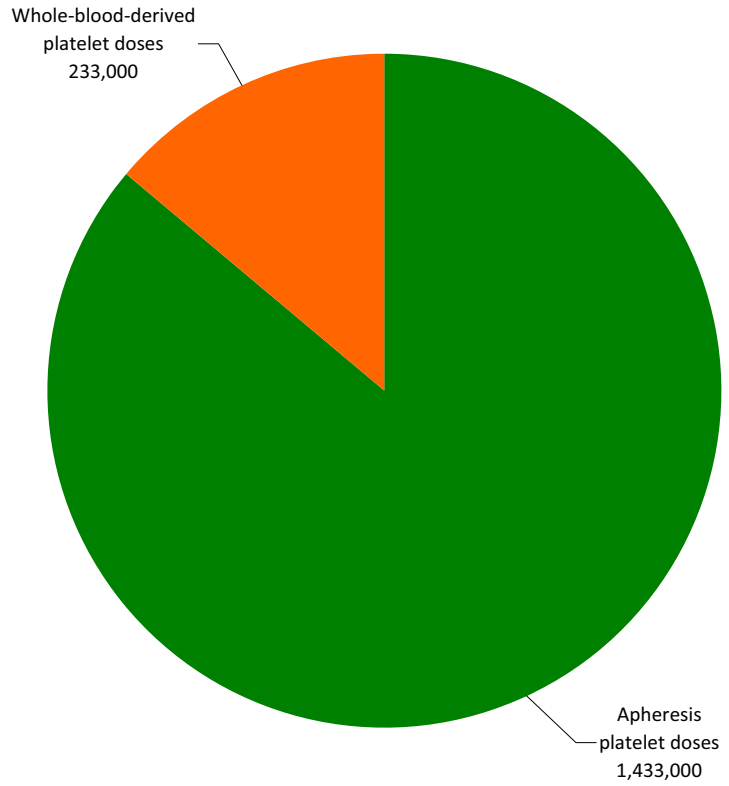

Figure 4-3. Therapeutic platelet doses transfused in 2008.

Facilities reporting WBD platelet concentrate doses indicated the most common dosage used in their institutions (**Figure 4-4**; n = 459). As compared to 2006, a higher percentage of facilities reported five or fewer platelet concentrates in a dose. The use of five or fewer has increased over the recent surveys. In 2008 this represented the majority of hospitals (47.5%). The next largest cohort reported using six (38.7%).

Outdated Units

The national estimate for the number of WB units and all component units outdated by blood centers and hospitals in 2008 was 1,346,000 units. Blood centers reported 44.9% of all outdates. Allogeneic, nondirected RBC outdates were more commonly reported by blood centers over hospitals in 2008 (1.5:1), while hospitals were responsible for most of the directed and autologous outdates (96.4% and 96.2%, respectively). This is reasonable considering that most blood centers distribute the directed and autologous units to hospitals for specific patients. Most non-RBC components, with the exception of WBD platelets, were outdated by hospitals. Plasma (FFP or PF24) and cryoprecipitate were least likely to be outdated by blood centers.

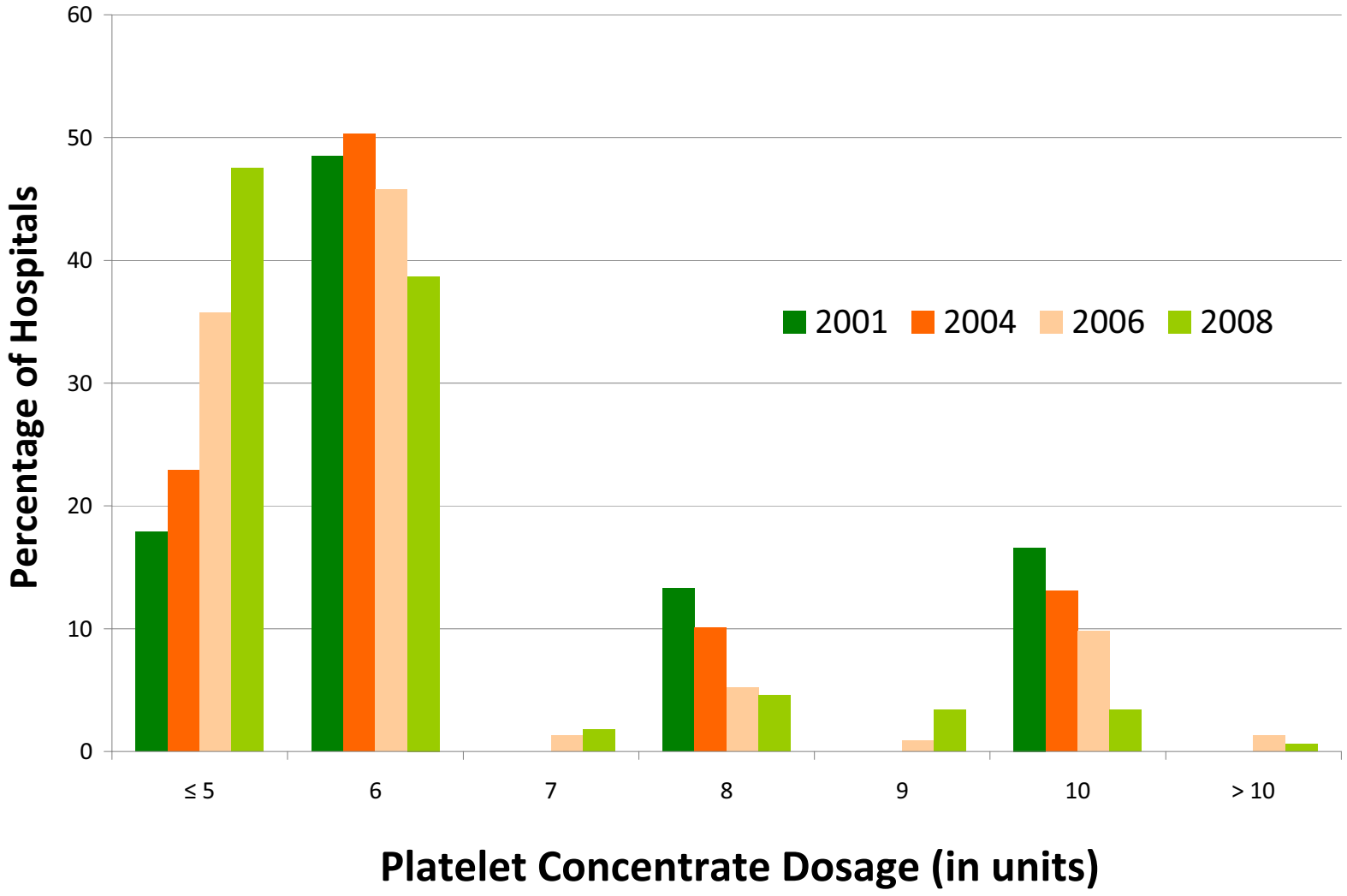

Figure 4-4. Most common platelet concentrate dosage reported by hospitals.

As shown in **Table 4-2**, outdated WB/RBCs accounted for 2.6% of all WB/RBC units processed in 2008. The total number of WB/RBC units outdated was 11.7% higher than the 2006 total.

Outdated WB and RBCs totaled 447,000, of which 337,000 were allogeneic, non-directed RBCs. The remaining outdates were: autologous units (93,000), directed units (3,000), and whole blood (13,000). The percentage of outdated WB/RBCs contributed by each collection type is illustrated in **Figure 4-5**. The percentage of directed units collected that outdated (4.8%) increased when compared to the directed outdates from 2006 (1.2% of reported directed collections), whereas the autologous unit outdate rate was comparable (31.8% in 2008 compared to 32.7% 2006). Allogeneic donations continue to be more likely to lead to fewer outdates and greater utilization than autologous or directed donations.

As in 2006, the current survey inquired specifically about blood group O-positive and O-negative outdates (**Figure 4-6**). In 2008 they accounted for a total of 8.4% of the total outdated allogeneic WB/RBCs: 5.4% of outdated units were group O-positive, 3.0% were O-negative. The previous survey reported a slightly larger outdate percentage for group O units (12.2% in total).

As has been the case in previous surveys, WBD platelet concentrates accounted for the greatest percentage of total individual components outdated, 35.7% (480,000/1,346,000). These were 53,000 (9.9%) fewer units outdated than reported in 2006. Outdated WBD platelets accounted for 24.4% of all WBD platelets processed in 2008.

Apheresis platelets contributed 270,000 units, or 20.1% to total outdates. This represents 12.7% of apheresis platelets processed, slightly more than were outdated in 2006 (10.9% of production).

Table 4-2. Outdated Components as a Percentage of the Total Number of Units of Each Type, Processed for Transfusion in 2008

	WB/RBCs	Whole-Blood-Derived Platelets	Apheresis Platelets	Plasma	Cryoprecipitate	All Components
Outdated Total	447,000	480,000	270,000	103,000	46,000	1,346,000
Processed/ Produced	17,402,000*	1,964,000	2,130,000*	5,700,000	1,462,000	28,658,000
Percent Outdated	2.6%	24.4%	12.7%	1.8%	3.1%	4.7%

*Numbers reported as processed or produced by an institution; this may differ from the number reported as collected, but not significantly.

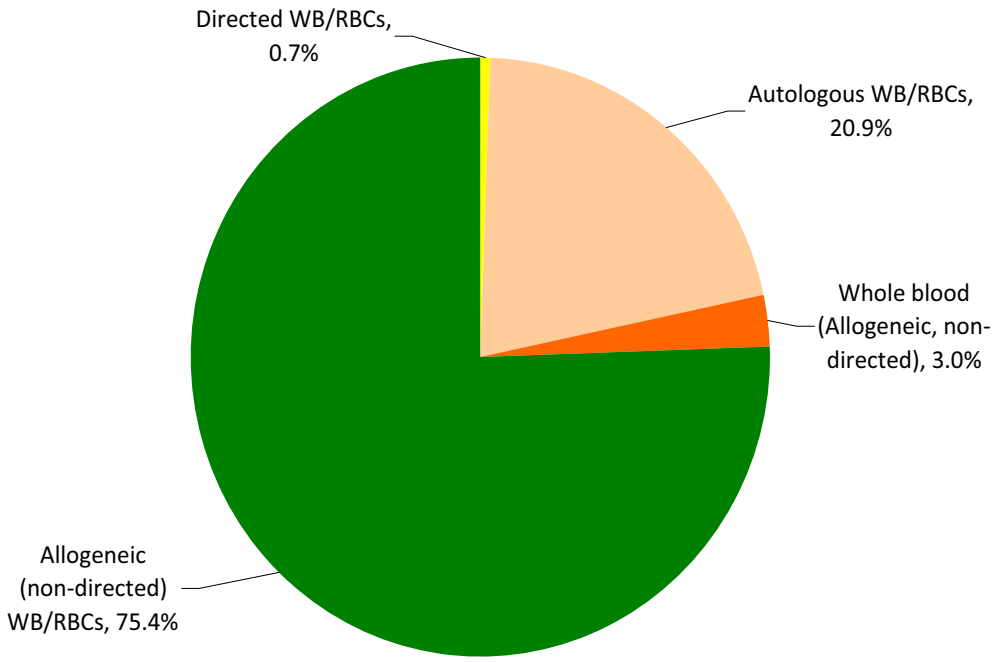

Figure 4-5. WB/RBC outdates by collection type.

Outdated plasma totaled 103,000 units, only 1.8% of the plasma units processed for transfusion. The number of outdated cryoprecipitate units was 46,000, 3.1% of the cryoprecipitate processed.

Apheresis platelets, plasma, and cryoprecipitate combined accounted for 31.9% of all outdated units, 6% more than in 2006. Overall, efficiency of utilization was very comparable to that reported in 2006. The percentage of units processed or produced in 2008 that outdated (4.7%) was comparable to that of 2006 (4.6%).

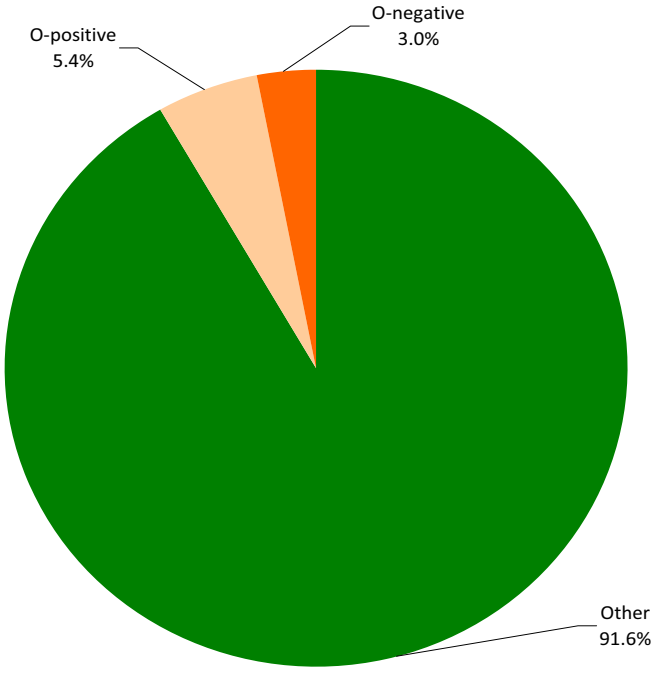

Figure 4-6. Percentage of allogeneic RBC outdates by blood group and type.

5. Component Modification

Leukocyte Reduction

Blood components are leukocyte reduced (LR) to reduce the risk of febrile nonhemolytic reactions, transmission of cytomegalovirus infection, and HLA alloimmunization that may lead to platelet refractoriness. Other indications exist but are controversial. Leukocyte reduction may occur during collection, at various points in the storage process, or at the bedside. A total of 14,791,000 (56.3%) component units, including pediatric aliquots, were LR by blood centers and those hospitals that collect blood (**Table 5-1**).

The most frequently LR components were WB/RBCs and apheresis platelets. The percent of all WB/RBCs that were LR before storage in 2008 was 80% (an increase of almost 10% over 2006). It is expected that 100% of apheresis platelets are LR in the collection process.

Compared to 2006, preparation of components* that were LR before storage increased 19.2% in blood centers, and increased 86.5% in hospitals (**Table 5-2**). Overall, the number of these components* prepared increased by 21% from 2006. In 2008, 96% of LR components were prepared at blood centers.

Transfusion of Modified Components

Table 5-3 summarizes the types and numbers of irradiated and LR blood component units transfused during 2008. A total of 100,000 irradiated units were reported as transfused by blood center transfusion services and 2,567,000 by hospital transfusion services. In total, 11% of all component units transfused were irradiated.

In 2008, 11,153,000 LR component units were transfused—231,000 (2%) by blood center transfusion services and 10,922,000 (98%) by hospital transfusion services. Of the total, 98% were LR before or after storage (not at bedside) and 2% at bedside.

Table 5-4 and **Figure 5-1** summarize the trends in numbers of irradiated and LR RBC units transfused. Between 2006 and 2008 the number of irradiated RBC units transfused increased 30.3%, representing approximately 10% of all units transfused.

Because most irradiation is performed in response to physicians' orders, this increase most likely reflects an increase in demand.

The dip in transfusion of LR units observed in 2006 was not seen in 2008. In 2008, the transfusion of LR RBC units increased 27.5% from 2006. However, the declining trend of bedside leukocyte filtration seen in previous years continued, decreasing 5.8% in 2008.

**Does not include apheresis platelets.*

Table 5-1. Blood Components* Modified to Achieve Prestorage Leukocyte Reduction in All Facilities

Blood Component	2008 Leukocyte-Reduced Prestorage	2008 Leukocyte-Reduced % of Total Available Components	2006 Leukocyte-Reduced Prestorage	2006 Leukocyte-Reduced % of Total Available Components
WB/RBCs	13,791,000	80.4	11,312,000	70.6
WBD Platelets	926,000	47.1	897,000	37.4
Other Component Units*	74,000	1.0	16,000	0.2

*Apheresis platelets not included in totals.
WB = Whole Blood; RBCs = Red Blood Cells; WBD = whole-blood-derived.

Table 5-2. Change in Number of Blood Components* Modified to Achieve Prestorage Leukocyte Reduction by Facility Type from 2006 to 2008 (expressed in thousands of units)

Modification	Blood Centers 2008	Blood Centers 2006	Blood Centers % Change	Hospitals 2008	Hospitals 2006	Hospitals % Change	All Facilities 2008	All Facilities 2006	All Facilities % Change
Components leukocyte reduced before storage (not at the bedside)	14,196	11,906	19.2	595	319	86.5	14,791	12,225	21.0

*Red cell/whole blood units, whole-blood-derived platelets, other components including plasma, cryoprecipitate included (apheresis platelets not included in total).

Table 5-3. Estimated Number of Blood Component Units Modified by Irradiation or Leukocyte Reduction and Transfused by All Facilities in 2008 (expressed in thousands of units)

Blood Component	Components Irradiated	Components Leukocyte Reduced Before or After Storage (not at the bedside)	Components Leukocte Reduced by Filtration at the Bedside	Total Leukocyte-Reduced Units	Irradiated: % of Total Units Transfused	Leukocyte-Reduced: % of Total Units Transfused
All Facilities						
WB/RBCs	1,502	10,115	179	10,294	10.0	68.6
WBD Platelets	291	635	63	697	22.4	53.7
Apheresis Platelets	773	*	*	*	43.9	*
Other Component Units	101	160	1	162	1.8	2.9
Total Components	2,666	10,910	243	11,153	11.3	51.1
Blood Centers						
WB/RBCs	64	191	0.3	191	0.4	1.3
WBD Platelets	11	35	0	35	0.8	2.7
Apheresis Platelets	24	*	*	*	1.3	*
Other Component Units	2	5	0	5	0.0	0.1
Total Components	100	231	0.3	231	0.4	1.1
Hospitals						
WB/RBCs	1,438	9,924	178	10,103	9.6	67.3
WBD Platelets	280	599	63	662	21.6	50.9
Apheresis Platelets	749	*	*	*	42.5	*
Other Component Units	99	155	1	157	1.8	2.8
Total Components	2,567	10,678	242	10,922	10.8	52.5

*Apheresis platelets not included in totals.

Table 5-4. Total Number of Irradiated and Leukocyte-Reduced Red Blood Cell (RBC) Units Transfused in 2008, Compared with RBC Units Transfused in 2006 (expressed in thousands of units)

Modification	Units			
	2008	2006	Change 2008-2006	% Change
Irradiated RBCs	1,502	1,153	349	30.3
Leukocyte-reduced RBCs, total	10,294	8,076	2,218	27.5
Before or after storage (not at the bedside)	10,115	7,886	2,229	28.3
At the bedside	179	190	–11	–5.8

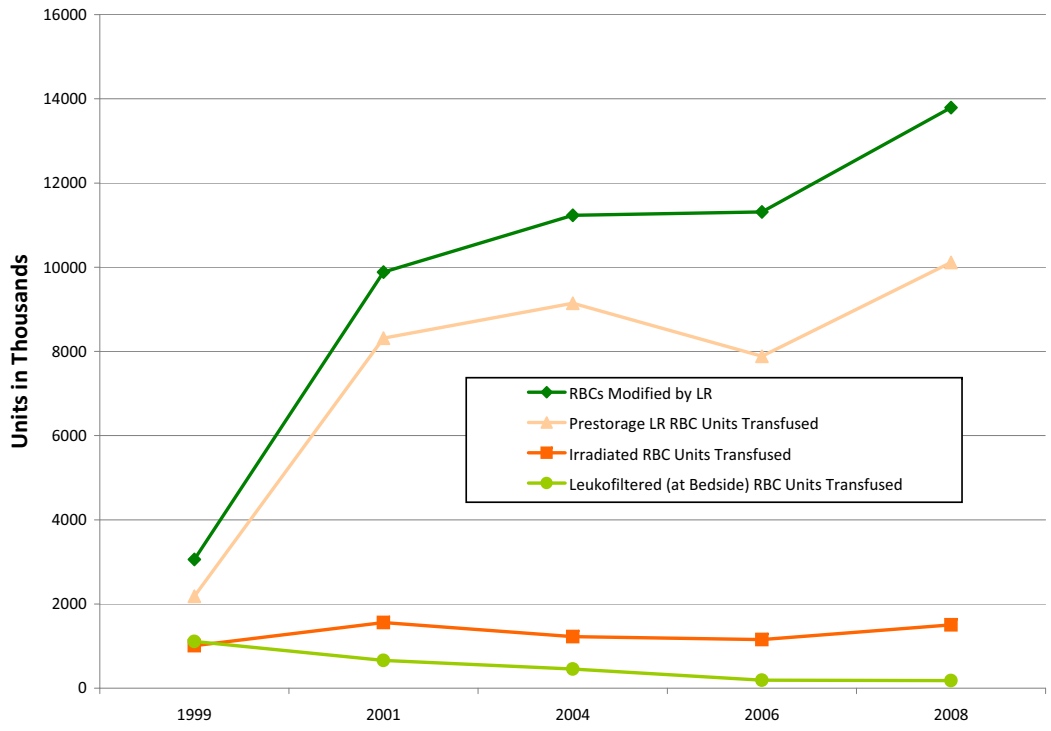

Figure 5-1. Transfusion of modified red cell components.

6. Current Issues in Blood Collection and Screening

Donors

In 2008, 19,339,000 individuals presented to donate blood. The majority (93.6%) presented at blood centers with 6.4% presenting at hospital donor centers. Of these, there were 10,805,000 allogeneic nondirected donors who successfully gave blood; 3,165,000 (29.3%) were first-time donors and 7,640,000 (70.7%) were repeat donors.* These repeat allogeneic donors provided 11,461,000 donations, the equivalent of 1.5 donations per donor, a reduction from 1.7 units per repeat donor reported in 2006.

There were 72,000 directed donors reported who successfully donated an allogeneic unit intended for a specific patient. Although the number of directed units reported to have been collected was only 63,000 units (manual and apheresis collections combined), many blood centers and hospitals reported that they were unable to specify which donors had directed their donation (as described in Chapter 5). Thus, there was a discrepancy in the numbers, as was also the case in 2006.

Blood collection from younger donors has been an area of interest in recent years. There were 3,284,000 units collected from donors aged 16-24. This represents approximately one-fifth of the total allogeneic collections (19.3%).

There were reported to be 1,826,000 units collected from minority populations (including African, Asian, and/or Hispanic). Although some respondents were unable to specifically report by race/ethnicity, these donations represent a critical contribution to the nation's blood supply (10.7%) and are likely an underestimate of minority collections.

Mobile blood drive sites were the source of 10,606,000 units, or 61.4% of collected units. Blood centers obtained a greater proportion of their collections through mobile blood drives (62.3%), while hospitals reported use of mobile blood drives for 47.7% of collections.

Screening

Of the 19,339,000 presenting individuals, 2,428,000 (12.6%) were deferred for various reasons. The deferral rate was slightly higher in hospital collection environments (14.5%) as compared with that of blood centers (12.4%). Donors were most commonly deferred temporarily for low hemoglobin (59.3% of deferrals), defined as those

**Repeat donors as defined by the reporting facility.*

who do not meet FDA blood hemoglobin level requirements for blood donation. As seen in **Figure 6-1**, additional categories for deferral include other medical reasons for deferral (29.9% of deferrals), high-risk behavior as identified on the Donor History Questionnaire (DHQ) deferrals (2.9% of deferrals), and deferrals for specific foreign travel (7.9% of deferrals). Deferrals for other medical reasons may include the use of medications on the medication deferral list; exposure to human-derived growth hormone, bovine insulin, hepatitis B immune globulin, or unlicensed vaccines; or presentation with physical conditions or symptoms incompatible with blood donation. High-risk behavior deferrals include those intended to reduce the risk of transmission of infectious diseases, including human immunodeficiency virus (HIV) and hepatitis viruses.

A total of 127,000 units, from 1.2% of donors (0.7% of units tested), were rejected for abnormal disease marker test results.

Donor Hemovigilance

This survey provided the opportunity to collect baseline data for donor hemovigilance, one of four elements making up biovigilance. The Donor Hemovigilance system was completed in 2010 and is designed to monitor adverse reactions associated with blood donation. For the purposes of this survey, severe donor adverse events were defined as adverse events occurring in donors attributed to the donation process that

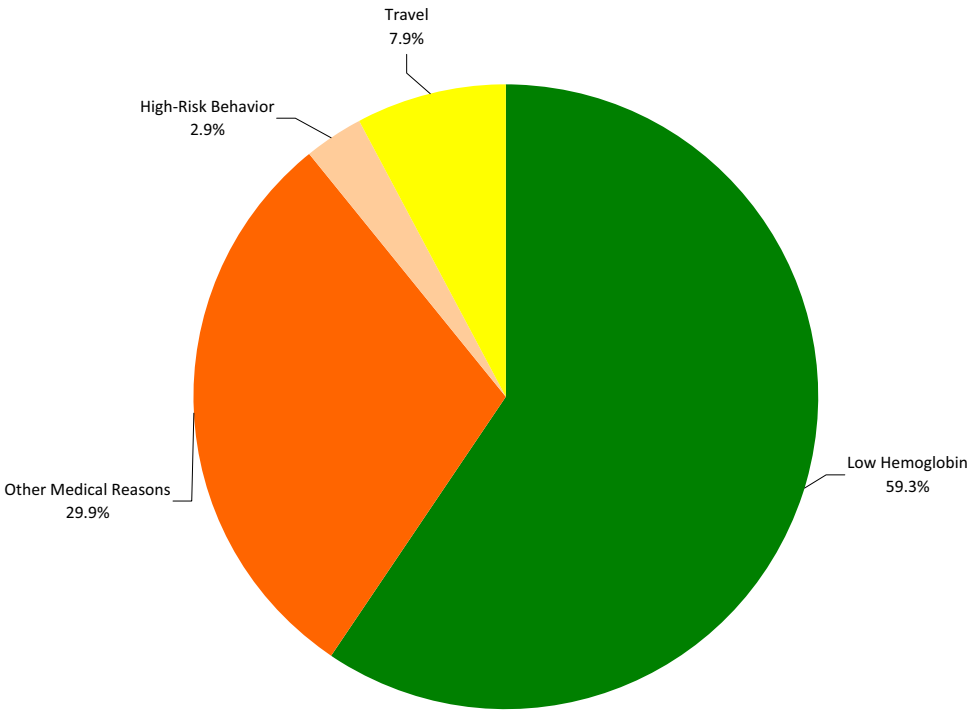

Figure 6-1. Categories for deferral.

included major allergic reaction, loss of consciousness of a minute or more, loss of consciousness with injury, nerve irritation, etc.

A total of 16,000 of these events were reported by collection organizations for 2008—significantly more adverse events than the 11,000 events reported in 2006 ($p<0.05$). The rate of severe adverse events was 16,000/17,779,000 collection procedures (0.09%). The rate of severe adverse reactions per unit collected was also 0.09% (16,000/17,286,000). There was no difference in overall reaction rates for manual collections vs automated procedures, nor were there differences between blood centers and hospital collectors in reaction rates. However, hospitals had significantly fewer severe donor adverse reactions ($p<0.005$) with automated collection procedures (a rate of 0.04%) than with manual collection procedures (0.10% of all manual collection procedures). Nevertheless, blood donation, either through traditional manual whole blood collection processes or using automated procedures, rarely results in an untoward consequence.

7. Current Issues in Blood Transfusion

US Population Trends

Figure 7-1 illustrates the trends in the estimated rates of WB/RBC collection and transfusion in the United States from 1980 to 2008. The rate of collection, the upper line, was calculated from the national estimate of total allogeneic WB and RBCs collected per thousand population (aged 18-64 for survey years 1980-2006; 16-64 for 2008). The rate of transfusion, the lower line, was calculated from the national estimate of allogeneic WB/RBC units transfused per thousand total population of all ages for that year. Population figures were obtained from the US Bureau of the Census.

Allogeneic blood collection in the US population of age 16 to 64 was 85.2 units per thousand persons in 2008 compared with 84.1 units per thousand persons aged 18 to 64 in 2006. In many, if not most, areas of the country, persons as young as 16 years of age may donate and this expansion to include the additional population of donors is reflected in the analysis. Although the actual proportion made up by this age cohort has probably increased over the past few survey years, this year the cohort has been included in its entirety to reflect the change in collection/donation practice. Allogeneic blood collected per thousand total population (including those under 16 and over 65) is reflected in the middle line of **Figure 7-1** and shows that the rate of blood collection in the population only marginally exceeded the rate of transfusion per person.

Based on the number of donors reported in the 2008 survey year, 5.4% of the 16- to 64-year-old US population donated in 2008, quite comparable to the 4.8% of the 18- to 64-year-old US population* reported to have donated in 2006. The current survey also assessed the donations that were contributed by donors of age 16 to 24 years of age. The rate of donations in this population was 84.8 units per thousand persons in 2008, nearly as high as in the eligible population overall and only slightly lower than the rate from persons aged 25-64 (85.2 units per thousand persons). Although there has been discussion that the potential donor base may be smaller than previously assumed,* the rate of donations per 1,000 persons of eligible age (using the slightly reduced age categories imposed by the US Census) has remained more or less constant since 2000.

The US WB/RBC transfusion rate in 2008 was 48.8 allogeneic units per thou-

**Although 65 is no longer the age limit for donation, <65 years of age was used for consistency with historical analyses.*

**Riley W, Schwei M, McCullough J. The United States' potential blood donor pool: Estimating the prevalent donor-exclusion factors on the pool of potential donors. Transfusion 2007;47:1180-8.*

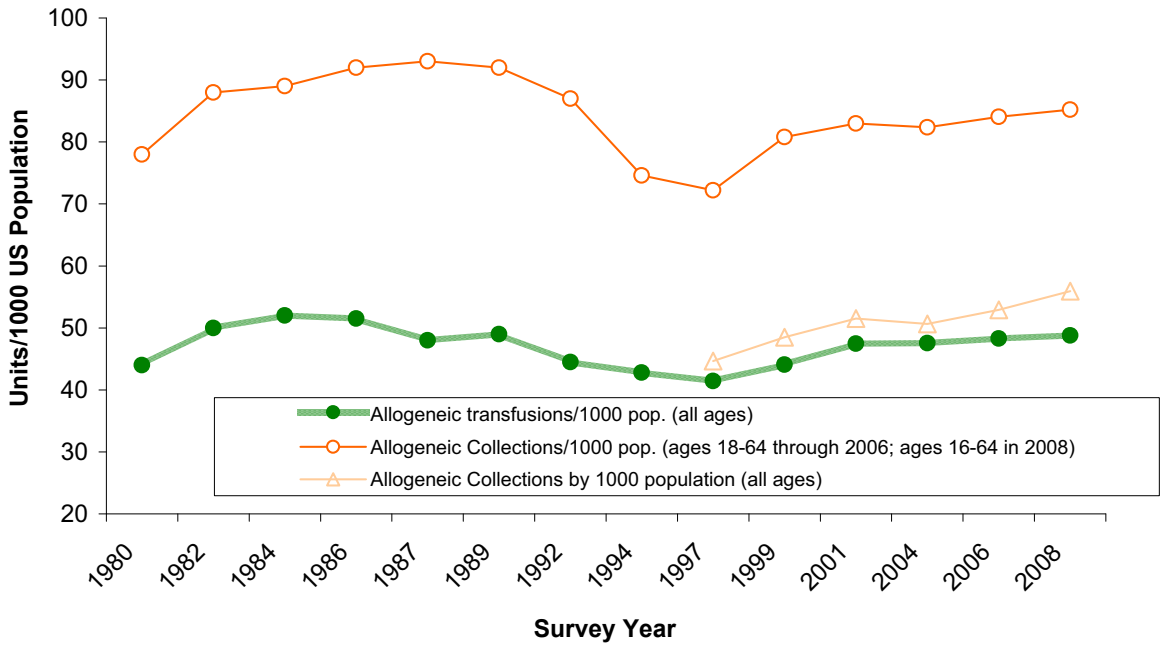

Figure 7-1. Trends in estimated rates of blood collection and transfusion in the United States, 1980-2008.

sand overall population. This rate is not statistically different from the allogeneic transfusion rate in 2006 (48.3/1,000 population), and the trend suggests a steady state from approximately 2001.

The 2008 transfusion rate does not indicate an impact of the recession on the overall use of blood in the United States. It will be of interest to review transfusion rates in future surveys considering the national interest in blood management and the reported impact of the recession on the number of elective surgeries.

Note: Allogeneic blood collection per thousand total population in 2008 was 55.9. The age-adjusted value of 85.2 was used in ***Figure 7-1*** *for consistency with historical analyses.*

Trends in Utilization

Figure 7-2 illustrates the relationship between allogeneic WB/RBC collections and transfusions from 1989-2008, as well as the margin between units collected and those transfused, which is discussed below. The rise in the number of collections reported since 1997 continues through 2008 with 17 million collected, a 6.9% increase over 2006. Allogeneic collections have increased 42% from their low point in 1997.

The available supply of both WB/RBCs and non-RBC components was more than sufficient to meet overall transfusion demands in 2008. Shortages discussed in Chapter 8 suggest that the few cases of reduced

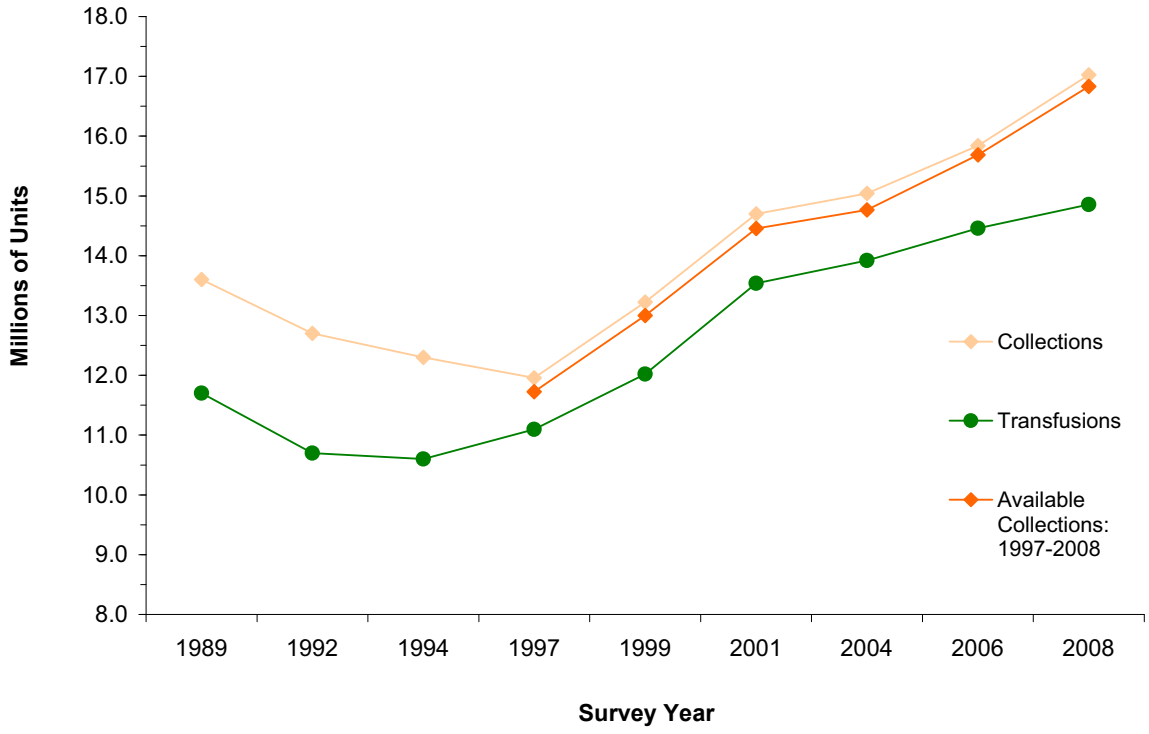

Figure 7-2. Allogeneic whole blood and red blood cell collections and transfusions, 1989-2008.

availability were local in nature.

The margin between allogeneic WB/RBC supply and demand depicted in **Figure 7-2** provides an indication of the degree of supply sufficiency or oversupply.

In 1989, allogeneic collections totaled 13.6 million, with a margin of 1.9 million, 14% of supply. By 1997, the difference between units collected and transfused had decreased to 862,000 units. When the available supply variable was introduced, this demonstrated that actual *available* units, (ie, units that have passed all laboratory tests and are available for transfusion) had decreased to 632,000, only 5.3% of the supply. In response to increasing demand for RBCs in 1999, blood centers successfully increased allogeneic collections to 13.2 million, increasing the available margin to 7.5% in spite of an 8.3% increase in transfusions. Collections increased significantly ($p<0.0001$) in 2001 due largely to the extraordinary response to the terrorist events of September 11; however, there was a concomitant increase in transfusions of the same magnitude. There were nearly one million excess units available, or 6.3% of available supply. Since 2004, growth in utilization has increased at a slower rate than the increase in collection.

In 2008, there was a substantial increase in available allogeneic collections to 16.9 million units. With

only a small increase in the number of units transfused there was a margin of 2.0 million units, or 12% of supply. This margin was wider than experienced in recent history.

Additional information about availability was obtained in 2008. AABB's Interorganizational Task Force on Disasters, in the course of its deliberations on how to communicate the status of the blood supply to DHHS during disasters, settled on a simple quantitative approach that reports the US blood center on-shelf blood supply in terms of days of available supply. This led to a decision to collect and report data daily for task force use and a weekly report to DHHS. The participating organizations that submit data are America's Blood Centers, the American Red Cross, and Blood Centers of America. The data are aggregated and disseminated through AABB's Center for Data and Special Programs in collaboration with the National Blood Exchange. The first complete year for these supply estimates was 2008. **Figure 7-3** indicates the overall days of nationwide group O RBC availability throughout the calendar year. This does not take into consideration possible geographic differences in availability; however, blood can be moved quickly from one location to another through the use of various supply networks. Toward the end of the 2008 calendar year there was an increase in days of supply, which carried on through 2009 and beyond (data not shown).

Blood Inventories

The 2008 and previous surveys asked hospitals to indicate the number of days in the survey year that elective surgery was postponed due

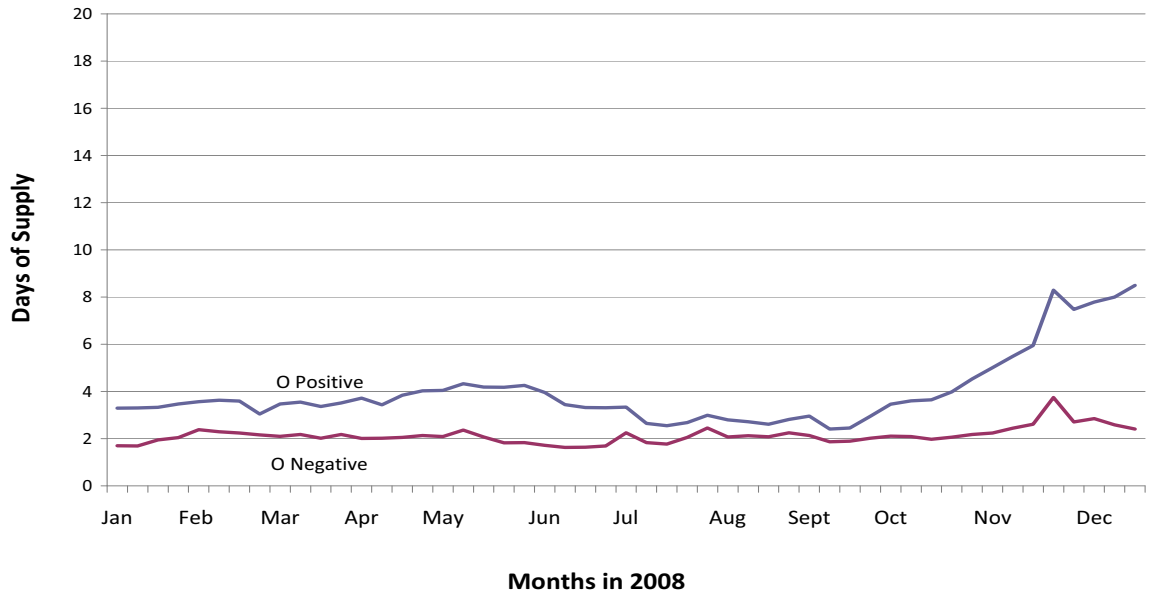

Figure 7-3. Days of group O blood supply in 2008.

to actual blood inventory shortages, and the number of days that they were unable to meet other non-surgical blood requests. In addition, the 2008 survey queried the number of days on which the hospital's regular order was incomplete by component type.

A total of 62 hospitals (4.4%) reported that elective surgery was postponed on one or more days in 2008 due to blood inventory shortages. **Table 7-1** provides a characterization of cancellation reports in 2008 in comparison with previous survey years, using unweighted data. The number of reported days of delay ranged from 1 to 100 with a median of 2 days. When the three outliers (100, 32, 40 days) are eliminated, the range of reported delay narrows to 1-14 days. This suggests that in 2008 shortages were rare and significant for only a very few hospitals.

Hospitals indicated separately that the total number of postponed surgical procedures was 325 compared with 721 in 2006, using weighted data. This was a significant drop of 55% ($p<0.001$) in the number of procedures postponed, suggesting improved availability and continuing the declining trend since 2001 for the numbers of patients affected by shortages. Hospitals in the 1,400-2,399 surgery stratum and hospitals in the largest stratum had significantly fewer delays ($p<0.001$ and $p<0.05$, respectively). The cost of postponing surgical procedures due to an inadequate blood supply was not calculated.

Hospitals indicated the number of days in which non-surgical blood requests were not met. Of responding hospitals, 13.2% (213 hospitals) reported at least one day in which non-surgical blood needs could not be met; this was unchanged from the 2007 NBCUS report in which 13.5% (231 hospitals) reported unmet need. The total number of days reported was 4,146 and the range was 1 to 365. There was no difference between the mean number of days (using weighted data) of unmet non-surgical needs for all respondents between 2006 (22.0) and 2008 (21.7). However, hospitals in USPHS Region II (New York-New Jersey) had significantly fewer days of

Table 7-1. Cancellation of Elective Surgeries by US Hospitals, 1997-2008*

Year	% Hospitals with Cancellation of ≥1 Day	Range of Days	Median Number of Days	Number of Patients Affected
1997	8.6	1-21	2	Not determined
1999	7.4	1-150	2	568
2001	12.7	1-63	2	952
2004	8.4	1-39	2	546
2006	6.9	1-120	3	412 (721 weighted)
2008	4.4	1-100	2	151 (325 weighted)

unmet requests ($p<0.001$) in 2008 than in 2006. Six hospitals reported 365 days in which non-surgical blood requests were not met in 2008, as did six in 2006. The facilities in both 2006 and 2008 were geographically dispersed and did not repeat from survey to survey.

Hospitals were asked to indicate the number of days on which their regular or standing order of components was incomplete for different components. The total number of "reported days incomplete" among all components was 45,322 days, compared with 44,910 days in 2006. The weighted means of incomplete days across all hospitals were 28 days for RBC orders, 23 days for plasma orders, 21 days for apheresis platelet orders, and 20 days for WBD platelet orders (**Figure 7-4**).

Blood centers reporting as transfusion services maintained an average weekday inventory of group O RBCs of 48.4 units. Average hospital weekday inventories varied by the number of surgeries performed, with the largest hospitals maintaining the largest inventories (45.4 units) and the smallest keeping an average of 14.1 units. The threshold for group O uncrossmatched units considered to be critically low ranged from 6.7 units among the smallest hospitals to 34.9 units in the largest hospitals. Blood centers reporting as transfusion services reported 31.6 uncrossmatched group O units as the critical inventory threshold.

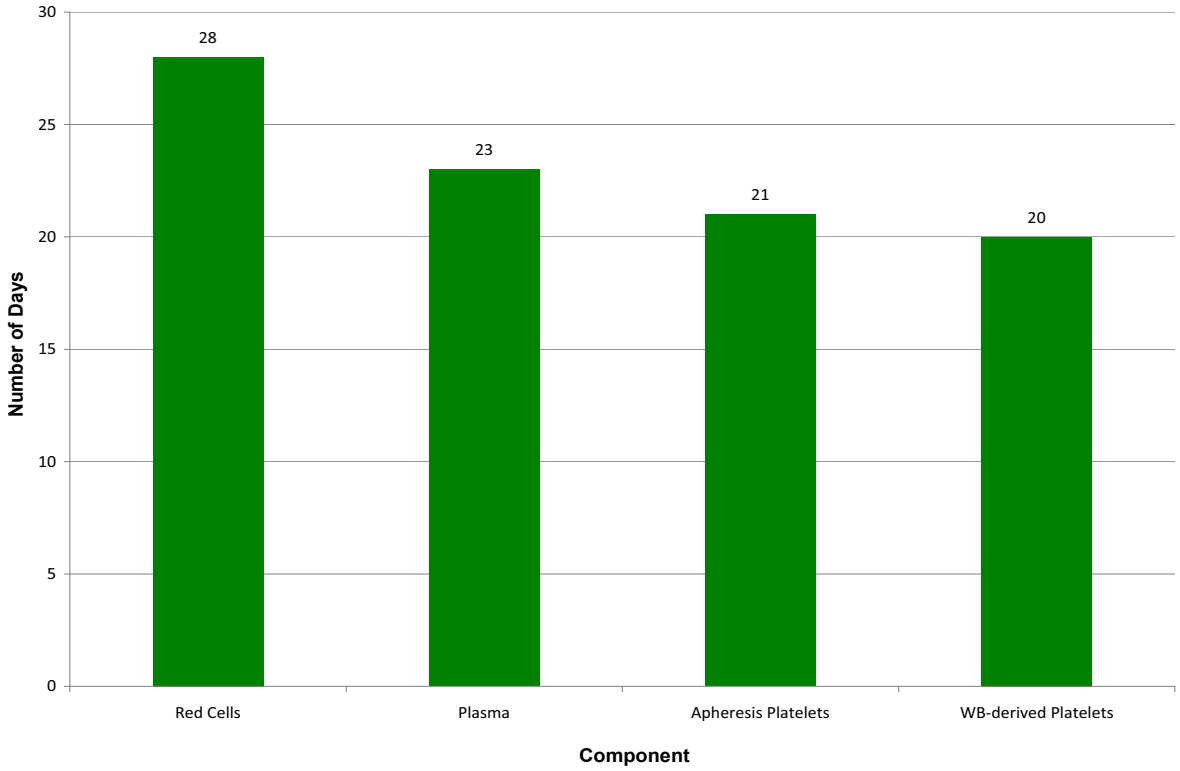

Figure 7-4. Average number of days a hospital order was incomplete.

Institutions were questioned about the use of blood management programs. Fifteen percent of responding hospitals reported having an established "bloodless" surgery program, 101% more than reported such a program in 2006 ($p<0.001$). In addition, 68% of responding hospitals reported having intraoperative autologous blood recovery therapies, compared to 62% in 2006 ($p<0.01$).

Blood Use

Hospitals were asked to indicate the number of RBC and platelet units distributed to individual hospital services (eg, Surgery, Hematology/Oncology, Transplant, etc) in 2008 (**Figures 7-5** and **7-6**). The highest use of RBCs was attributed to General Medicine (28.2%) and Surgery (23.6%; general surgery, orthopedic, and cardiac combined). Approximately 52% of WB/RBC transfusions were accounted for by these services in the hospitals that reported service use details. Many hospitals were unable to report transfusion by department or service. Data are reported on the basis of unweighted responses.

The services reporting the greatest use of platelet products were Hematology/Oncology (31.6%), General Medicine (14.9%), and Cardiac Surgery (12.1%). Of the hospitals that reported such data, 58.6% of platelet transfusions were accounted for by these services.

Service utilization reporting was possibly confounded by the use of self-defined categories where some hospitals have combined reporting categories.

Bacterial Testing

The 2009 NBCUS was the second survey to include a section on bacterial testing. In the 2008 survey year, 486 institutions (30.6%) performed bacterial testing of platelets, compared with 27.3% in 2006. Of the 91 blood centers responding to this question, 94.5% reported performing bacterial testing; however, only 26.7% of all hospitals reported testing.

Respondents were asked to indicate their methods used to detect bacterial contamination of platelet components. Of the 260 facilities reporting testing apheresis platelets, 74.6% reported using culture-based testing. Of hospitals that reported testing apheresis platelets, 62.7% reported using culture-based testing. Of blood centers that reported testing, 96.7% reported using culture-based testing. Of the 353 facilities reporting testing WBD platelets singly, 81.9% reported using pH methods and 37.7% reported using glucose methods, with some facilities reporting more than one method of testing. Among the 117 facilities testing WBD platelet pools, 52.1% used pH testing and 36.8% used culture-based methods. Overall, blood centers were more likely to use culture-based testing, whereas many hospitals employ alternative testing methods.

Bacterial testing results for 1,483,000 platelet units were reported in 2008. Culture-based methods accounted for 64.5% of the units tested (956,000 units) and for 539 (88.9%) of the 606 confirmed positives. Most blood centers (97%) reported using culture-based test methods, whereas only 63% of hospitals reported use of culture-based tests. There were no reports of blood centers using rapid immunoassay techniques. The false-positive rates reported for different methods in 2008 were comparable (0.26% reported for culture-based

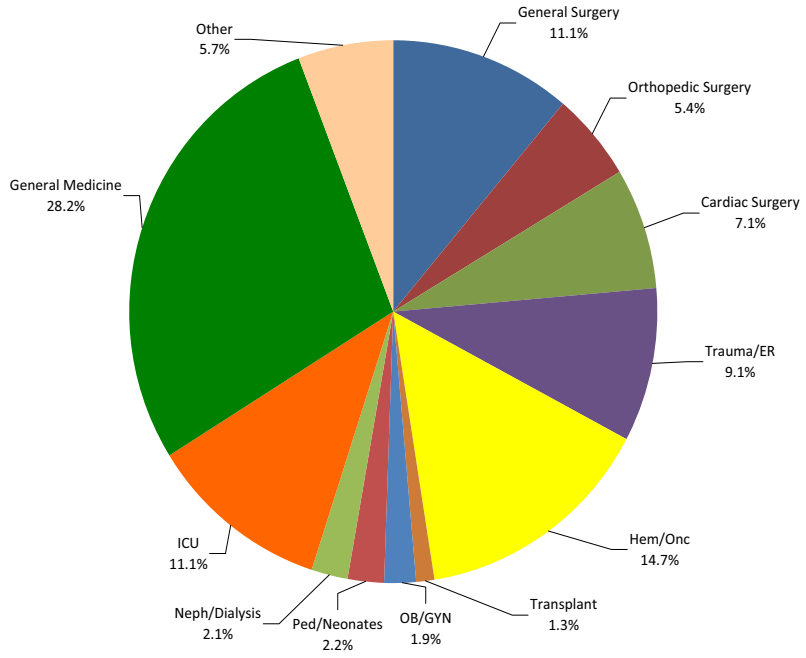

Figure 7-5. RBC use by hospital service in 2008.

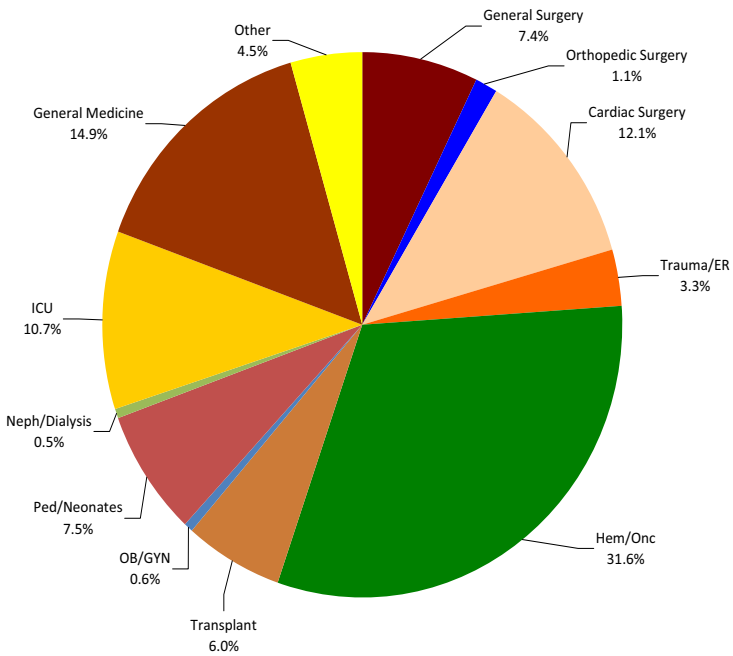

Figure 7-6. Platelet use by hospital service in 2008.

methods vs 0.29% for alternative methods), whereas in 2006 false-positive rates from culture (0.15%) were lower than by alternative methods (1.8%).

Biovigilance

This survey provided the opportunity to collect baseline recipient hemovigilance data. The Hemovigilance Module (recipient) of CDC's NHSN was piloted in 2009 and launched nationally in 2010.

The coordinated effort by the public and private sectors to develop a national hemovigilance system for tracking adverse events associated with transfusion, one component of biovigilance, continued during 2008. During 2008, the public and private sectors worked to communicate common definitions to be used in the program and a number of hospitals and blood centers expressed interest in participation. The baseline questions that first appeared for the 2006 survey year were expanded in the 2009 NBCUS. The NBCUS will continue to collect these data until participation in the NHSN Hemovigilance Module is sufficient to accurately reflect transfusion nationally.

An estimated total of 60,000 transfusion-related adverse reactions occurred in 2008. These were defined as events that required any diagnostic or therapeutic intervention. There was no difference between hospitals of different sizes, based on surgical volume. This represents an adverse reaction rate of approximately 0.25%, (2.5 per 1,000 units transfused), the same rate reported in 2006 (2.6 events per 1,000 units) and well below the range of other national hemovigilance reporting systems (3-7 events per 1,000 units). Given this discrepancy, there is speculation that many adverse events may not be reported to the transfusion service at all and additional education is needed at all levels of the transfusion chain regarding adverse transfusion reactions for full implementation of recipient hemovigilance in the United States.

The rates reported by hospitals for types of transfusion-related adverse reactions are included in **Table 7-2**. There were significant decreases in the reports of delayed transfusion reactions ($p<0.001$) and sepsis ($p<0.001$), **Figure 7-7**. Reports of transfusion-associated circulatory overload (TACO) and allergic reactions were significantly higher ($p<0.05$ and $p<0.01$, respectively) than reported in 2006. Of the other adverse events, there were only 460 (1/51,443) reports of transfusion-related acute lung injury (TRALI). There was no difference in the number of TRALI reports between 2006 and 2008. This finding is unexpected, due to the implementation of several TRALI reduction strategies in the interim.* It is likely that both TACO and TRALI figures are the result of better recognition and reporting of these events. There may also be some overlap in these reporting categories.

**Transfusion-related acute lung injury. Association Bulletin #06-07. (November 3, 2006) Bethesda, MD: AABB, 2006.*

Correction

Reanalysis of the 2006 transfusion-related adverse event data revealed an error that, when subjected to hospital size weighting, erroneously inflated the total number of adverse reactions and the number of transfusion-related acute lung injury cases reported to the NBCUS. The analysis here reflects the corrected 2006 data.

Table 7-2. Transfusion-Related Adverse Reactions Reported to the Transfusion Service

Adverse Transfusion Reactions	Number of Occurrences	Reactions: Components Transfused (n=23,669,000 total components)
Total number of reactions that required any diagnostic or therapeutic intervention	60,110	1:394
Febrile, nonhemolytic transfusion reaction	28,997	1:816
Severe allergic reactions	6,555	1:3,611
Delayed serologic transfusion reaction	2,143	1:11,044
Transfusion-associated circulatory overload (TACO)	1,417	1:16,706
Transfusion-associated dyspnea	1,150	1:20,588
Hypotensive transfusion reaction	1,140	1:20,757
Delayed hemolytic reaction	819	1:28,887
Posttransfusion purpura	493	1:47,993
Transfusion-related acute lung injury (TRALI)	460	1:51,443
Acute hemolysis (due to ABO incompatibility)	39	1:606,978
Acute hemolysis (due to other causes)	143	1:164,936
Posttransfusion sepsis	32	1:738,437
Transfusion-associated graft-vs-host disease	0	—
Reactions that were life-threatening, requiring major medical intervention following the transfusion; eg, vasopressors, blood pressure support, intubation, or transfer to the intensive care unit	169	1:139,908

Hospitals reported 96,000 sample collection errors (eg, wrong blood in tube) from an estimated 19,290,000 patient specimens submitted for testing in the blood bank, an error rate of 0.5% or 1:200 specimens.

Participants reported whether they had an electronic system for tracking events, which were defined as unplanned, unexpected, and undesired occurrences. Fifty-two percent of hospitals reported having such a system to track events, an increase from the 34% reported in 2006. Larger hospitals were more likely to report having these electronic systems.

Crossmatch Procedures

Transfusing facilities reported the total number of crossmatch procedures. Weighted hospital data on crossmatch procedures indicate that 19,881,000 procedures were performed in 2008, compared to 18,801,000 procedures

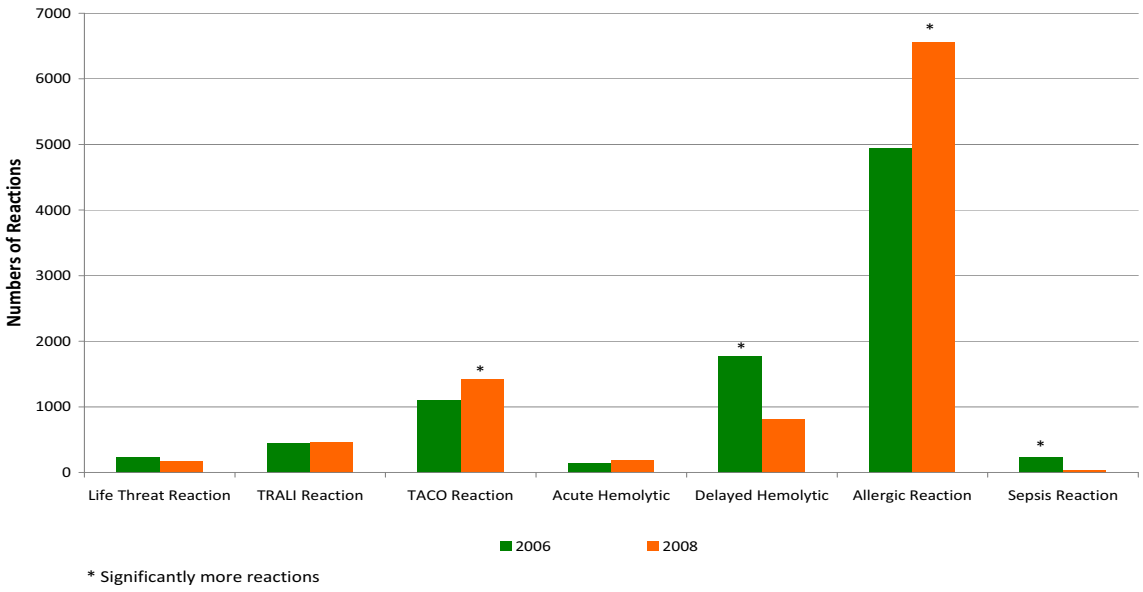

Figure 7-7. Adverse reactions by type, 2006-2008.

in 2006, a positive difference of 5.7%.

In order to calculate the crossmatch to transfusion (C:T) ratio, the total number of allogeneic WB/RBC units transfused was used as the denominator (14,855,000). The overall C:T ratio was 1.3 procedures per unit transfused; the same was reported in 2006.

Red Cell Age

In follow up to earlier surveys, the 2009 survey attempted to clarify the data on the average age of a unit of RBCs at the time of transfusion. In this survey, 750 hospitals responded to this question, an increase from 573 in the last survey. Hospitals were asked to indicate whether they reported a calculated age or an estimate of age. By calculation or estimation, the mean age of red cell components at transfusion was quite comparable at approximately 18 days. The estimated mean age was 18.2 days and the calculated mean age was 17.9 days at transfusion. Only 12.9% (97 hospitals) of hospitals responding to this question were able to calculate the component age at transfusion; this was twice the number reporting calculations in the previous survey.

Platelet Age

In the 2009 survey, 222 hospitals responded with an average age of WBD platelets at transfusion. Hospitals were asked to indicate whether they reported a calculated age or an estimate of age. The estimated mean age was 3.2 days and the mean calculated age was 2.9 days at transfusion. Only 11.2% (26 hospitals) were able to calculate the component age at transfusion. More hospitals (868 hospitals or 53% of hospi-

tals overall) responded with an age for apheresis platelets at the time of transfusion. The mean reported age for 5-day apheresis platelets at transfusion was 3.1 days (calculated average) to 3.2 days (estimate). The mean reported age for 7-day apheresis platelets at transfusion was 3.5 days (calculated average) to 3.7 days (estimate). Only 11.9% (103 hospitals) of hospitals responding to this question were able to calculate the 5-day apheresis platelet component age; even fewer reported a calculated age for the 7-day component (9 hospitals). The actual number of 7-day platelets that were transfused in 2008 was not reported.

Table 7-3. Human Tissue Implants/Grafts Used in 2008

	Blood Centers	Hospitals	All Facilities
Used/implanted	15,000	383,000	398,000
Discarded	2,000	8,000	10,000
Returned	1,000	13,000	15,000*
Removed/Explanted	1	361	362

*Rounding produces columns/rows that do not sum.

Tissue

Forty-four percent of all surveyed institutions (740 facilities) reported using or maintaining an inventory of human tissue for transplantation. Of these institutions, 1% were blood centers and 99% were hospitals.

As detailed in **Table 7-3**, the total number of human tissue implants/grafts that reporting facilities used or implanted was 398,000 in 2008, an increase in reported use of tissue implants and/or grafts of 74% from 2006. Tissue use reported through this survey instrument has increased each year of reporting since 2004 when the question was first included on the

Table 7-4. Adverse Events Associated with Tissue Transplants

	Blood Centers	Hospitals	All Facilities	% of Total Reported Human Tissue Transplanted	% of All Tissue Adverse Reactions
Viral transmission	0	2	2	0.001	3.6
Bacterial infection	0	4	4	0.001	7.1
Fungal infection	0	2	2	0.001	3.6
Graft failure	0	12	12	0.003	21.4
Other events (unspecified)	0	36	36	0.009	64.3
Total proven tissue adverse events	0	56	56	0.014	100.0

survey. The total number of implants or grafts reported to have been discarded was 10,000 and the number returned to the supplier was 15,000. Participants also reported 362 implants/grafts removed or explanted.

Three blood centers and 170 hospitals reported maintaining an inventory of human skin (23% of those reporting tissue use). This product is used for burn applications, traumatic wounds, and integument problems.

In 2008, 56 proven tissue-related adverse events were reported for a rate of 1:7,110 implants/grafts used (**Table 7-4**). Some facilities were able to provide additional detail about these reactions, with graft failure being the largest category of reported events (1:33,181 implants/grafts). Rates are lower than reported in 2006, perhaps because the question requested the number of *proven* tissue-related events. Events that were not imputable or were partially imputable to the graft/implant, and which may have been included in the last survey, were not included.

8. Component Costs

Hospitals were requested to report the average dollar amount paid per unit in 2008 for each of six specific components. The mean hospital cost for each component is presented in **Table 8-1** and compared with the 2006 value. **Table 8-2** displays the mean hospital cost of each component by region of the country and provides a statistical comparison with the national average. The mean or average component costs are stratified by hospital surgical volume in **Table 8-3**.

All calculations are based on weighted estimates. Component costs are weighted in two respects. First, each component cost is weighted according to the units transfused at each facility. As a result, facilities that transfuse larger volumes of apheresis platelets will contribute more toward the estimated average component cost for apheresis platelets than facilities with smaller transfusion volumes. Second, the sampling weights are also applied when calculating the average, resulting in the final weighted estimates.

Red Blood Cells

The mean of the average amount paid nationally for a unit of LR RBCs in 2008 was $223.09 (**Table 8-1**). This was a significant increase of 5.5% from the 2006 average of $211.50 ($p<0.0001$). When analyzed by USPHS region, the mean hospital amount paid was significantly higher than the national mean in the Northeastern and Southwestern states (Regions I, II, and IX; see **Figure A-1** in the Appendix). Significantly lower means were found in the Mid-Atlantic, Southeastern, Central, North and South Central, and Northwestern states (Regions III, IV, V, VI, VII, and X; see **Table 8-2**).

When analyzed by surgical volume, the largest hospitals (those reporting at least 8,000 surgeries annually) paid significantly less than the mean price for RBCs ($216.96). Hospitals reporting 1,400-2,399 and 2,400-4,999 surgeries per year paid significantly more. Hospitals of other surgical strata did not pay significantly more or less than the mean (**Table 8-3**).

Plasma

The hospital cost for PF24 (Plasma, frozen within 24 hours of phlebotomy) averaged $53.85 nationally (**Table 8-1**), only marginally higher (2.3%) than the 2006 average of $52.63. When analyzed by USPHS Region, hospitals paid statistically less per component unit in Regions IV and V (Southeastern and Central states). The smallest hospitals (100-999 and 1,000-1,399 surgeries per year) paid significantly more than the mean for PF24. They paid significantly more in Regions II, VIII, and IX (New York-New Jersey, Mountain states, and Southwestern states).

Table 8-1. Mean Hospital Amount ($) Paid per Selected Component Unit in 2006-2008

Component	Average Amount Paid ($)		
	2008	2006	% Change (2006-2008)
Red cells, leukocyte filtered	223.09*	211.50	5.5*
Fresh Frozen Plasma	57.78	—	—
Plasma Frozen Within 24 Hours After Phlebotomy	53.85*	52.63	2.3*
Whole-blood-derived platelets, not leukocyte reduced or irradiated	64.98	65.54	–0.9
Apheresis platelets, leukocyte reduced	538.56*	525.05	2.6*
Cryoprecipitate	65.10*	46.67	39.5*

*Significantly different from 2006 data.

In 2008, hospitals were also asked to report the average dollar amount paid for Plasma, frozen within 8 hours of phlebotomy. The average dollar amount was $57.78 per component unit (**Table 8-1**). Analysis by USPHS region indicated statistically higher costs in Region VIII (Central states) and Region X (Northwestern states) and significantly lower costs in Region IV (Southeastern states) than the national average (**Table 8-2**). Hospitals with a large surgical volume (8,000 surgeries per year) paid significantly less for Plasma, frozen within 8 hours of phlebotomy (**Table 8-3**); whereas hospitals reporting 1,400-2,399 and 2,400-4,999 surgeries paid significantly more.

Whole-Blood-Derived Platelets

The national hospital average paid for a unit of WBD platelet concentrate (individual concentrate, not pooled), that was not LR or irradiated, was $64.98 in 2008 (**Table 8-1**). This was a small decrease in amount paid (0.9%) from 2006 cost. Hospitals in USPHS Region VI (South Central states) paid significantly less for WBD platelets than the national norm. The mean cost was significantly higher in Region X. Hospitals reporting 1,400-2,399 surgeries per year paid significantly more for WBD platelets ($79.08) than the national mean.

Apheresis Platelets

For a unit of apheresis platelets, hospitals paid an average of $538.56 in comparison with $525.05 in 2006, a significant increase of 2.6% ($p<0.005$) (**Table 8-1**). When stratified by surgical volume, the largest hospitals paid significantly less than other hospitals. Again, hospitals in the 1,400-2,399 surgical strata paid significantly more.

The mean cost was significantly higher in USPHS Region II (New York-New Jersey) and Region VIII (Mountain states). The mean hospital cost was significantly lower for apheresis platelets in Regions IV, V, and VII—the Southeastern, North Central, and Central states.

Table 8-2. Average Hospital Component Cost ($) by USPHS Region

USPHS Region	No. of Hospitals*	Mean Dollar Values											
		RBCs		Plasma, frozen (8hr)		Plasma, frozen (24hr)		WBD Platelets		Apheresis Platelets		Cryoprecipitate	
		Avg	p Value	Avg	p Value	Avg	p Value	Avg	p Value	Avg	p Value	Avg	p Value
I	74	250.64	<0.0001	56.94	0.8334	55.70	0.4480	73.39	0.0609	514.14	0.2401	50.67	0.1179
II	134	249.16	<0.0001	58.15	0.7369	59.94	0.0001	89.22	0.0945	601.42	<0.0001	52.38	<0.0001
III	152	217.96	0.0028	54.63	0.0810	54.26	0.8347	69.40	0.6490	536.52	0.6942	44.24	<0.0001
IV	259	207.86	<0.0001	52.41	<0.0001	47.46	<0.0001	64.24	0.7741	516.06	<0.0001	51.42	0.0003
V	250	210.79	<0.0001	54.96	0.0541	48.76	0.0009	66.78	0.6012	512.26	<0.0001	74.95	0.2458
VI	169	215.40	<0.0001	58.26	0.6692	54.93	0.6840	48.26	<0.0001	534.80	0.5789	59.55	0.2237
VII	94	211.68	<0.0001	59.64	0.1776	52.56	0.5990	106.03	0.1501	497.44	<0.0001	51.18	0.0001
VIII	51	223.79	0.8458	73.25	<0.0001	62.18	0.0069			582.67	0.0020	120.86	0.0029
IX	134	257.14	<0.0001	62.19	0.1253	64.42	0.0361	68.19	0.1127	556.30	0.1164	82.88	0.0043
X	48	205.46	0.0001	72.61	0.0001	53.22	0.8148	70.09	0.0117	574.67	0.1208	106.28	0.1721
All Hospitals	1,365	223.09		57.78		53.85		64.98		538.56		65.10	

*The number of responses for each blood component varies because some hospitals did not provide answers to all questions.
RBCs = Red Blood Cells; USPHS = US Public Health Service; WBD = whole-blood-derived.

Table 8-3. Average Hospital Component Cost ($) by Surgical Volume

Annual Surgical Volume	No. of Hospitals*	Mean Dollar Values											
		RBCs		Plasma, frozen (8hr)		Plasma, frozen (24hr)		WBD Platelets		Apheresis Platelets		Cryoprecipitate	
		Avg	p Value	Avg	p Value	Avg	p Value	Avg	p Value	Avg	p Value	Avg	p Value
100-999	214	224.80	0.5671	67.93	0.0630	63.38	0.0498	67.81	0.7203	525.40	0.5947	56.96	0.4366
1,000-1,399	143	217.51	0.1015	60.79	0.0527	58.68	0.0307	65.93	0.8431	550.17	0.1385	137.00	0.2823
1,400-2,399	279	229.05	0.0056	66.95	0.0001	58.33	0.0754	79.08	0.0003	566.34	<0.0001	106.75	0.0298
2,400-4,999	405	226.17	0.0293	60.60	0.0013	53.32	0.6447	68.45	0.2874	543.70	0.3311	69.49	0.2961
5,000-7,999	186	224.72	0.5116	57.93	0.8818	54.41	0.7017	64.13	0.8217	545.81	0.3706	62.88	0.5576
8,000	138	216.96	0.0001	52.66	<0.0001	52.31	0.3191	61.52	0.1758	526.80	0.0037	58.16	0.0096
All Hospitals	1,365	223.09		57.78		53.85		64.98		538.56		65.10	

*The number of responses for each blood component varies because some hospitals did not provide answers to all questions.
RBCs = Red Blood Cells; WBD = whole-blood-derived.

Cryoprecipitate

The average hospital cost per component unit of cryoprecipitate increased significantly to $65.10 in comparison with $46.67 in 2006 ($p < 0.0001$; **Table 8-1**). Hospitals with a surgical volume of 1,400-2,399 paid significantly more on average ($106.75) than the mean, while hospitals with 8,000 annual surgeries paid significantly less on average ($58.16) (**Table 8-3**). Seventy-six percent of responding hospitals reported cryoprecipitate cost.

When stratified by UPSHS region, hospitals paid significantly less for cryoprecipitate in Regions II, III, IV, and VII. Hospitals in Regions VIII and IX paid significantly more.

Reimbursement

The CMS 2008 hospital outpatient prospective payment system (OPPS)* reimbursement rates for six components assessed are reported in **Table 8-4**.

Although hospital cost increases for different components ranged from a decrease of almost 1% to an increase of 39.5% (**Table 8-1**) between 2006 and 2008, most CMS OPPS reimbursement rates increased 13% to 35%, except for the rates for cryoprecipitate, which decreased 12.4%, and for single-donor Plasma, frozen within 8 hours of phlebotomy, which decreased 4.9%.

On the basis of these figures, the reimbursement for a unit of LR RBCs in 2008 was approximately 83% of the average hospital cost. For a unit of plasma for transfusion, reimbursement was more than the average cost to hospitals (by 16% to 45%). The reimbursement for a unit of WBD platelets exceeded the average cost by 7%. For a unit of apheresis platelets, reimbursement covers 92.8% of the average cost paid by hospitals. For cryoprecipitate, reimbursement was approximately 63.3% of the average hospital cost of a unit.

CMS OPPS rates are reported here because they are the only clearly identifiable measure of Medicare reimbursement for individual blood components. Most Medicare reimbursement for blood is part of the diagnosis-related group (DRG) payment made for inpatient services and is impossible to tease apart from the other aspects of the DRG. Other payers, besides Medicare, pay for blood using varying mechanisms that are not included in this report.

Summary

In summary, the average hospital costs for blood components increased between 2006 and 2008. Amounts paid for RBCs, apheresis platelets, and cryoprecipitate all increased significantly. Geographic regional costs, when they differ from the mean, tended to be consistently higher along the Northeastern and Western coasts, and lower in the Southeastern states and in the central areas of the country. As seen in previous surveys, larger hospitals typically pay less than the national average for blood components, which was likely the result of more favorable pricing agreements with a supplier based on the volume purchased. Suppliers may also offer hospitals preferential pricing for components that are closer to expiration, an option that would be feasible only for a large transfusion service.

**Department of Health and Human Services. Medicare Program; Changes to the Hospital Outpatient Prospective Payment System and Calendar Year 2008 Payment Rates; Final rule with comment period. Washington, DC: DHHS, 2008.*

Table 8-4. CMS Hospital Outpatient Prospective Payment System Rates for Selected Blood Components

Blood Component	Reimbursement Code		Hospital Average $ Amount Paid	Reimbursement Rate			% Difference Between Reimbursed Rate and Hospital Average Paid
	CPT/HCPCS	APC	2008	2006†	2008*	% Change (2008-2006)	
Red Blood Cells (leukocyte-reduced)	P9016	0954	223.09	163.16	185.15	13.5	–17.0
Fresh Frozen Plasma (frozen within 8 hours of phlebotomy)	P9017	9508	57.78	70.47	67.03	–4.9	16.0
Fresh Frozen Plasma (frozen between 8 and 24 hours of phlebotomy)	P9059	0955	53.85	74.78	77.93	4.2	44.7
Whole-blood-derived platelets	P9019	0957	64.98	51.50	69.50	35.0	7.0
Apheresis platelets (leukocyte-reduced)	P9035	9501	538.56	493.12	499.53	1.3	–7.2
Cryoprecipitate	P9012	0952	65.10	47.10	41.24	–12.4	–36.7

*Department of Health and Human Services. Medicare Program; Changes to the Hospital Outpatient Prospective Payment System and Calendar Year 2004 Payment Rates; Final rule with comment period.
†Medicare Program; Changes to the Hospital Outpatient Prospective Payment System and Calendar Year 2006 Payment Rates; Final rule with comment period
CMS = Centers for Medicare and Medicaid Services; CPT = current procedural terminology; HCPCS = health-care common procedure coding system; APC = ambulatory patient classification.

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11. Appendix: Methods

Survey Instrument

The primary survey instrument was designed to capture quantitative data regarding blood collection, processing, transfusion, and final disposition, as well as other information describing current policies and practices, and the adoption of new technologies by the blood community. A secondary questionnaire was designed to capture information on cellular therapy products.

Sampling Frame

Blood Collection and Utilization Survey

The sampling frame for the 2009 NBCUS questionnaire was compiled from two data sources. The first source was the AABB database, which is a list of all non-hospital-based blood collecting facilities and cord blood banks in the 50 states and the District of Columbia. This list also contains hospitals that are members of AABB. The second source was the comprehensive 2006 AHA hospital database, the most recent year available during the field period of this study.

Eligible population members included non-federal (state, county, city, corporate, etc) hospitals located within the 50 United States and the District of Columbia and Veterans Affairs hospitals. These hospitals provide general medical and surgical; children's general medical and surgical; cancer; heart; obstetrics and gynecology; eye, ear, nose and throat; or orthopedic services. The sampling frame was restricted to hospitals with inpatient surgical volumes of at least 100 surgeries per year.

To prepare the AABB database for sampling, hospitals on the AABB list were matched to the AHA database and the AHA identification numbers were assigned to avoid duplication. Hospitals on both lists were included, subject to the hospital eligibility criteria given above. Hospitals unique to AABB were included in the study with certainty (ie, a probability of 1.0). The facilities in the AABB database were categorized into three groups, hospitals unique to AABB, blood collection centers, and cord blood banks. The final list of eligible facilities (from both AABB and AHA) contained a total of 4,218 hospitals, blood collection centers, and cord blood banks.

Cellular Therapy Questionnaire

The sampling frame for the 2009 NBCUS Cellular Therapy (CT) questionnaire was compiled from multiple sources. Hospitals, blood collection centers, and cord blood banks were identified from the 2007 NBCUS respondents who completed the "Cellular Therapy Products" section of the questionnaire. Additional institutions known to AABB were also included in the sample file. The final cellu-

lar therapy mailing list contained 201 institutions.

Sample Selection

The NBCUS sampling frame consisted of all hospitals in the 2006 AHA data set and all hospitals unique to AABB, as well as all blood collection centers and cord blood banks identified by AABB. A total of 3,161 facilities were sampled from the NBCUS frame (**Table A-1**). Hospitals were stratified into six categories according to annual inpatient surgical volume: 100-999 surgeries; 1,000-1,399 surgeries; 1,400-2,399 surgeries; 2,400-4,999 surgeries; 5,000-7,999 surgeries; and 8,000 or more surgeries. Within the 100-999 surgeries category, hospitals were stratified further by the 10 US Public Health Service (USPHS) regions. Hospitals of unknown surgical volume, such as those unique to the AABB database for which no surgical volume could be determined, were assigned to an additional group labeled; "Unknown surgical volume." Hospitals with 1,000 or more surgeries were sampled at a rate of 100%. Hospitals with 100-999 surgeries were sampled at a rate of 33%, using US Public Health Service region as an additional sampling control.

Data Collection

The primary 23-page NBCUS questionnaire, cover letter, and return postage paid envelope were mailed to all blood center and hospital institutions on the mailing list. The CT questionnaire was mailed to all institutions on the CT sample frame. The instructions for the questionnaire provided a notice that institutions could submit their responses either online (described below) or by mail. Results from the CT survey are reported in a supplement to this report.

The initial mailing to all institutions was sent on October 30, 2009 with a deadline of December 18, 2009; however, to maximize the response rate, the data collection procedure was extended to March 31, 2010. To encourage timely responses, institutions that responded by the original deadline were entered into a drawing and 10 portable MP3 players (iPod Nanos) were given away. Winners were chosen using a random number generator from those submitting their responses by midnight on December 18, 2009, the initial deadline. Institutions responding after the initial deadline were not eligible for the drawing.

Table A-1. Sampling Frame Counts and Sampling Rates (50 States and the District of Columbia)

	Total Population	Sample	Sampling Probability (%)
Hospitals			
100-999 surgeries/year	1,586	529	33.3
1,000-1,399 surgeries/year	386	386	100.0
1,400-2,399 surgeries/year	637	637	100.0
2,400-4,999 surgeries/year	810	810	100.0
5,000-7,999 surgeries/year	369	369	100.0
≥8,000 surgeries/year	237	237	100.0
Unknown surgical volume	34	34	100.0
Blood Centers	135	135	100.0
Cord Blood Banks	24	24	100.0
Total Facilities	4,218	3,161	

A postcard reminder was sent to all institutions that had not completed the questionnaire approximately one month after the initial mailing. The postcard reminder was sent to the director of either the blood center or hospital blood bank or treatment service. Following the postcard reminder, non-responding blood center and hospitals were contacted via phone and encouraged to complete the questionnaire. Institutions were again provided their unique ID so they could log into the online questionnaire to print a hard copy version or complete the questionnaire electronically. A small number of institutions preferred to have the questionnaire mailed to them. In the process of contacting non-responding institutions, personnel who completed the 2007 NBCUS and who had been selected for the 2009 NBCUS were identified and contacted directly with a request to complete the survey.

Prior to the conclusion of the study, all institutions that did not respond were contacted by telephone and encouraged to complete the survey(s).

Paper Questionnaire

Paper questionnaires were returned for centralized data entry. Questionnaires were batched in groups of 10 and manually keyed by two different clerks. Output from both clerks were compared and discrepancies researched and corrected as necessary. Data files were reviewed on a semi-weekly basis. At the conclusion of data collection, paper questionnaires were forwarded to AABB.

Online Questionnaire

Online questionnaires similar in format to the primary and secondary paper questionnaires, but with imbedded skip logic, were developed. Institutions used their unique ID, provided on the paper survey and the reminder postcard, to log into the system. Upon log-in, the institution's name was automatically populated, and responders were asked to confirm the information. Respondents completing the primary online questionnaire were asked "Does your institution collect, process, manufacture, store, distribute, issue, and/or infuse hematopoietic progenitor cells (HPCs) or other cell therapy products?" If respondents answered "Yes" they were also provided access to the CT questionnaire.

Data Management

Data Review

Prior to analysis, the data files were incorporated into a statistical analysis software data set (SAS Institute, Cary, NC). During this process, the online and paper survey codebooks were reviewed to ensure all data were obtained and each variable in the data set corresponded to the annotated questionnaires. Facilities that logged into the online questionnaire but did not complete any portion of the questionnaire or submit a paper questionnaire were removed from the data file.

Similarly, respondents who provided limited data (ie, multiple sections of the questionnaire were left blank) were reviewed and excluded from the data file as they were considered non-responders. Duplicates in the data file were identified and removed and the response from the most complete and up-to-date record was retained.

Facilities were assigned to the established USPHS regions based on each institution's state location. Tar-

geted data cleaning was conducted for sections where follow-on responses were contingent on the initial question. For example, if an institution left an introductory "Yes/No" question blank or answered "No" but then responded affirmatively to a follow-up question, the lead question was made consistent with the institutions response(s). All "Don't Know" responses were coded similarly and "N/A" and "Not Available" responses to numeric variables were coded as missing. Frequencies were reviewed and extreme outliers were investigated and corrected. Finally, the ratio of total transfusions to surgical volume was reviewed for consistency and potential outliers investigated.

Data Apportionment

During data review, responding institutions that provided data for themselves, for additional institutions (question A5), and for institutions which they serve (question A6) were enumerated. A new record was created for each of the organizations listed in questions A5 and A6 for which surgical volume was known. No new records were created for 1) institutions for which surgical volume could not be identified by either the 2006 or the 2009 AHA data file (obtained following the field period of the study) or could not be ascertained by AABB or 2) institutions that had a surgical volume of less than 100.

The new records were formed by copying the categorical data from the responding institution's records into every record in the reporting group. For example, the responding institution's answer to the question; "Do you routinely transfuse plasma (to non-pediatric patients) based on patient size or unit volume" was given to each institution in the reporting group.

The responding institution's data that represented counts were apportioned among those in the reporting group according to each institution's surgical volume. However, responses to questions C8, C10, C12, C15, C16, C17, and C19 were not apportioned because these questions were not directly related to surgical volume. These variables were treated in the same manner as the categorical variables and copied to each of the new records.

Response Rates

Table A-2 summarizes the outcome of the data collection efforts. After eliminating ineligible institutions that ceased operations (closed), merged with an institution not included on the sampling frame, or were reported by an affiliate that was included in the sampling frame, the combined survey response rate was 53.1% (1,660/3,129) representing a decline over the combined survey response rate of 61.3% for the 2007 survey. The response rate for blood centers was 93.3% (126/135). The overall response rate for eligible hospitals was 51.5% (1,529/2,970). Response rates by surgical volume classes ranged from 44.5% to 58.3%. Only 20.8% of the cord blood banks responded (5/24). The total number of hospitals, blood centers, and cord blood banks that responded to the 2009 survey was 1,660 vs 1,849 in 2007. The CT questionnaire response rate was 44.3% (89/201). An additional 77 institutions not on the original sampling frame completed the CT questionnaire online, for a total of 166 (77 + 89) respondents.

For the first time, respondents had the opportunity

Table A-2. Response Rates by Type of Facility and Surgical Volume (50 States and the District of Columbia)

	Number Eligible	Respondents	Response Rate (%)
Hospitals			
100-999 surgeries/year	524	278	53.1
1,000-1,399 surgeries/year	380	169	44.5
1,400-2,399 surgeries/year	631	316	50.1
2,400-4,999 surgeries/year	800	433	54.1
5,000-7,999 surgeries/year	369	183	49.6
≥8,000 surgeries/year	235	137	58.3
Unknown surgical volume	31	13	41.9
Subtotal	2,970	1,529	51.5
Blood Centers	135	126	93.3
Cord Blood Banks	24	5	20.8
Total Facilities	3,129	1,660	53.1

to submit survey results electronically. Three-quarters of respondents (74.5%; 1,237/1,660) completed the survey online. The utility of an online survey, therefore, has been demonstrated by the large number of respondents choosing this method to complete the survey.

Figure A-1 illustrates the distribution of responding blood centers and hospitals among the 10 geographic regions defined by the USPHS (**Table A-3**).

Sampling Weights

The final sampling weights for hospitals and blood centers were calculated using a three-stage process. At the first stage, a base weight was computed as the reciprocal of the selection probability for the institution. For example, the base weight for hospitals on the AHA list was calculated as follows:

Base Weight = (Number in Stratum)/(Number Sampled in Stratum).

The "number sampled" in the denominator includes all hospitals sampled, including those later determined to be ineligible. These ineligible hospitals remain in the denominator because they represent other, unidentified ineligible hospitals in the sampling frame. If these ineligibles were removed from the raw weight calculation, resulting data estimates would be overstated. The base weights take on the value of 1.0 for hospitals sampled from all but the smallest size stratum. For the smallest stratum, the base weight is 3.0 to reflect the sampling rate of 1/3. The base weights were fur-

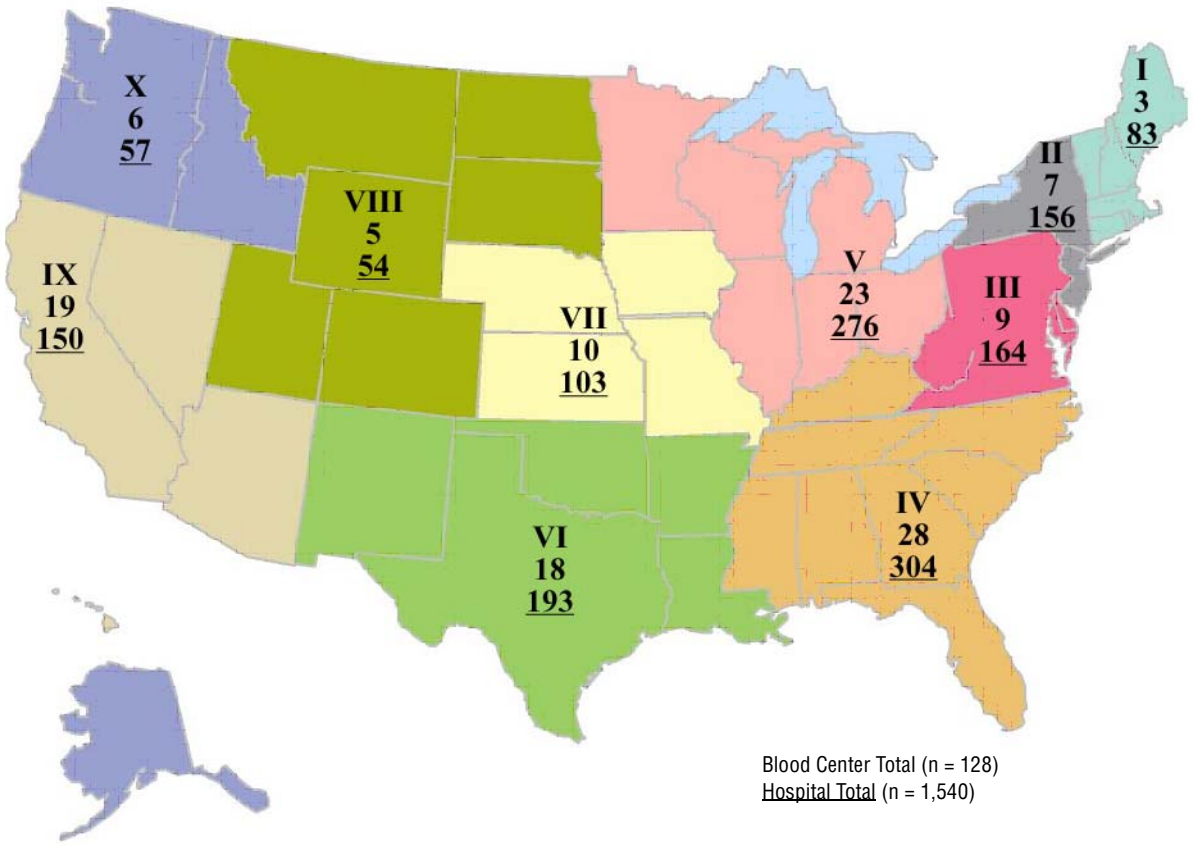

Figure A-1. Distribution of blood center and hospital respondents by USPHS region.

ther adjusted in a few cases to account for multiple chances of selection for hospitals that were not in the original sample, but that were included in the analysis as a result of being reported by other hospitals.

The base weight for blood centers and hospitals from the AABB list is 1.0, since all of these units were included with certainty in the 2009 NBCUS. **Table A-4** shows the number in each stratum, the number sampled, and the results of the base weight calculation.

At the second stage, the imbalance among the strata due to different response rates among the institutions in the sample was corrected. A raking adjustment factor was calculated to adjust for non-response and to achieve agreement with the known surgical volume control totals in two dimensions (ie, hospital sampling stratum and USPHS region). Raking is an iterative procedure that ratio-adjusts the weights to marginal control totals one dimension at a time, until convergence (defined as very small relative changes in the weights and agreement with the dimension control totals) is achieved. For blood centers and hospitals on the AABB list for which surgical volume was not available, the number of institutions on the frame was used as the control total instead. **Tables A-5** and **A-6** display the number of responding facilities, and the average raking factor for each hospital

Table A-3. United States Public Health Service Regions

USPHS Region	States
I	CT, ME, MA, NH, RI, VT
II	NJ, NY, (Puerto Rico, Virgin Islands)
III	DE, DC, MD, PA, VA, WV
IV	AL, FL, GA, KY, MS, NC, SC, TN
V	IL, IN, MI, MN, OH, WI
VI	AR, LA, NM, OK, TX
VII	IA, KS, MO, NE
VIII	CO, MT, ND, SD, UT, WY
IX	AZ, CA, HI, NV (Guam, American Samoa)
X	AK, ID, OR, WA

sampling stratum and USPHS region.

At the third stage, the final full sample weight was then calculated as the product of the base weight and the final raking factor for each facility. The final sampling weights appear in **Table A-7** together with the base sampling weights from **Table A-4.**

Variance Estimation

The Jackknife method, which involves taking repeated stratified samples from the full pool of responding institutions, was used for variance estimation.* Briefly, for every repetition, or replicate sample, estimates are made for each parameter of interest (eg, number of units collected, number of units transfused).

**Wolter KM. Introduction to variance estimation. New York, NY: Springer-Verlag, 1985.*

Table A-4. Base Weights (50 States and the District of Columbia)

	Number in Stratum	Number Sampled in Stratum	Base Weight
Hospitals			
100-999 surgeries/year	1,586	529	3.00
1,000-1,399 surgeries/year	386	386	1.00
1,400-2,399 surgeries/year	637	637	1.00
2,400-4,999 surgeries/year	810	810	1.00
5,000-7,999 surgeries/year	369	369	1.00
≥8,000 surgeries/year	237	237	1.00
Unknown surgical volume	34	34	1.00
Blood Centers	135	135	1.00
Cord Blood Banks	24	24	1.00
Total Facilities	4,218	3,161	

Table A-5. Average Raking Factor by Surgical Volume (50 States and the District of Columbia)

Type of Facility	Surgical Volume Control Total	Surgical Volume Estimate Before Raking	Average Raking Factor	Responding Sample Size
Hospitals				
100-999 surgeries/year				
USPHS Region I and II	59,222	30,108	1.97	25
USPHS Region III	52,126	27,696	1.88	28
USPHS Region IV	149,283	73,304	2.04	47
USPHS Region V	150,970	66,483	2.27	65
USPHS Region VI	115,543	43,827	2.64	39
USPHS Region VII	52,843	29,658	1.78	27
USPHS Region VIII	41,322	14,661	2.82	14
USPHS Region IX	68,720	21,123	3.25	20
USPHS Region X	39,157	11,872	3.30	13
1,000-1,399 surgeries/year	456,834	214,287	2.13	169
1,400-2,399 surgeries/year	1,181,010	594,463	1.99	316
2,400-4,999 surgeries/year	2,779,898	1,415,673	1.96	433
5,000-7,999 surgeries/year	2,320,362	1,273,759	1.82	183
≥8,000 surgeries/year	2,791,735	1,578,450	1.77	137
Unknown surgical volume (AABB)	34	25	1.36	13
Blood Centers	135	126	1.08	126
Cord Blood Banks	24	5	4.80	5
Total Facilities	10,259,218	5,395,520	1.91	1,660

Table A-6. Average Raking Factor for Hospitals by USPHS Region (50 States and the District of Columbia)

USPHS Region	Surgical Volume Control Total	Surgical Volume Estimate Before Raking	Average Raking Factor	Responding Sample Size
I	447,397	230,482	1.94	83
II	983,360	590,029	1.67	145
III	1,136,717	687,419	1.65	164
IV	2,217,983	1,162,783	1.91	304
V	1,775,296	916,007	1.94	276
VI	1,287,753	661,332	1.95	193
VII	483,096	252,952	1.91	103
VIII	314,981	154,065	2.04	54
IX	1,257,510	561,251	2.24	150
X	354,932	179,044	1.98	57
Total Facilities	10,259,025	5,395,369	1.91	1,529

The variance between the replicate estimates and full sample estimate is used to estimate the sampling variance. A sufficient number of replicates is used to ensure reasonably precise estimates of variance for most parameter estimates.

Imputation

Missing values for critical questions were imputed using a model-based regression method. The method utilizes an iterative procedure that capitalizes on information available from variables that are highly correlated with the variables that have missing values. Imputation models were developed separately for blood centers and hospitals and for continuous and categorical variables. This procedure was used to impute values for critical questions with fewer than 20% missing values to ensure valid and reliable estimates. Alternatively, information from the 2006 survey was used to "impute" data for two critical questions with greater than 20% of the values missing. Specifically, using the AHA identification number, hospitals that participated in both surveys were identified and data were imported from the previous year (when available) to fill in the missing values. Imputed cases were flagged to allow the analyst to identify which cases were imputed.

Table A-7. Final Sampling Weights (50 States and the District of Columbia)

Type of Facility	Base Weight	Average Final Sample Weight
Hospitals		
100-999 surgeries/year		
USPHS Region I	3.00	6.47
USPHS Region II	3.00	5.68
USPHS Region III	3.00	5.65
USPHS Region IV	3.00	6.02
USPHS Region V	3.00	6.73
USPHS Region VI	3.00	7.62
USPHS Region VII	3.00	5.22
USPHS Region VIII	3.00	8.46
USPHS Region IX	3.00	9.76
USPHS Region X	3.00	9.24
1,000-1,399 surgeries/year	1.00	2.13
1,400-2,399 surgeries/year	1.00	1.99
2,400-4,999 surgeries/year	1.00	1.96
5,000-7,999 surgeries/year	1.00	1.83
≥8,000 surgeries/year	1.00	1.77
Unknown surgical volume (AABB)	1.00	1.00
Blood Centers	1.00	1.08
Cord Blood Banks	1.00	—

Characterization of Respondents

The majority of blood centers (105) self-identified as such. Additionally, 21 blood centers selected the centralized transfusion service option, "A local or regional blood center that collects blood from donors and supplies blood, components, and crossmatched blood products to participating facilities (such as a centralized transfusion service)," to describe themselves. In 2006, 19 blood centers reported themselves to be centralized transfusion services. A total of 1,260 hospital respondents identified themselves as a transfusion service and 190 (compared with 236 in 2006) characterized themselves as a hospital-based blood bank and transfusion service that collects blood.

Limitations of the Survey

The full sample weights described here account for survey non-response and for varying probabilities of selection among the facilities. Sampling strata and USPHS regions were used to calculate average raking factors to account for survey non-response, and were effective to the extent that facilities within the same strata are similar. Several respondents provided data for themselves as well as other institutions included in either the sample or the sampling frame. In these instances, an overall joint probability of selection was calculated as a function of the probability of selection associated with the constituent institutions.

Other limitations to the study include: confounding of survey response mode and coverage of institutions providing cellular therapy procedures, and poor representation of cord blood banks. Survey response mode is a limitation because institutions that chose to respond to the pri-

mary questionnaire via mail did not have a chance to complete the secondary questionnaire. Poor representation of cord blood banks is a limitation because the census from which the sample was taken was not well defined; thus, no meaningful comparisons can be made to previous years and no extrapolations can be made to the cord blood bank population.

Finally, unlike previous surveys, the sampling frame for the 2009 NBCUS included 101 institutions in the US territories of Guam, Puerto Rico, American Samoa, and the Virgin Islands. However, only 55 of the 101 institutions were found to be eligible after eliminating institutions that ceased operations, merged with an institution not included on the sampling frame, or were reported for by an affiliate that was included on the sampling frame.

Moreover, only 12 of the 55 responded to the primary NBCUS questionnaire, for a response rate of 22%. This low response rate may be due to a number of factors, including language (Puerto Rico), lack of recognition of AABB, and/or the voluntary nature of the survey where resources may be needed for patient care.

Because no meaningful extrapolations to the population can be made from the small number of responding institutions, no data for territories are included in this year's summary report.

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