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ORIGINAL RESEARCH

TRANSFUSION

Supplemental findings of the 2021 National Blood Collection and Utilization Survey

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Abstract

Background: The Department of Health and Human Services' National Blood Collection and Utilization Survey (NBCUS) has been conducted biennially since 1997. Data are used to estimate national blood collection and use. Supplemental data from the 2021 NBCUS not presented elsewhere are presented here.

Methods: Data on survey participation, donor characteristics, blood component cost, transfusion-associated adverse reactions, and implementation of blood safety measures, including pathogen-reduction of platelets, during 2021, were analyzed. Comparisons are made to 2019 survey data where available (2013–2019 for survey participation).

Results: During 2021, there were 11,507,000 successful blood donations in the United States, a 4.8% increase from 2019. Persons aged 45–64 years accounted for 42% of all successful blood donations. Donations by persons aged 65 years and older increased by 40.7%, while donations among minorities and donors aged <25 years decreased. From 2019 to 2021, the median price hospitals paid per unit of leukoreduced red blood cells, leukoreduced and pathogen-reduced apheresis platelets, and fresh frozen plasma increased. The largest increase in price per unit of blood component in 2021 was for leukoreduced apheresis platelets, which increased by ∼$51. Between 2019 and 2021, the proportion of transfusing facilities reporting use of pathogen-reduced platelets increased, from 13% to 60%. Transfusion-related adverse reactions declined slightly between 2019 and 2021, although the rate of transfusion-transmitted bacterial infections remained unchanged.

Conclusion: During 2021, blood donations increased nationally, although donations from those aged <25 years and minorities declined. The prices

Abbreviations: AHA, American Hospital Association; AHF, antihemophilic factor; CDC, U.S. Centers for Disease Control and Prevention; CIs, confidence intervals; FDA-BER, Food and Drug Administration's Blood Establishment Registration; FFP, fresh frozen plasma; HHS, Health and Human Services; INR, international normalized ratio; MSM, men who have sex with men; NBCUS, National Blood Collection and Utilization Survey; OASH, Office of the Assistant Secretary for Health; PAS, platelet additive solution; PRT, pathogen reduction technology; RBC, red blood cell.

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hospitals paid for most blood products increased, as did the use of pathogen-reduced platelets.

KEYWORDS
blood center operations, donors, transfusion practices (adult)

1 | INTRODUCTION

Blood transfusions are one of the most common medical procedures performed in the United States and provide life-saving treatment across a variety of healthcare settings.[1] Because the blood products are labile and new processes and safety measures are often introduced, regular collection of data on blood collection and use in the United States, as well as implementation of blood safety practices, is crucial for ensuring the safety and availability of the blood supply. Since 2013, the U.S. Centers for Disease Control and Prevention (CDC) and the Office of the Assistant Secretary for Health (OASH) have been conducting the National Blood Collection and Utilization Survey (NBCUS), a biennial survey of blood collection organizations and transfusing hospitals, to estimate blood collection and use in the United States.[2–4] The main purposes of NBCUS are to quantify blood collection and transfusion, monitor trends in donor demographics and adverse reactions, and identify changes in transfusion safety practices. Data are also collected on blood donor and donation characteristics, cost of blood products, blood inventory and supply, transfusion-associated adverse event risk mitigation, and other policies and practices related to blood component collection, processing, and transfusion. Data from NBCUS have been considered in developing public health policy and deliberating efforts to ensure blood supply sustainability in the United States.[5]

The 2021 NBCUS survey questions were largely consistent with the previous four surveys conducted by CDC and OASH to allow for longitudinal comparison. The information presented here include findings from the 2021 NBCUS that have not been presented elsewhere, providing additional insight into collection, availability, and use of blood and blood components.

2 | METHODS

The survey methods are consistent with the 2013, 2015, 2017, and 2019 NBCUS surveys and have been previously described.[4,5]

2.1 | Questionnaire design

The 2021 survey included 21 questions for blood collection centers and 28 questions for transfusing hospitals. As with the 2019 survey, the 2021 NBCUS was administered using the Research Electronic Data Capture (REDCap) survey platform used routinely by CDC for public health surveys.[6]

2.2 | Sampling method

The methodology used to develop the sampling frame for the 2021 survey was the same as that used for the previous surveys.[2,3,5,7] Facilities that collect or manufacture blood products (i.e., blood collection centers) are required to register in the Food and Drug Administration's Blood Establishment Registration (FDA-BER) database.[8] A list of all community-based blood collection centers and hospital-based blood collection centers registered in the FDA-BER was obtained in September 2021. All US hospitals that potentially transfuse blood were identified using the 2019 American Hospital Association (AHA) annual survey database, the most recent annual data available at the time the survey sampling frame was created.[9] The resulting list of transfusing hospitals from this annual database was updated in June 2021 using AHA's monthly updates of facility openings and closures. Hospitals were excluded from the sampling frame if they performed fewer than 100 inpatient surgeries annually, were located in US territories, were operated by the military or Department of Justice, or were classified as a rehabilitation, long-term acute care, or psychiatric hospital. Hospitals in the sampling frame that performed 100–999 inpatient surgeries per year were sampled at 40%; hospitals that performed 1000 or more inpatient surgeries per year were sampled at 100%. All blood collection centers in the sampling frame were surveyed.

2.3 | Confirmation of facility points of contact

In prior years, extensive contact confirmation prior to the survey's launch was found to be instrumental in achieving a high response rate. Community-based blood collection centers were contacted via email or telephone to confirm contact information. All hospitals in the sample (including hospital-based blood collection centers) were sent a web-based contact information form via email. Follow-up outreach was conducted by letter, and subsequently by telephone, for facilities that did not complete the web-based contact information form. Facility contact information was confirmed for all facilities included in the 2021 NBCUS between October 2021 and March 2022.

The survey was disseminated in March 2022. Each facility received a unique survey link via email. Respondents were initially given 2 months, with an additional 3-week extension. Regular reminders were sent to facilities via email, physical mail, and by phone, to increase participation.

2.4 | Stratification, imputation, and weighting

Blood centers and hospitals were stratified using the established approach from the 2019 survey.[5] Community-based blood collection centers were stratified into four categories based on annual red blood cell (RBC) collections: <50,000 units; 50,000–199,999 units; 200,000–399,999 units; and ≥400,000 units. Hospital-based blood collection centers were stratified into three categories for collection questions based on annual inpatient surgeries as obtained from the AHA annual survey: <1000, 1000–7999, and ≥8000 inpatient surgeries. For transfusion data, hospitals were stratified separately based on annual inpatient surgeries from the AHA annual survey: 100–999, 1000–1399, 1400–2399, 2400–4999, 5000–7999, and ≥8000 inpatient surgeries.

As in prior surveys, multiple imputation was used to impute missing data items from respondent facilities. All imputed variables were continuous and non-normally distributed. The imputation procedure involved a two-step method for variables skewed toward zero.[10,11] Imputation was utilized only when missing data items were less than 20% and for variables for which a national estimate was described. Case analysis, rather than imputation, was used for variables with missing data exceeding 20% of respondents.[12]

Survey weighting was used to account for non-responses. Weights were calculated separately for each stratum by dividing the total number of eligible facilities by the number of respondents for each stratum. The largest community-based blood collection centers (i.e., those with ≥400,000 RBC units collected annually) could not be reliably weighted or imputed, so weighted estimates were not calculated for missing data involving one or more of these facilities. Hospitals with 100–999 annual inpatient surgeries were sampled at a rate of 40% with additional weighting (of 0.4) for sampling. Confidence intervals (CIs) were determined for national collection and transfusion estimates and calculated using the Taylor series method.[13]

Weighting and imputation were used to determine national estimates for the following variables: allogeneic, autologous, and directed blood component donations, transfusions, and recipients; plasma component collections and transfusions; granulocyte collections and transfusions; and pediatric and neonatal transfusions. The following were estimated using available case analysis: number of persons presenting to donate; deferred donors; donations by age and race/ethnicity; first-time and repeat allogeneic donors; irradiated and leukoreduced whole blood and RBC units transfused by hospitals; crossmatch procedures performed on whole blood and RBC units; and transfusion-associated adverse reactions. Summary statistics were calculated for the remaining variables and are presented as means, medians, and percentages of responding facilities.

Responses to questions on cost paid by hospitals were subject to additional adjustment following the methodology from prior surveys and are summarized here. Values exceeding five times the SD above the mean were excluded. Reported values for whole blood-derived platelets and cryoprecipitated antihemophilic factor (AHF) required additional cleaning due to some facilities incorrectly reporting pooled component costs. To adjust for outliers resulting from pooled estimates, a threshold of $350 for whole blood-derived platelets and $200 for cryoprecipitated AHF was implemented. Costs are presented in whole dollar amounts. A *t*-test was used to determine significant changes in the mean cost of blood components between 2019 and 2021. The significance for these associations was set at $p < .05$. The matched mean difference was calculated as the mean of the individual facility differences (2021 − 2019). All analyses were performed using SAS software version 9.4 (SAS Institute Inc., Cary, NC).

2.5 | Variables analyzed in this report

The survey response rate is presented overall by facility type and by the following stratification schema: annual RBC collections, annual inpatient surgeries, and geographic region (determined using Health and Human Services [HHS] region classification), with data from 2013, 2015, 2017, and 2019 included for comparison[14] (for all other presented analyses, 2019 data is included for comparison, where available). National estimates are reported for donor deferrals (stratified by deferral reason), total donors presenting to donate (stratified by sex), and number of successful donations (stratified by donor age and donor race/ethnicity). The total number of individual blood donors are categorized by first-time and repeat allogeneic donors.

Estimates are presented of the number of allogeneic whole blood/RBC units transfused, the number of allogeneic transfusion recipients, the number of autologous and directed whole blood/RBC units transfused, and the number of directed platelet units transfused. Total units of apheresis and whole blood-derived plasma distributed and transfused by component type are presented, as are estimates of the number of granulocytes distributed and transfused.

The median and mean dollar amount paid per blood product unit by hospitals are reported for the following blood products: leukoreduced RBCs, leukoreduced apheresis platelets, pathogen-reduced apheresis platelets, fresh frozen plasma (FFP), plasma frozen between 8 and 24 h of donation (PF24), and cryoprecipitated AHF. Blood component costs paid by hospitals are stratified by annual inpatient surgeries and HHS region.

The reported age of RBC units, apheresis platelet units, and whole blood-derived platelet units at the time of transfusion are presented. Group O+ and O− RBC units distributed, transfused, and outdated are shown.

Various policies and practices related to blood collection, processing, and transfusion are presented. The estimated number of apheresis platelet units distributed to hospitals that underwent bacterial risk control strategies is tabulated based on a new question added to the 2021 survey. The number of hospitals (stratified by annual inpatient surgeries) performing pre-transfusion bacterial testing of platelets and the number of secondary culture and rapid bacterial tests performed are shown. The number of blood collection centers that report collecting and distributing pathogen-reduced apheresis platelets and the number of hospitals that report transfusing pathogen-reduced apheresis platelets are shown. Use of platelet additive solution to prepare apheresis platelets and leukoreduction and irradiation of blood components, as reported by facilities, are presented. The number of donors and recipients genotyped at blood centers and hospitals, respectively, are described. Total crossmatch procedures are reported overall and by procedure method. Routine dosing criteria used by reporting facilities to dose plasma, prophylactic platelets, and therapeutic platelets for transfusion are shown. And reported hospital policies and practices to enhance transfusion safety, including the presence of a Transfusion Safety Officer on staff, are presented.

Pediatric (aged >4 months) and neonatal (aged ≤4 months) transfusions and recipients are presented, stratified by whole blood/RBC, apheresis platelet, and plasma transfusions. Reported hospital policies for neonatal aliquot production are shown.

Estimates of the number of transfusion-associated adverse reactions are tabulated by reaction type.

3 | RESULTS

3.1 | Survey participation

Response rates in 2021 for community-based blood collection centers (92.5%) and transfusing hospitals (76.3%) were similar to those in 2019 (94.3% and 76.2%, respectively) (Table 1). The response rate in 2021 for hospital-based blood collection centers (74.7%) decreased from that in 2019 (84.4%). For additional details on facility-level changes observed between 2019 and 2021, please refer to previously published data from the 2021 NBCUS: https://onlinelibrary.wiley.com/doi/full/10.1111/trf.17360.[15]

After stratification by annual number of RBC collections, the response rate for community-based blood collection centers with <50,000 collections per year decreased slightly between 2019 and 2021, from 88% in 2019 to 84.6% in 2021; response rates for community-based blood collection centers in other strata remained unchanged (Table 2). After stratification by annual number of inpatient surgeries, the response rates for hospital-based blood collection centers decreased across all strata in 2021 compared with 2019.

Among transfusing facilities, response rates in 2021 were lower than in 2019 for facilities with 100–999 annual inpatient surgeries and those with ≥8000 annual inpatient surgeries but were higher in 2021 for facilities in all other strata (Table 3). Stratification by HHS region revealed more variation in response rates, with the lowest response rates in 2021 observed in Regions 6 and 9 (69.7% and 69.0%, respectively) and the highest response rate in 2021 observed in Region 1 (90.9%) (Table 4). Between 2019 and 2021, the most pronounced change in response rates of transfusing facilities, stratified by HHS region, was observed in Region 2 (7.1% decrease).

3.2 | Donor characteristics

The estimated number of donors presenting to donate blood and the number of deferred donors stratified by reason for deferral are presented in Table 5. The total number of donors presenting to donate declined by 5.5% between 2019 and 2021, from 13,022,000 in 2019 to 12,302,000 (95% CI, 11,684,000–12,921,000) in 2021. During 2021, more females than males presented to donate

TABLE 1 National Blood Collection and Utilization Survey response rates among blood collection centers and hospitals, 2013–2021.

Facility type	2021 (*n*/*N*)	2019 (*n*/*N*)	2017 (*n*/*N*)	2015 (*n*/*N*)	2013 (*n*/*N*)
Community-based blood collection centers	92.5% (49/53)	94.3% (50/53)	93.8% (61/65)	90.0% (72/80)	64.8% (59/91)
Hospital-based blood collection centers	74.7% (62/83)	84.4% (76/90)	85.2% (92/108)	71.8% (102/142)	41.2% (63/153)
Hospitals (transfusing blood)	76.3% (2102/2754)[a]	76.2% (2140/2808)[a]	85.5% (2435/2847)[a]	73.9% (2138/2892)[a]	33.3% (1101/3305)[b]

[a]The 2015, 2017, 2019, and 2021 surveys included a sample of 40% of surgical operation Category 1 (100–999 inpatient surgical procedures annually) hospitals.
[b]The 2013 survey did not use sampling, but contact information was unavailable for 610 of 3915 hospitals, and these were not sampled.

TABLE 2 National Blood Collection and Utilization Survey response rates among blood collection centers stratified by annual number of red blood cell (RBC) collections and annual number of inpatient surgeries, 2013–2021.

		2021		2019		2017		2015		2013	
Facility type	**Strata**	**%**	***n*/*N***	**%**	***n*/*N***	**%**	***n*/*N***	**%**	***n*/*N***	**%**	***n*/*N***
Community-based blood collection centers	Less than 50,000 RBC collections per year	84.6	22/26	88.0	22/25	90.0	27/30	92.5	37/40	56.9	29/51
	50,000–199,999 RBC collections per year	100	17/17	100	19/19	96.2	25/26	87.1	27/31	74.2	23/31
	200,000–399,999 RBC collections per year	100	5/5	100.	4/4	100	6/6	75.0	3/4	42.9	3/7
	400,000 or more RBC collections per year	100	5/5	100	5/5	100	3/3	100	5/5	100	4/4
Hospital-based blood collection centers	Less than 1000 surgeries per year	77.8	14/18	84.2	16/19	94.7	18/19	58.3	7/12	38.5	5/13
	1000–7999 surgeries per year	68.6	24/35	83.8	31/37	86.7	39/45	73.5	61/83	35.5	33/93
	8000 or more surgeries per year	80.0	24/30	85.3	29/34	79.5	35/44	72.3	34/47	53.2	25/47

TABLE 3 National Blood Collection and Utilization Survey response rates among transfusing facilities stratified by annual number of inpatient surgical operations, 2013–2021.

	2021		2019		2017		2015		2013[a]	
Inpatient surgical operation category	**%**	***n*/*N***	**%**	***n*/*N***	**%**	***n*/*N***	**%**	***n*/*N***	**%**	***n*/*N***
100–999 surgeries	68.8	466/677	73.1	489/669	82.9	525/633	73.6	495/673	26.1	426/1634
1000–1399 surgeries	74.0	268/362	72.0	252/350	87.1	352/404	72.4	283/391	28.8	117/406
1400–2399 surgeries	77.3	422/546	76.7	452/589	85.7	504/588	72.3	416/575	27.3	155/567
2400–4999 surgeries	79.9	544/681	77.0	525/682	84.7	611/721	75.2	547/727	28.6	219/765
5000–7999 surgeries	81.7	219/268	78.6	221/281	89.0	251/282	75.3	225/299	31.2	97/311
8000 or more surgeries	83.2	183/220	84.8	201/237	87.7	192/219	75.8	172/227	37.5	87/232

[a]The 2013 survey did not use sampling, but contact information was unavailable for 610 of 3915 hospitals, and these were not sampled.

(54.1% vs. 45.9%). In 2019, slightly more males presented to donate than females (6,644,000 males [51.0%] compared to 6,378,000 females [49.0%]).

The donor deferral rate (i.e., total deferrals divided by total donors presenting to donate) was slightly lower in 2021 than in 2019 (16.3% vs. 19.0%) (Table 5). During 2021, total donor deferrals (2,010,000 [95% CI, 1,921,000–2,099,000]) were 18.7% lower than in 2019 (when 2,472,000 total deferrals were observed). Donor deferrals were mostly driven by low hemoglobin or hematocrit

TABLE 4 National Blood Collection and Utilization Survey response rates among transfusing facilities stratified by Health and Human Services (HHS) region, 2013–2021.

HHS region	2021		2019		2017		2015		2013[a]	
	%	n/N	%	n/N	%	n/N	%	n/N	%	n/N
1 (CT, MA, ME, NH, RI, VT)	90.9	110/121	86.5	109/126	94.4	119/126	71.2	94/132	39.5	70/177
2 (NJ, NY)	84.5	153/181	91.6	174/190	91.3	189/207	80.5	165/205	32.9	77/234
3 (DC, DE, MD, PA, VA, WV)	78.9	198/251	76.0	200/263	91.0	252/277	78.5	219/279	33.8	114/337
4 (AL, FL, GA, KY, MS, NC, SC, TN)	75.6	411/544	72.7	412/567	84.9	496/584	75.2	436/580	25.4	197/777
5 (IL, IN, MI, MN, OH, WI)	80.3	392/488	80.5	408/507	85.7	437/510	77.2	407/527	26.9	201/746
6 (AR, LA, NM, OK, TX)	69.7	274/393	72.0	283/393	79.2	316/399	70.3	281/400	31.5	182/577
7 (IA, KS, MO, NE)	77.2	125/162	81.7	134/164	90.1	145/161	71.1	118/166	26.7	70/262
8 (CO, MT, ND, SD, UT, WY)	74.6	91/122	71.7	81/113	88.2	97/110	75.8	91/120	20.0	38/190
9 (AZ, CA, HI, NV)	69.0	249/361	67.7	245/362	79.9	282/353	65.0	234/360	25.1	112/446
10 (AK, ID, OR, WA)	72.8	83/114	76.4	94/123	85.0	102/120	75.6	93/123	23.7	40/169
All regions	76.3	2102/2754	76.2	2140/2808	85.5	2435/2847	73.9	2138/2892	28.1	1101/3915

[a]The 2013 survey did not use sampling, but contact information was unavailable for 610 of 3915 hospitals, and these were not sampled.

(51.1%), followed by other non-medical reasons (24.6%), pulse (6.9%), and blood pressure (6.4%). Females accounted for 67.4% (1,355,000/2,010,000) of all deferrals, with 1,355,000 (95% CI, 1,287,000–1,423,000) females deferred during 2021. Females also accounted for most of the deferrals due to low hemoglobin or hematocrit (79.8%, 820,000/1,028,000). The number of deferrals for men who have sex with men (MSM) decreased by 57.1% between 2019 and 2021, with 7000 deferrals for MSM in 2019 and 3000 (95% CI, 3000–4000) in 2021. Substantial decreases in deferrals between 2019 and 2021 were also noted for travel or residence (84.0% decrease), tattoo/piercing/scarring (79.4% decrease), and high-risk behaviors other than MSM (40.0% decrease). The only substantial increase in number of deferrals between 2019 and 2021 was for medication use (26.4% increase).

Successful donations stratified by donor age and race/ethnicity are shown in Table 6. There was a 4.8% increase in total successful donations during 2021 (11,507,000 [95% CI, 10,866,000–12,149,000]) compared with 2019 (10,981,000). In 2021, the total number of successful racial or ethnic minority donations (from Black or African American, Asian, Native Hawaiian or Pacific Islander, American Indian or Alaskan Native, and Hispanic or Latino donors) was 1,387,000 (95% CI, 1,162,000–1,613,000), a decrease of 35.4% compared with 2019, when 2,146,000 successful racial or ethnic minority donations were made. Most successful donations during 2021 were from donors aged 25–64 years, with 68.8% (7,920,000/11,507,000) of successful donations occurring in this group. Further stratification of donors by age in the 2021 NBCUS revealed that donors aged 45–64 years accounted for 42.0% of successful donations during 2021, and donors aged 25–44 years accounted for 28.0%. The age group that saw the greatest increase in successful donations between 2019 and 2021 was donors aged 65 years and older (40.7% increase). Successful donations by persons aged 19–24 years decreased by 31.9% between 2019 and 2021, from 948,000 donations in 2019 to 646,000 (95% CI, 609,000–683,000) donations in 2021, and donations by persons aged 16–18 years decreased by 60.7% between 2019 and 2021, from 1,226,000 donations in 2019 to 482,000 (95% CI, 419,000–545,000) donations in 2021.

The total number of repeat allogeneic donors who donated successfully decreased by 4.5% between 2019 and 2021, from 5,069,000 donors in 2019 to 4,840,000 (95% CI, 4,461,000–5,220,000) donors in 2021 (Table 7). First-time allogenic donors also decreased, by 22.3%, between 2019 and 2021, with 2,213,000 first-time donors in 2019 and 1,719,000 (95% CI, 1,594,000–1,844,000) first-time donors in 2021.

3.3 | Whole blood and RBC transfusions

Table 8 shows the estimated number of allogeneic RBC units transfused, the number of recipients of allogeneic RBC transfusions, and the number of allogeneic RBC units transfused per recipient. From 2019 to 2021, the number of allogeneic RBC units transfused was stable, with 10,801,000 units transfused in 2019 and 10,668,000 (95% CI, 10,265,000–11,072,000) units transfused in 2021.

TABLE 5 Estimated number of donors and donor deferrals in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

	2021		2019		
	Donors (95% CI)	Percent of total	Donors	Percent of total	% Change 2021–2019
Donor deferrals					
Low hemoglobin or low hematocrit	1028 (978–1077)	51.1	1066	43.1	−3.6
Male	207 (187–228)	10.3	205	8.3	1.0
Female	820 (778–862)	40.8	861	34.8	−4.8
Medication use	91 (83–98)	4.5	72	2.9	26.4
Pulse	140 (128–152)	6.9			
Blood pressure	130 (123–136)	6.4			
Pulse and/or blood pressure			278	11.2	
High-risk behavior, restricted to MSM	3 (3–4)[a]	0.2	7	0.3	−57.1
High-risk behavior, all other behaviors	9 (9–10)[b]	0.5	15	0.6	−40.0
Travel or residence	27 (24–29)	1.3	169	6.8	−84.0
Tattoo/piercing/scarring	13 (11–15)	0.6	63	2.5	−79.4
Other non-medical reasons	494 (474–514)	24.6	529	21.4	−6.6
Other medical reasons			192	7.8	
Total deferrals	2010 (1921–2099)		2472		−18.7
Male	655 (619–691)	32.6	844	34.1	−22.4
Female	1355 (1287–1423)	67.4	1628	65.9	−16.8
Total donors presenting to donate[c]	12,302 (11,684–12,921)		13,022		−5.5
Male	5642 (5389–5894)	45.9	6644	51.0	−15.1
Female	6659 (6364–6955)	54.1	6378	49.0	4.4
Prefer other self-description	1 (1–2)[d]	0.0			

Abbreviation: CI, confidence interval; MSM, men who have sex with men.
[a]Estimate is rounded from 3491 to 3000. Lower bound of the 95% CI is rounded from 3079 to 3000; upper bound of the 95% CI is rounded from 3903 to 4000.
[b]Estimate is rounded from 9288 to 9000. Lower bound of the 95% CI is rounded from 8540 to 9000; upper bound of the 95% CI is rounded from 10,035 to 10,000.
[c]Repeat donors who donated more than one time are counted once.
[d]Estimate is rounded from 1243 to 1000. Lower bound of the 95% CI is rounded from 523 to 1000; upper bound of the 95% CI is rounded from 1962 to 2000.

The number of recipients of allogeneic RBC transfusions and the number of allogeneic RBC units transfused per recipient were also stable between 2019 and 2021.

During 2021, the estimated number of units of autologous whole blood, whole blood-derived RBCs, and apheresis RBCs transfused was 15,000 (95% CI, 0–33,000 units), compared to 29,000 units in 2019 (Table 9). The total number of directed units transfused was stable between 2019 and 2021, with 19,000 (95% CI, 6000–31,000) units transfused in 2021 and 21,000 units transfused in 2019. This included 15,000 (95% CI, 2000–27,000) directed whole blood, whole blood-derived RBC, and apheresis RBC units transfused in 2021 (18,000 units in 2019) and 4000 (95% CI, 2000–7000) directed platelet units transfused in 2021 (3000 units in 2019).

3.4 | Plasma distributions and transfusions

Estimates for the number of plasma units distributed in the United States during 2021, by plasma product type, from both whole blood and apheresis collections, are displayed in Table 10. The total number of plasma units distributed increased between 2019 and 2021, from 2,679,000 units in 2019 to 3,114,000 (95% CI, 2,929,000–3,298,000) units in 2021. PF24 accounted for 53.8% (1,674,000/3,114,000) of the plasma units distributed during 2021. The number of PF24 units distributed increased between 2019 (1,506,000) and 2021 (1,674,000 [95% CI, 1,481,000–1,866,000]). Of the PF24 units distributed, 83.6% (1,399,000 [95% CI, 1,233,000–1,565,000] of 1,674,000 units) were manufactured from

TABLE 6 Estimated number of successful donations stratified by donor age and race/ethnicity in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

	2021		2019		
	Donations (95% CI)	Percent of total	Donations	Percent of total	% Change 2021–2019
Successful donations by donor age (years)					
15	1 (0–2)[a]	0.0	8	0.1	−87.5
16–18	482 (419–545)	4.2	1226	11.2	−60.7
16	108 (91–125)	0.9	285	2.6	−62.1
17	206 (175–237)	1.8	517	4.7	−60.2
18	167 (149–186)	1.5	414	3.8	−59.7
19–24	646 (609–683)	5.6	948	8.6	−31.9
25–64	7920 (7573–8267)	68.8	6943	63.2	14.1
25–44	3221 (2925–3517)	28.0			
45–64	4829 (4612–5045)	42.0			
65 or older	2493 (2181–2805)	21.7	1772	16.1	40.7
65–74	1936 (1825–2047)	16.8			
75 or older	569 (307–831)	4.9			
Total successful minority donations[b]	1387 (1162–1613)		2,146[c]	19.5	−35.4
Successful donations by race/ethnicity					
Hispanic or Latino	667 (553–781)	5.8			
Black or African American	305 (270–340)	2.7			
Asian	350 (202–498)	3.0			
Native Hawaiian or Pacific Islander	27 (0–74)	0.2			
American Indian or Alaska Native	53 (12–93)	0.5			
Total successful donations	11,507 (10,866–12,149)		10,981		4.8

Abbreviation: CI, confidence interval.

[a]Estimate is rounded from 633 to 1000. Lower bound of the 95% CI is 0; upper bound of the 95% CI is rounded from 1868 to 2000.

[b]Minority donors include donors who identify as Hispanic or Latino, Black or African American, Asian, Native Hawaiian or Pacific Islander, and American Indian or Alaska Native.

[c]The definition of minority donors for 2019 was donors who identify as African American, Pacific Islander, American Indian, and Hispanic.

TABLE 7 Estimated number of allogeneic blood donors in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

	2021		2019		
	Donors (95% CI)	Percent of total	Donors	Percent of total	% Change 2021–2019
First-time, allogeneic	1719 (1594–1844)	26.3	2213	30.2	−22.3
Repeat, allogeneic[a]	4840 (4461–5220)	74.0	5069	69.3	−4.5
Total individual donors[b]	6545 (6172–6918)		7316		−10.5

Abbreviation: CI, confidence interval.

[a]Repeat donors who donated more than one time are counted once.

[b]Excludes directed and autologous donors. Only includes donors from which blood products were successfully collected.

whole blood collections. Of the remaining plasma units distributed during 2021, 615,000 (95% CI, 495,000–736,000) units of plasma were frozen within 24 h after phlebotomy, held at room temperature up to 24 h after phlebotomy (PF24RT24), and 548,000 (95% CI, 286,000–811,000) units of FFP (69.3% of which were

TABLE 8 Estimated number of allogeneic red blood cell units transfused and recipients of allogeneic transfusions in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

	2021 (95% CI)	2019
Allogeneic units	10,668[a] (10,265–11,072)	10,801
Allogeneic recipients	4065 (3879–4250)	4206
Allogeneic units per recipient	2.63 (2.51–2.74)	2.57

Abbreviation: CI, confidence interval.
[a]The estimated number of allogeneic units transfused in 2021, shown here, differs from the main paper (which reported allogeneic, nondirected whole blood, and red blood cell units) because the 83,821 allogeneic whole blood units transfused reported to NBCUS have been removed.

TABLE 9 Estimated number of autologous and directed blood component units transfused in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

Component	Units transfused, 2021 (95% CI)	Units transfused, 2019
Autologous whole blood/RBCs[a]	15 (0–33)	29
Directed whole blood/RBCs[a]	15 (2–27)	18
Directed platelets	4 (2–7)	3
Total directed units	19 (6–31)	21

Abbreviations: CI, confidence interval; RBC, red blood cell.
[a]"Whole blood/RBCs" includes whole blood, whole blood-derived RBC, and apheresis RBC units.

manufactured from whole blood collections) were distributed.

During 2021, the estimated number of units of plasma products transfused in the United States remained relatively stable from 2019, with 2,215,000 (95% CI, 2,083,000–2,346,000) plasma units transfused in 2021 and 2,185,000 units transfused in 2019 (Table 11).

3.5 | Granulocyte distributions and transfusions

Estimates of granulocyte units distributed and transfused in 2021 are shown in Table 12. Compared to 2019, the number of granulocyte units distributed and transfused during 2021 both decreased, with 1308 (95% CI, 986–1631) granulocyte units distributed in 2021 (compared to 1857 units in 2019) and 990 (95% CI, 581–1398) granulocyte units transfused in 2021 (compared to 2215 units in 2019).

3.6 | Cost

The per unit cost of blood products reported by hospitals in the United States is shown in Table 13. Pathogen-reduced platelet products were the most expensive (median cost of $660 per unit, interquartile range: $624–$689 per unit), as reported by 939 hospitals, and cost almost $100 more per unit than conventional leukoreduced apheresis platelets (median cost of $567 per unit). Between 2019 and 2021, the median price paid per unit of blood product increased for all component types, with the largest increases in prices observed for leukoreduced apheresis platelets ($516 per unit in 2019 vs. $567 per unit in 2021), pathogen-reduced apheresis platelets ($617 per unit in 2019 vs. $660 per unit in 2021), and leukoreduced RBCs ($208 per unit in 2019 vs. $214 per unit in 2021). The median price paid per unit of FFP, PF24, and cryoprecipitated AHF all increased by $1–$2 per unit between 2019 and 2021. All mean increases in cost from 2019 to 2021 were statistically significant except for cryoprecipitated AHF.

The cost per unit of blood components in 2021 stratified by annual inpatient surgical volume is presented in Table 14. Between 2019 and 2021, the median price paid per unit of blood components increased across nearly all strata but varied by facility inpatient surgical volume. In general, facilities in the smallest strata (100–999 annual inpatient surgeries) pay more per unit of blood product than facilities in other strata. Facilities in the largest strata (≥8000 annual inpatient surgeries) paid the lowest price per unit, although the difference in the amount paid per unit among the different strata was not large. For example, the median price paid for a unit of pathogen-reduced apheresis platelets in 2021 was $663 among facilities that perform 100–999 annual inpatient surgeries and $650 among facilities that perform ≥8000 annual inpatient surgeries (in 2019, the median price for a unit of pathogen-reduced apheresis platelets was $600 among facilities that perform 100–999 annual inpatient surgeries and $612 among facilities that perform ≥8000 annual inpatient surgeries).

Similar to the trend seen in 2019, during 2021, there was geographic variation in the price per unit of blood products paid by hospitals across the United States (Table 15). The median price paid per leukoreduced RBC unit ranged from a low of $203 in HHS Region 5 (IL, IN, MI, MN, OH, WI) to a high of $225 in HHS Regions 1 (CT, MA, ME, NH, RI, VT) and 2 (NJ, NY). The median price paid per apheresis platelet unit ranged from a low of $537 in HHS Region 4 (AL, FL, GA, KY, MS, NC) to a high of $589 in HHS Region 3 (DC, DE, MD, PA, VA, WV). The median price paid per apheresis platelet unit treated with pathogen reduction technology (PRT)

TABLE 10 Estimated number of apheresis and whole blood-derived plasma units distributed in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

Plasma product	2021 (95% CI) Whole blood-derived units	2021 (95% CI) Apheresis units	2021 (95% CI) All units[a]	2019 Whole blood-derived units	2019 Apheresis units	2019 All units
All plasma products			3114 (2929–3298)			2679
FFP	380 (209–552)	164 (87–241)	548 (286–811)	497	168	680
FFP, jumbo size (>400 mL)		23 (1–46)	23 (1–46)		47	
PF24	1399 (1233–1565)	278 (212–343)	1674 (1481–1866)	1356	196	1506
Plasma, PF24RT24[b]	47 (0–126)	562 (511–613)	615 (495–736)	203	293	494
Liquid[c]	186 (169–204)	29 (19–40)	216 (195–237)	152		
Cryoprecipitate reduced	175 (148–201)		175 (148–201)	30		
Group AB[d]			401 (363–439)			341

Abbreviations: CI, confidence interval; FFP, fresh frozen plasma.
[a]Individual values for whole blood-derived and apheresis units were not forced to sum to the total (i.e., "all units"); all three values are reported as calculated after cleaning, multiple imputation, and weighting.
[b]PF24RT24, plasma frozen within 24 h after phlebotomy, held at room temperature up to 24 h after phlebotomy.
[c]Liquid plasma here includes thawed plasma ± liquid plasma.
[d]Group AB plasma is not an exclusive category and includes units counted as other product types.

TABLE 11 Estimated number of plasma units transfused in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

Plasma product	2021 (95% CI)	2019
All plasma products	2215 (2083–2346)	2185
Liquid[a]	76 (60–92)	56
Group AB[b]	268 (236–300)	255

Abbreviation: CI, confidence interval.
[a]Liquid plasma here includes thawed plasma ± liquid plasma.
[b]Group AB plasma is not an exclusive category and includes units counted as other product types.

TABLE 12 Estimated number of granulocyte units distributed and transfused in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	2021 (95% CI)	2019
Granulocytes distributed	1308 (986–1631)	1857
Granulocytes transfused	990 (581–1398)	2215

Abbreviation: CI, confidence interval.

ranged from a low of $627 in HHS Region 6 (AR, LA, NM, OK, TX) to a high of $683 in HHS Region 2 (NJ, NY). Hospitals in all 10 HHS regions reported an increase in price paid per unit of blood product between 2019 and 2021 for leukoreduced RBCs, apheresis platelets, and FFP, with the exception of FFP in Region 8 (CO, MT, ND, SD, UT, WY) (median price paid decreased from $59 per unit in 2019 to $54 per unit in 2021) and FFP in Region 9 (AZ, CA, HI, NV) (no change in median price paid per unit of FFP between 2019 and 2021). The largest increases in median price paid per unit of blood product between 2019 and 2021 were seen for apheresis platelets.

3.7 | Inventory and supply

3.7.1 | Age of transfused units

Table 16 presents the proportion of RBC, apheresis platelet, and whole-blood derived platelet units transfused, by unit age at the time of transfusion, as reported by transfusing facilities answering the survey question. During 2021, most transfused RBCs (80.9%) were aged 1–35 days at the time of transfusion, which is stable from 2019, when 80.9% of transfused RBCs were aged 1–35 days. The proportion of apheresis platelets aged 1–3 days at the time of transfusion increased between 2019 and 2021, from 38.5% in 2019 to 41.4% in 2021. However, the proportion of apheresis platelets aged 6–7 days at the time of transfusion also increased between 2019 and 2021, from 2.4% in 2019 to 10.1% in 2021. The proportion of whole blood-derived platelets aged 1–3 days at the time of transfusion similarly increased between 2019 and 2021, from 15.7% in 2019 to 37.6% in 2021.

TABLE 13 Median and mean dollar amount paid per blood product unit (in US dollars), 2019 and 2021, as reported by hospitals in the United States to the National Blood Collection and Utilization Survey.

	Amount paid, 2021 ($)			Amount paid, 2019 ($)			Difference, 2021–2019 ($)		
Component	Median (*N*)	IQR	Mean	Median (*N*)	IQR	Mean	Median	Mean	Matched mean
RBCs, leukoreduced	214 (1435)	202–230	221	208 (1607)	198–223	215	6	6[a]	6.5
Apheresis platelets, leukoreduced	567 (1278)	520–618	573	516 (1537)	491–543	520	51	53[a]	49.7
Pathogen-reduced apheresis platelets	660 (939)	624–689	659	617 (314)	570–659	610	43	49[a]	41.6
FFP	52 (869)	45–60	56	50 (941)	43–59	53	2	3[a]	3.7
PF24	51 (1187)	43–60	56	50 (1276)	43–58	53	1	3[a]	1.7
Cryoprecipitated AHF, each unit	52 (656)	43–64	55	51 (731)	42–62	55	1	0	1.6

Abbreviations: AHF, antihemophilic factor; FFP, fresh frozen plasma; IQR, interquartile range; RBC, red blood cell.
[a]Statistically significant difference between 2019 and 2021 with $p < .05$.

3.7.2 | Group O positive and group O negative units distributed, transfused, and outdated

The proportions of allogeneic RBC units processed, distributed, transfused, and outdated that were group O positive and group O negative are shown in Table 17. During 2021, 38.5% of distributed RBC units in the United States were O positive, and 9.8% were O negative, relatively stable from the 37.1% and 11.4%, respectively, during 2019. Of RBC outdates at blood centers during 2021, 10.0% were group O positive (compared to 9.5% in 2019), and 5.3% were group O negative (compared to 4.6% in 2019). Of RBC units transfused during 2021, 42.2% were group O positive (41.3% in 2019), and 12.5% were group O negative (11.6% in 2019).

3.8 | Policies and practices related to blood collection, processing, and transfusion

3.8.1 | Bacterial testing of platelets

The estimated number of apheresis platelet units distributed that were tested using primary bacterial culture is shown in Table 18. Among the blood collection centers that responded to the question, the most common primary bacterial culture practice for apheresis platelets was large volume, delayed sampling performed no sooner than 36 h after collection (35%, 406,000 [95% CI, 377,000–436,000] units) followed by primary culture performed no sooner than 24 h after collection (34%, 394,000 [95% CI, 280,000–509,000] units).

Table 19 presents the number of hospitals in the United States, stratified by annual surgical volume, that reported performing secondary pre-transfusion bacterial testing of platelets. The proportion of hospitals that reported performing pre-transfusion bacterial testing in 2021 (3.5%, 63/1821) was lower than in 2019 (6.4%, 125/1946), although only a small number of hospitals reported this practice. The largest decline in the proportion of facilities reporting use of secondary bacterial testing occurred among the largest stratum of hospitals (those performing ≥8000 annual inpatient surgeries), with 10% reporting the practice in 2021 compared to 19% in 2019.

During 2021, transfusing hospitals reported performing 9098 secondary bacterial culture tests prior to transfusion no sooner than day 3, and none were positive (Table 20). Of the 14,764 rapid bacterial tests performed in 2021, six (0.04%) were positive, compared to 22 (0.02%) of 92,805 rapid tests performed in 2019.

3.8.2 | Pathogen reduction technology treatment of platelets

Table 21 shows the proportion of blood collection centers reporting use of platelets treated with PRT in the United States. Although the proportion of community blood collection centers in the two largest strata (i.e., those collecting 200,000 or more RBC units annually) reporting collection of PRT-treated platelets in 2019 and 2021 remained relatively stable (78% in 2019 and 80% in 2021), reported collection of PRT-treated

TABLE 14 Median and mean dollar amount paid per blood product unit (in US dollars), as reported by US hospitals to the National Blood Collection and Utilization Survey and stratified by annual inpatient surgical procedures, 2019 and 2021.

Component	Surgical procedures per year	Amount paid, 2021 ($)			Amount paid, 2019 ($)		Difference, 2021–2019 ($)	
		N	Median	Mean	Median	Mean	Median	Mean
RBCs, leukoreduced	100–999	350	$223	$233	$217	$224	6	9
	1000–1399	196	$217	$225	$210	$215	7	10
	1400–2399	327	$211	$218	$208	$215	3	3
	2400–4999	395	$214	$219	$206	$212	8	7
	5000–7999	178	$213	$216	$205	$208	8	8
	≥8000	161	$208	$213	$203	$207	5	6
Apheresis PLTs, leukoreduced	100–999	296	$593	$599	$527	$534	66	65
	1000–1399	194	$572	$582	$520	$534	52	48
	1400–2399	322	$553	$563	$520	$523	33	40
	2400–4999	391	$564	$568	$511	$514	53	54
	5000–7999	174	$560	$570	$510	$504	50	66
	≥8000	160	$551	$556	$506	$502	45	54
Pathogen-reduced apheresis PLTs	100–999	38	$663	$665	$600	$577	63	88
	1000–1399	34	$665	$658	$625	$611	40	47
	1400–2399	64	$664	$657	$622	$618	42	39
	2400–4999	85	$660	$661	$634	$624	26	37
	5000–7999	42	$662	$662	$614	$604	48	58
	≥8000	51	$650	$647	$612	$603	38	44
FFP	100–999	133	$57	$69	$57	$61	0	8
	1000–1399	111	$55	$58	$52	$56	3	2
	1400–2399	186	$51	$55	$50	$55	1	0
	2400–4999	261	$52	$55	$50	$51	2	4
	5000–7999	127	$52	$52	$47	$48	5	4
	≥8000	123	$47	$52	$45	$49	2	3
Plasma frozen between 8 and 24 h of donation (PF24)	100–999	226	$57	$67	$57	$63	0	4
	1000–1399	153	$53	$59	$53	$56	0	3
	1400–2399	264	$50	$55	$50	$54	0	1
	2400–4999	327	$51	$53	$48	$50	3	3
	5000–7999	158	$48	$50	$47	$49	1	1
	≥8000	148	$47	$49	$45	$48	2	1
Cryoprecipitate, each unit	100–999	71	$53	$56	$59	$62	−6	−6
	1000–1399	96	$56	$59	$56	$57	0	2
	1400–2399	141	$52	$55	$51	$58	1	−3
	2400–4999	205	$52	$54	$52	$54	0	0
	5000–7999	104	$52	$55	$48	$51	4	4
	≥8000	114	$47	$52	$48	$49	−1	3

Abbreviations: FFP, fresh frozen plasma; PLT, platelet; RBC, red blood cell.

platelets increased among smaller community blood collection centers (i.e., those collecting less than 200,000 RBC units annually), from 36% in 2019 to 56% in 2021. The proportion of hospital-based blood collection centers reporting collection of PRT-treated platelets also increased between 2019 and 2021, with 10% reporting doing so in 2019 and 19% in 2021. Table 22 shows estimated use of PRT by transfusing

TABLE 15 Median and mean dollar amount paid per blood product unit (in US dollars), as reported by US hospitals to the National Blood Collection and Utilization Survey and stratified by Health and Human Services (HHS) region, 2019 and 2021.

		Leukoreduced RBCs		Apheresis PLTs		FFP		PRT apheresis PLTs	
HHS region	Year	Median (*N*)	Mean (SD)	Median (*N*)	Mean (SD)	Median (*N*)	Mean (SD)	Median (*N*)	Mean (SD)
1 (CT, MA, ME, NH, RI, VT)	2019	$222 (74)	$227 ($26)	$504 (72)	$520 ($72)	$41 (44)	$50 ($16)	$657 (66)	$658 ($63)
	2021	$225 (72)	$233 ($38)	$585 (65)	$592 ($89)	$43 (49)	$58 ($49)		
	2021–2019[a]	3	6	81	72	2	8		
2 (NJ, NY)	2019	$213 (142)	$218 ($21)	$525 (137)	$534 ($63)	$42 (95)	$47 ($12)	$683 (88)	$685 ($93)
	2021	$225 (111)	$232 ($28)	$579 (95)	$585 ($100)	$46 (70)	$51 ($14)		
	2021–2019[a]	12	14	54	51	4	4		
3 (DC, DE, MD, PA, VA, WV)	2019	$210 (152)	$216 ($25)	$520 (144)	$532 ($42)	$50 (82)	$53 ($12)	$672 (108)	$677 ($83)
	2021	$220 (132)	$230 ($40)	$589 (116)	$598 ($97)	$51 (69)	$57 ($25)		
	2021–2019[a]	10	14	69	66	1	4		
4 (AL, FL, GA, KY, MS, NC)	2019	$202 (314)	$207 ($22)	$520 (300)	$520 ($74)	$51 (197)	$54 ($18)	$670 (182)	$650 ($75)
	2021	$205 (280)	$211 ($32)	$537 (261)	$560 ($83)	$55 (184)	$56 ($18)		
	2021–2019[a]	3	4	17	40	4	2		
5 (IL, IN, MI, MN, OH, WI)	2019	$199 (313)	$206 ($35)	$495 (301)	$503 ($62)	$50 (168)	$54 ($23)	$651 (214)	$658 ($55)
	2021	$203 (268)	$209 ($27)	$575 (232)	$571 ($76)	$53 (157)	$56 ($21)		
	2021–2019[a]	4	3	80	68	3	2		
6 (AR, LA, NM, OK, TX)	2019	$214 (209)	$220 ($32)	$525 (198)	$536 ($92)	$48 (130)	$54 ($19)	$627 (57)	$631 ($103)
	2021	$221 (196)	$226 ($29)	$572 (184)	$578 ($82)	$50 (109)	$56 ($21)		
	2021–2019[a]	7	6	47	42	2	2		
7 (IA, KS, MO, NE)	2019	$206 (96)	$209 ($25)	$500 (91)	$499 ($53)	$50 (43)	$52 ($7)	$644 (51)	$645 ($74)
	2021	$208 (91)	$215 ($41)	$552 (77)	$551 ($77)	$52 (45)	$56 ($20)		
	2021–2019[a]	2	6	52	52	2	4		
8 (CO, MT, ND, SD, UT, WY)	2019	$216 (61)	$222 ($32)	$516 (55)	$541 ($119)	$59 (42)	$60 ($15)	$675 (27)	$686 ($183)
	2021	$220 (66)	$237 ($79)	$555 (57)	$582 ($74)	$54 (40)	$67 ($47)		
	2021–2019[a]	4	15	39	41	−5	7		
9 (AZ, CA, HI, NV)	2019	$218 (170)	$226 ($33)	$491 (167)	$505 ($83)	$50 (95)	$53 ($18)	$646 (102)	$646 ($98)
	2021	$220 (161)	$228 ($30)	$560 (149)	$560 ($92)	$50 (100)	$55 ($25)		
	2021–2019[a]	2	2	69	55	0	2		
10 (AK, ID, OR, WA)	2019	$216 (76)	$224 ($36)	$522 (72)	$543 ($98)	$55 (45)	$60 ($16)	$681 (44)	$671 ($105)
	2021	$223 (58)	$236 ($50)	$558 (42)	$602 ($117)	$56 (46)	$64 ($27)		
	2021–2019[a]	7	12	36	59	1	4		

Abbreviations: FFP, fresh frozen plasma; PLT, platelet; PRT, pathogen reduction technology; RBC, red blood cell.
[a]"2021–2019" depicts difference in median and mean amount paid per blood product unit (in US dollars), from 2019 to 2021.

hospitals in the United States. From 2019 to 2021, among all transfusing hospitals reporting on PRT-treated platelet use, the proportion that reported using PRT-treated platelets increased substantially, from 13% in 2019 to 60% in 2021. Among transfusing hospitals with 8000 or more annual inpatient surgeries, the proportion that reported using PRT-treated platelets increased from 29% in 2019 to 76% in 2021.

3.8.3 | Use of platelet additive solution

During 2021, the proportion of blood collection centers in the United States that reported using platelet additive solution (PAS) to prepare apheresis platelet units was slightly higher than in 2019 (16.0% in 2021 compared to 14.0% in 2019), although in both years, exactly 16 facilities reported using PAS (Table 23). Of the 16 facilities that

TABLE 16 Percentage of units transfused by unit age in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	2021		2019	
Component	***N* facilities**	**% (*n*/*N*)**	***N* facilities**	**% (*n*/*N*)**
Red blood cells	557		799	
1–35 days		80.9% (1,439,992/1,780,854)		80.9% (1,601,634/1,980,959)[a]
36–42 days		19.1% (340,862/1,780,854)		19.1% (379,325/1,980,959)
Apheresis platelets	558		834	
1–3 days		41.4% (142,254/343,216)		38.5% (176,295/458,408)
4–5 days		48.5% (166,356/343,216)		59.2% (271,187/458,408)
6–7 days		10.1% (34,606/343,216)		2.4% (10,926/458,408)
Whole blood-derived platelets	749		1063	
1–3 days		37.6% (3965/10,553)		15.7% (3992/25,377)
4–5 days		62.4% (6588/10,553)		84.3% (21,385/25,377)

[a]Value for 2019 recalculated after additional data cleaning and validation.

TABLE 17 Group O positive red blood cell (RBC) units and group O negative RBC units distributed, transfused, and outdated as a percentage of all allogeneic RBC units in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	2021, % (SD, *n*)		2019, % (SD, *n*)	
	Group O+	**Group O−**	**Group O+**	**Group O−**
Processed	—	—	35.2% (18.8%, $n = 73$)	8.9% (6.0%, $n = 73$)
Distributed	38.5% (17.4%, $n = 57$)	9.8% (5.7%, $n = 57$)	37.1% (20.9%, $n = 48$)	11.4% (12.9%, $n = 48$)
Outdated (blood center)	10.0% (11.8%, $n = 51$)	5.3% (6.8%, $n = 50$)	9.5% (17.1%, $n = 46$)	4.6% (7.4%, $n = 46$)
Transfused	42.2% (12.3%, $n = 1159$)	12.5% (8.4%, $n = 1165$)	41.3% (12.3%, $n = 1433$)	11.6% (7.6%, $n = 1446$)
Outdated (hospital)	17.1% (23.2%, $n = 826$)	14.1% (20.6%, $n = 826$)	16.7% (22.1%, $n = 1059$)	12.9% (19.2%, $n = 1062$)

reported using PAS in 2021, 11 were community-based blood collection centers and five were hospital-based blood collection centers. The same breakdown was seen in 2019. The median number of platelet units prepared using PAS was also higher in 2021 compared to 2019 (2201 units in 2021 compared to 1631 units in 2019). However, the number of blood collection centers that reported use of PAS was unchanged from 2019 (16) to 2021 (16).

3.8.4 | Leukoreduction and irradiation of whole blood and RBCs

The proportion of whole blood and RBC units collected in the United States that were leukoreduced at blood collection centers prior to storage declined slightly in 2021 compared with 2019 (95.4% vs. 97.2%), although this change was not statistically significant (Table 24). The proportion of whole blood and RBC units transfused in the United States that were irradiated, leukoreduced before storage, and leukoreduced after storage at transfusing hospitals all remained relatively stable between 2019 and 2021 (Table 25). Of the 10,764,000 units of whole blood and RBCs transfused in 2021,[15] 9,305,000 (95% CI, 8,808,000–9,802,000) units were leukoreduced before storage, which corresponds to 86.4% of the total units transfused (compared to 85.4% in 2019). During 2021, 1,880,000 (95% CI, 1,615,000–2,145,000) units, or 17.5% of the total units transfused, were irradiated (18.6% in 2019), and 1,984,000 (95% CI, 1,699,000–2,270,000) units, or 18.4% of the total units transfused, were leukoreduced after storage (16.7% in 2019).

3.8.5 | Molecular genotyping of blood donors and recipients

Molecular genotyping to identify non-ABO RBC antigen expression among blood donors and recipients remains

TABLE 18 Estimated number of apheresis platelet units distributed that were tested with bacterial risk control strategies in the United States, 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

Apheresis platelet culture method	Units distributed in 2021		
	Community-based blood collection centers	Hospital-based blood collection centers	Combined (95% CI)
Primary culture performed no sooner than 24 h	385	9	394 (280–509)
Large volume, delayed sampling no sooner than 36 h	405	1	406 (377–436)
Large volume, delayed sampling no sooner than 48 h	336	17	353 (304–402)

Abbreviation: CI, confidence interval.

TABLE 19 Number of hospitals performing pre-transfusion bacterial testing[a] of platelets in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

Hospital size	Hospitals performing pre-transfusion bacterial testing on platelets, % (*n*/*N*)	
	2021	2019
All hospitals, total	3.5% (63/1821)	6.4% (125/1946)
100–999 surgeries per year	0% (1/382)	0% (2/440)
1000–1399 surgeries per year	1% (2/222)	3% (8/233)
1400–2399 surgeries per year	2% (9/370)	2% (9/410)
2400–4999 surgeries per year	4% (17/480)	9% (41/471)
5000–7999 surgeries per year	9% (18/205)	14% (29/207)
8000 or more surgeries per year	10% (16/162)	19% (36/185)

[a]Not including testing performed by the blood collection facility.

uncommon, although it increased somewhat in 2021 compared to 2019 (Table 26). In 2021, 27.6% (27/98) of blood collection centers that responded to this question

TABLE 20 Number of bacterial tests performed for pre-transfusion testing of platelet units by transfusing hospitals and number of confirmed positive results by type in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	Confirmed positive results/number of tests performed (false positive results, indeterminate results)	
	2021	2019
Secondary culture performed no sooner than day 3	0/9098 (1, 0)	—
Secondary culture performed no sooner than day 4	0/33 (2, 0)	—
Culture-based testing	—	14/35,266 (15, 2)[a]
Rapid test	6/14,764 (6, 4)	22/92,805 (209, 30)

[a]The 2019 survey asked about culture-based testing on any day.

TABLE 21 Estimated use of pathogen reduction technology (PRT) by blood collection centers in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

Facility type	Percent of facilities reporting collection of PRT-treated platelets, % (*n*/*N*)	
	2021	2019
All collection facilities	38 (42/111)	23 (26/112)
Blood collection centers with 200,000 or more RBC collections[a]	80 (8/10)	78 (7/9)
Blood collection centers with less than 200,000 RBC collections[a]	56 (22/39)	36 (12/33)
Hospital-based blood collection centers	19 (12/62)	10 (7/70)

Abbreviation: RBC, red blood cell.
[a]Excluding hospital-based blood centers.

reported molecular genotyping of donors, compared with 19.1% (21/110) in 2019. The mean proportion of units that were genotyped per blood collection facility in 2021 was slightly lower than in 2019 (3.1% compared to 3.8%). Additionally, a slightly lower proportion of transfusing hospitals reported molecular genotyping of recipients in 2021 compared with 2019 (1.9% compared to 2.4%), although the mean proportion of units that were genotyped per transfusing hospital in 2021 was slightly higher than in 2019 (7.8% compared to 5.7%).

TABLE 22 Estimated use of pathogen reduction technology (PRT) by transfusing hospitals in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

Facility type	Percent of facilities reporting use of PRT-treated platelets, % (*n*/*N*) 2021	2019
All transfusing hospitals	60 (1092/1816)	13 (247/1908)
Hospital-based blood collection centers	70 (33/47)	17 (11/64)
Transfusing hospitals with 8000 or more inpatient surgeries annually[a]	76 (114/150)	29 (46/159)
Transfusing hospitals with less than 8000 inpatient surgeries annually[a]	58 (945/1619)	11 (190/1685)

[a]Excluding hospital-based blood centers.

TABLE 23 Use of platelet additive solution to prepare apheresis platelets in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	2021, % (*n*/*N*)	2019, % (*n*/*N*)
Blood collection centers providing responses	90% (100/111)	90% (114/126)
Facilities reporting use of platelet additive solution	16.0% (16/100)	14.0% (16/114)
Median number of units prepared using platelet additive solution	2201 ($n = 15$)	1631 ($n = 13$)

TABLE 24 Estimated percent of whole blood and red blood cell (RBC) units leukoreduced before storage at blood collection centers in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	Percent units leukoreduced 2021, % (95% CI)	2019, %
Whole blood/RBC units	95.4 (90.6–100.0)	97.2

Abbreviation: CI, confidence interval.

3.8.6 | Crossmatch procedures on whole blood and RBCs

During 2021, the total estimated number of crossmatch procedures performed on whole blood and RBC units in the United States was 15,333,000 (95% CI, 14,527,000–16,139,000), which represents a slight decrease from 2019, when 15,562,000 procedures were reported, although this decrease was not statistically significant (Table 27). The proportion of crossmatch procedures performed electronically remained stable between 2019 (59.1%) and 2021 (60.9%).

3.8.7 | Dosing criteria for transfusions

Table 28 displays the criteria used by transfusing hospitals in the United States for routine dosing of plasma, prophylactic platelet, and therapeutic platelet transfusions for non-pediatric patients. During 2021, the majority of transfusing hospitals reported basing plasma and platelet dosages on the level of coagulation factor deficiency, international normalized ratio (INR), or degree of bleeding, with 64.4% of facilities reporting using this dosing criteria for plasma transfusions, 65.1% reporting using this dosing criteria for prophylactic platelet transfusions, and 71.5% reporting using this dosing criteria for therapeutic platelet transfusions. These proportions are similar to those reported during 2019. Dosing plasma and platelets based on a standard number of units, regardless of patient weight, was the reported dosing criteria used by 11.6% of transfusing hospitals for plasma transfusions, 12.9% of transfusing hospitals for prophylactic platelet transfusions, and 10.0% of transfusing hospitals for therapeutic platelet transfusions. Notably, during 2021, less than 5% of transfusing hospitals reported dosing plasma transfusions based on patient weight (this option was not an included response for the questions on dosing of platelet transfusions in the 2021 NBCUS).

3.8.8 | Hospital policies and practices to enhance recipient safety

The proportion of hospitals reporting various policies and practices to enhance the safety of recipients in 2021 was similar to that in 2019 (Table 29). During 2021, 17.3% (305/1765) of hospitals reported a Transfusion Safety Officer on staff, compared to 17.9% (338/1884) in 2019. Of the 1840 hospitals completing the question in 2021, 83.4% (1534) had a policy to only transfuse leukoreduced blood components; the proportion reporting this policy in 2019 was 83.9%. From 2019 to 2021, the percentage of transfusing hospitals that collected data on sample collection errors remained stable, with 81.1% of hospitals that answered this question reporting the practice in 2019 and 80.7% reporting the practice in 2021.

TABLE 25 Estimated number of whole blood and red blood cell units transfused at hospitals that were irradiated or leukoreduced, before and after storage, in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

	Units		% of total units	
	2021 (95% CI)	2019	2021	2019
Irradiated	1880 (1615–2145)	1983	17.5	18.6
Leukoreduced before storage	9305 (8808–9802)	9100	86.4	85.4
Leukoreduced after storage	1984 (1699–2270)	1777	18.4	16.7

Abbreviation: CI, confidence interval.

TABLE 26 Genotyping of whole blood and red blood cell (RBC) donors by blood collection centers and whole blood and RBC recipients by transfusing hospitals in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

Facility type	Question	2021, % (*n*/*N*)	2019, % (*n*/*N*)
BCCs	Facilities providing responses	88.3% (98/111)	87.3% (110/126)
	Facilities reporting genotyping for RBC antigens	27.6% (27/98)	19.1% (21/110)
	Facility mean (median) fraction of units	3.1% (1.1%)	3.8% (1.8%)
	Facility total units genotyped mean (median)	8951.3 (894)	4748.9 (1223)
Hospitals	Facilities providing responses	83.5% (1756/2102)	89.0% (1904/2140)
	Facilities reporting genotyping for RBC antigens	1.9% (33/1756)	2.4% (45/1904)
	Facility mean (median) fraction of units	7.8% (2.6%)	5.7% (2.6%)
	Facility total units genotyped mean (median)	1074.5 (42)	568.4 (72)

Abbreviation: BCC, Blood Collection Center.

TABLE 27 Estimated number of crossmatch procedures performed on whole blood and red blood cells in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

	2021		2019	
Crossmatch procedure method	Number of procedures (95% CI)	% of any method[a]	Number of procedures	% of any method[a]
Any method	15,333 (14,527–16,139)		15,562	
Electronic	9342 (8521–10,162)	60.9	9198	59.1
Manual serologic	5648 (5173–6123)	36.8	6228	40
Automated serologic	764 (554–975)	5.0	558	3.6

Abbreviation: CI, confidence interval.

[a]More than one crossmatch procedure method may be reported by respondents, so "% of any method" does not necessarily equate to "out of 100%."

3.9 | Pediatric transfusions

Table 30 shows the number of adult-equivalent units of whole blood or RBCs, apheresis platelets, and plasma used in whole or in part for pediatric and neonatal patients in the United States as well as the number of pediatric or neonatal recipients during 2021. Overall, 344,000 (95% CI, 245,000–443,000) adult-equivalent whole blood or RBC units, 150,000 (95% CI, 96,000–204,000) adult-equivalent apheresis platelets, and 78,000 (95% CI, 47,000–109,000) adult-equivalent plasma units were used in pediatric and neonatal patient transfusions. Between 2019 and 2021, the number of adult-equivalent units of whole blood or RBCs and apheresis platelets used for pediatric and neonatal patients declined by 15.1% and 10.7%, respectively. Compared to 2019, the number of adult-equivalent plasma units in 2021 also declined for neonatal patients (−19.4%) but not for pediatric patients (+10.4%).

Table 31 portrays data from hospitals that responded to a question on neonatal aliquot production. Of these hospitals, 451 (58.3%) reported that neonatal aliquots were made using syringes from full-size units, and 391 (50.5%) reported that neonatal aliquots were made using Pedipacks. Among 732 reporting hospitals during

TABLE 28 Routine dosing criteria used by US transfusing hospitals for non-pediatric patients, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	2021			2019		
Dosing criteria	Plasma % (*n*)	Prophylactic platelet transfusions % (*n*)	Therapeutic platelet transfusions % (*n*)	Plasma % (*n*)	Prophylactic platelet transfusions % (*n*)	Therapeutic platelet transfusions % (*n*)
Weight-based dosing (e.g., 20 mL/kg)	4.3% (66)	—	—	5.5% (90)	2.9% (46)	2.9% (48)
Standard number of units regardless of patient weight	11.6% (177)	12.9% (185)	10.0% (146)	10.3% (170)	13.9% (221)	12.3% (201)
Dosage varies based on level of coagulation factor deficiency, INR, or degree of bleeding	64.4% (980)	65.1% (934)	71.5% (1047)	66.7% (1102)	64.8% (1034)	68.5% (1115)
Number of units ordered not consistent with any of the above	19.6% (298)	22.0% (316)	18.5% (271)	17.5% (289)	18.4% (294)	16.2% (264)

Abbreviation: INR, international normalized ratio.

TABLE 29 Hospital policies and practices to enhance safety of recipients of blood components in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	2021		2019	
	%	*n*/*N*	%	*n*/*N*
Policy to transfuse only leukoreduced components	83.4%	(1534/1840)	83.9%	(1618/1928)
Program to treat patients who refused blood components for religious, cultural, or personal reasons	74.8%	(1327/1774)	75.3%	(1415/1880)
Transfusion Safety Officer on staff	17.3%	(305/1765)	17.9%	(338/1884)
Data on sample collection error	80.7%	(1451/1797)	81.1%	(1540/1899)

TABLE 30 Estimated pediatric transfusions and recipients in the United States, 2019 and 2021 (expressed in thousands), as reported to the National Blood Collection and Utilization Survey.

		Adult-equivalent units used in whole or part for pediatric patients			Total number of pediatric recipients	
Component	Patient group	2021 (95% CI)	2019	% Change 2021–2019	2021 (95% CI)	2019
Whole blood or RBCs	Pediatric and neonatal	344 (245–443)	405	−15.1	64 (48–80)	117
	Pediatric (4 months or older)	224 (135–313)	272	−17.6	35 (20–49)	77
	Neonatal (less than 4 months)	120 (98–142)	133	−9.8	30 (24–35)	40
Apheresis platelets	Pediatric and neonatal	150 (96–204)	168	−10.7	23 (15–30)	47
	Pediatric (4 months or older)	112 (61–163)	120	−6.7	13 (7–20)	30
	Neonatal (less than 4 months)	37 (27–48)	48	−22.9	9 (7–11)	17
Plasma	Pediatric and neonatal	78 (47–109)	79	−1.3	15 (12–19)	24
	Pediatric (4 months or older)	53 (25–80)	48	10.4	7 (4–10)	14
	Neonatal (less than 4 months)	25 (18–33)	31	−19.4	8 (6–10)	10

Abbreviations: CI, confidence interval; RBC, red blood cell.

TABLE 31 Hospital policies for neonatal aliquot production in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	2021		2019	
Question	**% Yes**	***n*/*N*[a]**	**% Yes**	***n*/*N*[a]**
Neonatal aliquots made using syringes from full-size units	58.3%	451/773	57.2%	465/813
Neonatal aliquots made using Pedipacks	50.5%	391/774	50.6%	411/813
For neonatal patients, attempt to use aliquots from the same full-size unit for every transfusion	84.4%	618/732	83.7%	647/773

[a]Excludes facilities that did not perform pediatric or neonatal transfusions.

2021, 618 (84.4%) reported that for neonatal transfusions, an attempt was made to use aliquots from the same full-size unit for every transfusion, which was stable from 2019 (when 83.7% of hospitals reported doing so).

3.10 | Transfusion-associated adverse reactions

The estimated number of transfusion-associated adverse reactions and reactions per 100,000 components transfused in the United States are shown in Table 32. The total number of reactions that required any diagnostic or therapeutic intervention decreased slightly between 2019 and 2021, from 48,342 reactions in 2019 to 45,142 (95% CI, 41,242–49,042) reactions in 2021, although this change was not statistically significant. Similarly, the number of reactions per 100,000 components transfused

TABLE 32 Transfusion-associated adverse reactions in the United States, 2019 and 2021, as reported to the National Blood Collection and Utilization Survey.

	Number of reactions (95% CI)		Reactions per 100,000 components transfused (95% CI)	
Adverse transfusion reactions	**2021**	**2019**	**2021**	**2019**
Total number of reactions that required any diagnostic or therapeutic intervention	45,142 (41,242–49,042)	48,342	273.8 (255.6–291.9)	293.7
Febrile, nonhemolytic transfusion reaction	18,918 (17,085–20,751)	19,891	113.3 (104.0–122.7)	119.1
Mild to moderate allergic reactions	12,010 (10,668–13,352)	13,697	71.4 (64.8–78.0)	81.5
Delayed serologic transfusion reaction	3732 (3034–4431)	3208	22.2 (18.2–26.2)	19.0
Transfusion-associated circulatory overload	2491 (2099–2884)	2247	14.7 (12.5–16.8)	13.4
Hypotensive transfusion reaction	1315 (1119–1511)	1442	7.8 (6.6–9.0)	8.7
Transfusion-associated dyspnea	918 (771–1065)	1150	5.5 (4.6–6.4)	7.0
Delayed hemolytic transfusion reaction	770 (601–939)	692	4.6 (3.6–5.5)	4.1
Severe allergic reactions	427 (285–570)	442	2.5 (1.7–3.3)	2.7
Acute hemolytic transfusion reaction (other antibodies)	227 (114–339)	173	1.4 (0.7–2.0)	1.0
Transfusion-related acute lung injury	192 (146–238)	258	1.1 (0.9–1.4)	1.5
Posttransfusion purpura	96 (27–165)	104	0.57 (0.16–0.99)	0.63
Acute hemolytic transfusion reaction (ABO)	62 (35–89)	55	0.37 (0.21–0.52)	0.33
Transfusion-transmitted bacterial infection (previously asked as posttransfusion sepsis)	57 (28–87)	58	0.34 (0.17–0.52)	0.35
Transfusion-transmitted viral infection	11 (0–25)	3	0.064 (0.000–0.152)	0.021
Transfusion-transmitted parasitic infection	4 (0–9)	4	0.023 (0.000–0.054)	0.023
Transfusion-associated graft-versus-host disease	0[a]	0[a]		
Reactions that were life threatening, requiring major medical intervention[b]	162 (93–232)	442	0.98 (0.56–1.39)	2.7

Abbreviation: CI, confidence interval.

[a]Zero events reported in the sample for 2021 and 2019. Therefore, no national estimate of the number of occurrences could be made in either year.

[b]For example, vasopressors, blood pressure support, intubation, or transfer to the intensive care unit.

also decreased slightly between 2019 and 2021, with 293.7 reactions per 100,000 components transfused in 2019 and 273.8 (95% CI, 255.6–291.9) reactions per 100,000 components transfused in 2021. During 2021, the most common type of transfusion-associated adverse reaction was febrile, nonhemolytic transfusion reaction, with an estimated 18,918 (95% CI, 17,085–20,751) reactions occurring during 2021. This was also the most common type of transfusion-associated adverse reaction during 2019, with an estimated 19,891 reactions. The number of most types of transfusion-associated adverse reactions remained relatively stable between 2019 and 2021, including transfusion-transmitted bacterial infections (or post-transfusion sepsis), for which there were an estimated 57 (95% CI, 28–87) reactions in 2021, compared to 58 reactions in 2019. The one exception is reactions that were life-threatening or required major medical intervention, which decreased between 2019 and 2021. There were an estimated 442 such reactions in 2019 and 162 (95% CI, 93–232) in 2021. Similarly, the rate per 100,000 components transfused was lower in 2021 for life-threatening reactions, with 0.98 (95% CI, 0.56–1.39) reactions per 100,000 components transfused in 2021 and 2.7 reactions per 100,000 components transfused in 2019.

4 | DISCUSSION

Continual monitoring of the blood supply is crucial for assessing its safety and adequacy, as well as for emergency preparedness and planning. This report provides an analysis of nationally representative data related to blood collection, processing, and use as reported to the 2021 NBCUS.

4.1 | Donor characteristics

Data from previous NBCUS surveys have demonstrated a persistent decline in the number of successful blood donations nationally, coupled with a persistent increase in the proportion of older donors.[5,7] Although findings from the 2021 NBCUS suggest the overall number of successful blood donations in the United States has stabilized (increasing 4.8% between 2019 and 2021), similar trends by age group continue to be observed. During 2021, the number of donations among persons aged 15–24 years continued to decrease while donations among persons aged ≥65 years continued to increase (by 40.7% between 2019 and 2021), further supporting the notion that the donor population base is aging.[5,16] In previous NBCUS surveys, persons aged 25–64 years were combined into one stratum and, in 2019, accounted for 63.2% of successful blood donations.[5,7] For the 2021 survey, this stratum was further divided into persons aged 25–44 years and persons aged 45–64 years, to provide additional granularity. During 2021, there was a 14.1% increase in the number of successful donations from donors aged 25–64 years (68.8% of successful donations), with most of these donations coming from donors aged 45–64 years (42.0% of total successful donations). The stratum of donors aged 65 years and older was also subdivided in 2021 into those aged 65–74 and those aged 75 years and older. Trends within these narrower strata will be monitored over time.

While the safety and efficacy of blood donations from older donors is comparable to that of younger donors,[17–19] the concern is that older donors will eventually become too medically frail to donate or will transition from the donor to the recipient side of the blood supply equation.[5,16] Because younger donors are thus needed to replace the aging donor population, past efforts had focused on recruiting younger first-time donors (aged <20 years), although, based on general population demographics, donors aged 25–45 years are notably underrepresented.[18] Consequently, an increase in donors aged <20 years was seen in the United States during 2002–2015.[5,7,20,21] However, this increase was followed by a decline in younger donors, observed in 2017, 2019, and now 2021.[5,7] Additionally, from 2019 to 2021, the number of first-time allogenic blood donors (who made up 26.3% of the total allogeneic blood donors in 2021) decreased, with 22.3% fewer first-time allogeneic donors in 2021. This is important because first-time donors are often young adults.[18] Both of these trends could reflect a reversal in recruitment practices, as policymakers and blood collectors move away from targeting the youngest donors due to concerns that adolescents and young adults are at increased risk for adverse events related to blood donation.[22,23] In addition to syncope-related injuries and other phlebotomy-related reactions, young donors are at increased risk for iron deficiency in the setting of frequent blood donation.[22,24,25] Further, blood drives at schools decreased sharply when schools took precautions to mitigate transmission of SARS-CoV-2 during the COVID-19 pandemic,[26] which could help explain the steep declines seen during 2021 among donors aged 16–18 years (decrease of 60.7% from 2019) and first-time donors (decrease of 22.3% from 2019).

The number of successful donations from those who identify as a minority race or ethnicity decreased by 35.4% between 2019 and 2021. This is a reversal of the trend seen in 2019, when donations from racial and ethnic minority donors increased.[5] However, the question on donor race and ethnicity was further specified in the

2021 NBCUS, to provide additional granularity on donors' inclusion in the following racial and ethnic groups: Hispanic or Latino, Black or African American, Asian, Native Hawaiian or Pacific Islander, and American Indian or Alaskan Native. Thus, it is not possible to compare trends within these different groups from previous years, and it is possible that, because of the difference in how the question was asked, race and ethnicity data from 2021 were more incomplete than usual. It is notable, however, that donors from each minority group seem to be substantially underrepresented, based on population demographics. For example, U.S. Census data indicate that 13.6% of the US population was Black or African American as of 2022,[27] whereas NBCUS data suggest that only 2.7% of successful blood donations during 2021 were from Black or African American donors. Similar trends were seen among all of the individual racial and ethnic groups included in the 2021 NBCUS, with the exception of Native Hawaiian or Pacific Islander donors—this group makes up 0.3% of the US population and accounted for 0.2% of successful blood donations during 2021.[27] Historically, other data sources have similarly shown an underrepresentation of minority blood donors—from 2006 to 2015, Black or African American donors made up between 4.9% and 5.2% of US blood donors[28,29]—although the 2021 NBCUS estimate of donations from Black or African American donors seems particularly low. Monitoring and ensuring the diversity of the blood supply is important because complications related to mismatched major and minor blood antigens are minimized when transfusion recipients receive blood from donors racially similar to themselves.[30] These trends will continue to be monitored.

4.2 | Donor deferrals and vital signs

Consistent with data from prior NBCUS surveys, women were more frequently deferred from donation than men during 2021, although the number of deferrals among both women and men decreased from 2019 (16.8% decrease for women and 22.4% decrease for men). Similar to previous years, most deferrals during 2021 (51.1%) were due to low hemoglobin or hematocrit.[5,7] The increased frequency of donor deferrals due to low hemoglobin or hematocrit among women can, in part, be attributed to menstruation and pregnancy, which can result in lower hemoglobin and iron stores.[31] One possibility for reducing the frequency of deferrals is the use of iron supplementation among women and frequent donors.[32,33]

An overall decrease in donor deferrals of 18.7% was seen between 2019 and 2021. This appears to be mostly driven by deferrals due to travel or residence, tattoos/piercings/scarring, high-risk behavior restricted to MSM, and high-risk behavior other than MSM. In the 2019 NBCUS, there was an observed increase in donor deferrals due to travel (47.9% increase from 2017) and tattoos/piercings (3.2% increase from 2017).[5] However, 2021 NBCUS results suggest both have since decreased—between 2019 and 2021, donor deferrals due to travel or residence decreased by 84.0%, and those due to tattoos/piercings/scarring decreased by 79.4%. The change in travel-related deferrals could partly be explained by a decrease in travel due to mitigation measures put in place in response to the COVID-19 pandemic. Prior to COVID-19, it was estimated that approximately 20% of the US population traveled abroad annually, with most reported travel occurring more than 28 days from the time of donation (in 2014, only 2.6% of donors reported travel within 28 days of presenting to donate).[34] Although international travel during 2021 rebounded slightly (∼4%) compared to 2020, the overall number of travelers during 2021 was still 72% lower than it had been in 2019.[35,36] Additionally, in response to the COVID-19 pandemic's impacts on the blood supply, the FDA implemented policy changes in April 2020 to reduce the deferral period (from 12 to 3 months) for a number of deferral reasons including tattoos and piercings and travel to malaria-endemic areas (policy for which was made permanent in December 2022).[37,38] Further, travel-related policies also now allow for donations from travelers to malaria-endemic areas if collected using PRT, and the deferral for travel to areas at risk for Creutzfeldt-Jakob Disease or Variant Creutzfeldt-Jakob Disease has been eliminated.[38,39]

Notably, donor deferrals related to MSM were 57.1% lower in 2021 compared to 2019. This is likely due to recent updates to policy and guidance related to blood donation from MSM. What started as a lifetime ban for MSM individuals was changed to a 12-month deferral period in 2015 and shortened further to 3 months in April 2020, in response to the COVID-19 pandemic's impact on the US blood supply.[37] FDA's most recent guidance update, released in May 2023, eliminates time-based blood donor deferral for MSM and replaces it with individual risk-based criteria.[40] Consequently, prospective donors who report a new sexual partner or more than one sexual partner, in addition to engaging in anal sex, in the previous 3 months, will be deferred, regardless of gender.[40] NBCUS will continue to capture data to monitor the impact of donor deferral changes on the nation's blood supply, including changes to MSM deferral policy.

4.3 | Cost

There were notable increases in the costs paid for most blood products between 2019 and 2021. The increases appear to be steeper than in previous years, for unclear reasons, although impacts from the COVID-19 pandemic and observed monthly fluctuations and transient shortages in the blood supply could play a role.[41] Additionally, as the uptake for certain safety interventions increases, the cost burden on hospitals is likely to be higher, since safety interventions like treating platelets with PRT and molecular genotyping of blood donors and recipients are generally more expensive than the alternatives. For example, data from the 2021 NBCUS indicate that pathogen-reduced apheresis platelets are approximately $100 more per unit, within each facility size stratum, than leukoreduced apheresis platelets (range: $70–$111). Thus, increased cost, at least to some degree, is likely to reflect efforts to enhance safety. Additionally, although costs paid for blood products were generally highest for the smallest hospitals, costs paid among the different sized facilities were not vastly different in 2021. Similarly, regional variations were seen in how much hospitals paid per blood product, but there were no discernable geographic patterns. However, because costs can ultimately impact supply, and a stable national blood supply is critical to activities like emergency preparedness planning, data related to blood product costs, supply issues, and safety outcomes will be important to continue monitoring.

4.4 | Uptake of safety interventions

An in-depth analysis of the implementation of blood safety measures in 2017, based on data reported to the 2017 NBCUS, showed that leukoreduction of both whole blood/RBC units and platelets was nearly universal, but the uptake of other blood safety interventions, including screening for *Babesia* and use of platelets subjected to PRT, remained low at the time.[42] The rate of transfusion-associated adverse events that required any diagnostic or therapeutic intervention was slightly lower in 2021 (273.8 reactions per 100,000 components transfused), compared to the rate in 2017 (282 reactions per 100,000 components transfused).[42] Of note, the rate in 2021 was significantly lower than in 2019 (when there were 293.7 reactions per 100,000 components transfused) and, interestingly, the rate of transfusion-associated adverse events was higher in 2019 than in 2017, for unclear reasons. However, the subsequent decrease seen in 2021 is likely due to increased uptake of several blood safety measures. For example, use of platelets subjected to PRT has increased substantially over time. In 2021, 26% of blood collection facilities reported collecting PRT-treated platelets and 52% of hospitals reported transfusing PRT-treated platelets. Both of these values increased from 2019, when 23% of reporting facilities noted collecting PRT-treated platelets and 13% of reporting hospitals reported transfusing PRT-treated platelets. The increasing use of platelets treated with PRT is important because the most common transfusion-transmitted infection (although rare as a group) is sepsis due to bacterial contamination of platelets, which occurs at an estimated rate of 1 in 100,000 to 1 in 10,000 platelet transfusions.[43–46] Historically, the most common transfusion-transmitted infection associated with transfusion of RBCs was babesiosis.[47–49] Importantly, FDA implemented a requirement for *Babesia* screening of blood donations in May 2020.[50] Because *Babesia* screening is now required of all blood collection centers, NBCUS no longer includes a question on its uptake. In 2017, however, of blood collection centers that answered the question on *Babesia* screening ($n = 141$), only 11.3% (16/141) reported doing so.[42]

4.5 | Limitations

The findings of this study are subject to the following limitations. First, the 2021 NBCUS was disseminated during the ongoing COVID-19 pandemic, which may have resulted in a decrease in the hospital response rate compared to previous years. Additionally, the COVID-19 pandemic might have affected data quality in ways that cannot be easily quantified and would not be encapsulated by the confidence intervals presented (e.g., respondents had less time to verify responses). Second, the NBCUS collects data that are self-reported by facilities and, except in rare circumstances, are not independently verified. As in previous years, some blood collection centers were contacted for clarification of reported data when data quality checks revealed potential discrepancies or missing information. Third, imputation and weighting were used to produce national estimates, with associated confidence intervals accounting for any non-responses and missing data. Although this approach allows for the determination of national estimates, individual values (from either collection data or transfusion data) are not constrained. When sample size or reported numbers are small, the estimates can become imprecise resulting in occasional mismatch between collection and transfusion values. Finally, the 2021 NBCUS sampling frame was created using annual inpatient surgeries obtained from the 2019 AHA annual survey database. While this was the most recent annual data available and monthly updates regarding facility openings and closures were consulted in June 2021, changes occurring among hospitals subsequent to June 2021 would not have been captured and may have resulted in inaccurate stratification. In addition, certain hospital types are excluded, which could lead to underestimates of national utilization measures. However, although the potential impact on the findings cannot be quantified, it is likely to be minimal.

5 | CONCLUSION

The ongoing COVID-19 pandemic has likely caused continuing disruptions for blood collection centers and transfusing facilities. Despite these disruptions, data from the 2021 NBCUS suggest a reversal in the trend of declining blood donations.

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CONFLICT OF INTEREST STATEMENT

The authors have disclosed no conflicts of interest.

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