

SUPPLEMENT ARTICLE

Impact of the early coronavirus disease 2019 pandemic on blood utilization in the United States: A time-series analysis of data reported to the National Healthcare Safety Network Hemovigilance Module

Ian Kracalik¹  | Sanjida Mowla^{1,2}  | Louis Katz³ | Melissa Cumming⁴ | Matthew R. P. Sapiano^{1,5}  | Sridhar V. Basavaraju¹

¹Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia, USA

²Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee, USA

³Mississippi Valley Regional Blood Center, Davenport, Iowa, USA

⁴Massachusetts Department of Public Health, Boston, Massachusetts, USA

⁵Lantana Consulting Group, Inc, East Thetford, Vermont, USA

Correspondence

Ian Kracalik, Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, GA, USA.

Email: nrm7@cdc.gov

Abstract

Introduction: The coronavirus disease 2019 (COVID-19) pandemic has disrupted healthcare services worldwide. However, little has been reported regarding the impact on blood utilization. We quantified the impact of COVID-19 on blood utilization and discards among facilities reporting to the National Healthcare Safety Network Hemovigilance Module.

Methods: Facilities continuously reporting data, during January 2016–June 2020, on transfused and discarded blood components, stratified by component type (red blood cells [RBC], platelets, and plasma), were included. Interrupted time-series analysis with generalized estimating equations, adjusting for facility surgical volume and seasonality, was used to quantify changes in blood utilization and discards relative to a Centers for Medicare & Medicaid Services notification delaying nonessential medical procedures (March 2020).

Results: Seventy-two facilities included in the analyses, on average, transfused 44,548 and discarded 2,202 blood components monthly. Following the March 2020 notification and after multivariable adjustment, RBC and platelet utilization declined, -9.9% ($p < .001$) and -13.6% ($p = .014$), respectively. Discards increased for RBCs (30.2% , $p = .047$) and platelets (60.4% , $p = .002$). No statistically significant change in plasma was found. Following these abrupt changes, blood utilization and discards rebounded toward baseline with RBC utilization

Abbreviations: CMS, Centers for Medicare & Medicaid Services; COVID-19, coronavirus disease 2019; HHS, Health and Human Services; NHSN HM, National Healthcare Safety Network Hemovigilance Module; PR-PLT, pathogen reduced platelets; RBC, red blood cell; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

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increasing by 5.7% ($p < .001$), and platelet and RBC discards decreasing $-16.4%$ (<0.001) and $-12.7%$ ($p = .001$), respectively.

Conclusion: Following notification delaying elective surgical procedures, blood utilization declined substantially while blood discards increased, resulting in substantial wastage of blood products. Ongoing and future pandemic response efforts should consider the impact of interventions on blood supply and demand to ensure blood availability.

KEYWORDS

blood center operations, blood management, transfusion service operations

1 | INTRODUCTION

The novel coronavirus disease 2019 (COVID-19) pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has disrupted healthcare services worldwide.¹⁻³ In the United States, COVID-19 was declared a national emergency on March 13, 2020. Shortly thereafter, the Centers for Medicare & Medicaid Services (CMS) issued recommendations to delay all non-essential medical procedures, resulting in the widespread cancellation of surgeries and nearly all elective procedures.⁴ At the same time, healthcare utilization declined substantially as the number of COVID-19 hospitalizations surged. Beginning in March, reports indicated substantial declines in hospital admissions and emergency room visits for non-COVID-19 related conditions,^{5,6} as well as disruptions to healthcare seeking behaviors such as routine vaccinations.⁷

These disruptions have also impacted the blood supply. Because blood has a limited shelf life, the supply must be continually replenished, and demand anticipated. As the potential scope of the pandemic was recognized, U.S. blood collections increased in anticipation of need (unpublished data: Blood Centers of America). However, early in the pandemic, many mobile blood collections and donations were canceled, impacting supply.⁸ One study in Washington reported, during a 2-week period early in the pandemic, a decline in blood donations and inpatient blood utilization.⁸ Other jurisdictions reported $>70%$ reductions in blood collections.⁹ These findings suggest supply constraints were initially offset by corresponding declines in demand due to the cancellation of surgeries and elective procedures in March 2020 as recommended by CMS.^{4,10} However, nonessential medical procedures quickly resumed the following month (April 2020), highlighting the uncertainties of the pandemic.

Monitoring blood utilization in the United States is fragmented and involves several, public and private, organizations. While data collection systems such as the

National Blood Collection and Utilization Survey provide a comprehensive view of blood utilization nationally, this survey is only administered every 2 years.¹¹ Conversely, the National Healthcare Safety Network (NHSN) Hemovigilance Module (HM) created to monitor recipient transfusion-related adverse reactions includes a smaller number of facilities, but provides near real-time monthly reporting of blood components transfused and discarded.¹² Thus, data reported to NHSN HM can be harnessed to provide a snapshot of blood utilization and discards. Given the evolving nature of the COVID-19 pandemic and ongoing challenges maintaining an adequate blood supply, data on impact of interventions on blood utilization and discards are essential. The objective of this study was to quantify the impact of COVID-19 on blood utilization and discards using data reported to the NHSN HM.

2 | METHODS

During January 2016–June 2020, data on monthly transfused blood components (blood utilization) and discarded blood components were obtained from the NHSN HM. Data consisted of monthly blood components transfused and discarded by component type including red blood cells (RBCs), platelets (combined apheresis and whole blood derived), pathogen-reduced apheresis platelets (PR-PLT), and plasma. Analysis was restricted to facilities with complete reporting of the required variables every month from January 2016 to June 2020. Annual inpatient surgical operations were used to group facilities by tercile into low (0–1050 procedures), medium (1051–3663 procedures), and high (≥ 3664 procedures) categories. The mean and 95% confidence interval (CI) were calculated for monthly components transfused and components discarded, surgical volume and Health and Human Services (HHS) Region.

An interrupted time series regression approach was used to quantify the impact of COVID-19 on blood utilization and discards. The month (March 2020) of the CMS

notification, which recommended delaying all nonessential medical procedures and surgeries, was used as the inflection point. March 2020 also coincided with the declaration of a U.S. national emergency. Data were modeled as a time-series of overdispersed counts at each facility by using generalized estimating equations with a negative binomial distribution and a first-order autoregressive (AR-1) correlation structure.^{13,14}

Six separate models were constructed: blood utilization and discards for RBCs, platelets, and plasma. The interrupted time series was defined by two periods: pre-CMS notification (January 2016–February 2020) and post-CMS notification (March 2020–June 2020). Models included an intercept, a secular time trend, a binary variable representing the impact of the March 2020 CMS notification (coded 1 post-CMS-notification, 0 otherwise), and the trend following CMS notification (coded 0 pre-CMS-notification, and sequentially thereafter). Models also included quarter of the year to account for seasonality and tercile of inpatient annual surgical procedures to account for differences in blood utilization by facility size.¹³ The interaction between the binary CMS notification variable and inpatient surgical operations tercile was tested to assess differences in the impact of the CMS notification by facility surgical volume. Results were reported as the relative (percent) change in blood components used and discarded was calculated using the following formula: $(\exp\beta - 1) * 100$. All models were run using SAS v9.4 (SAS Institute, NC).

3 | RESULTS

During January 2016–June 2020, 179 facilities reported data to the NHSN HM. Of these, 107 were excluded because they did not report data every month during the study period. Seventy-two facilities included in the analyses during the study period reported a total of 2,639,854 blood components transfused and 146,494 blood components discarded. These facilities were in 8 of 10 HHS regions with most facilities located in the state of Massachusetts.

3.1 | Blood utilization

Table 1 shows the average monthly number of blood components transfused by the 72 facilities included in the analysis during January 2016–June 2020, by component type, surgical volume, and HHS region. Most transfused components, on average, were RBCs (29,616; 66%). A greater number of components were transfused in high surgical volume facilities (34,825; 78%) than in low and medium surgical volume facilities (Table 1).

The observed number of monthly transfused components, by component type, relative to the CMS

TABLE 1 Transfused blood components among facilities reporting to the National Healthcare Safety Network Hemovigilance Module during January 2016–June 2020

Component type	Monthly units of blood transfused, mean (95% confidence interval)
Red blood cells	29,616 (29,111–30,121)
Platelets	8702 (8496–8909)
Pathogen-reduced-platelets ^a	494 (415–573)
Plasma	6230 (6025–6435)
Annual surgical volume	
Low (0–1050)	1655 (1608–1703)
Medium (1051–3663)	8067 (7887–8247)
High (≥ 3664)	34,825 (34,163–35,488)
Health and Human Services region (%), <i>N</i> = 72	
Region 1 (<i>n</i> = 60)	26,481 (26,048–26,913)
Region 2 (<i>n</i> = 2)	3343 (3257–3429)
Region 3 (<i>n</i> = 1)	6092 (5913–6271)
Region 4 (<i>n</i> = 2)	1413 (1362–1465)
Region 5 (<i>n</i> = 4)	5164 (5053–5275)
Region 6 (<i>n</i> = 1)	7 (5–8)
Region 7 (<i>n</i> = 1)	505 (483–529)
Region 8	-
Region 9 (<i>n</i> = 1)	1543 (1492–1596)
Region 10	-

^aPathogen-reduced apheresis platelets represent a subset of all platelet components used.

notification delaying nonessential medical procedures is shown in Figure 1. Following the CMS notification to delay all nonessential medical services, facilities reporting to NHSN HM showed a decline in transfused components. The lowest monthly number of transfused components occurred in April 2020 for all component types, except PR-platelets. Beginning in May 2020, the blood utilization rebounded toward baseline, although during the study period transfusions did not recover to pre-COVID-19 levels (Figure 1).

3.2 | Blood discards

Table 2 displays the average monthly number of blood components discarded, during January 2016–June 2020, by component type, surgical volume, and HHS region. Most discarded components, on average, were RBCs (43%, 852) and plasma (38%, 772). More components were discarded in high surgical volume facilities (1641; 82%) than in low and medium surgical volume facilities. The ratio of average monthly components discarded to

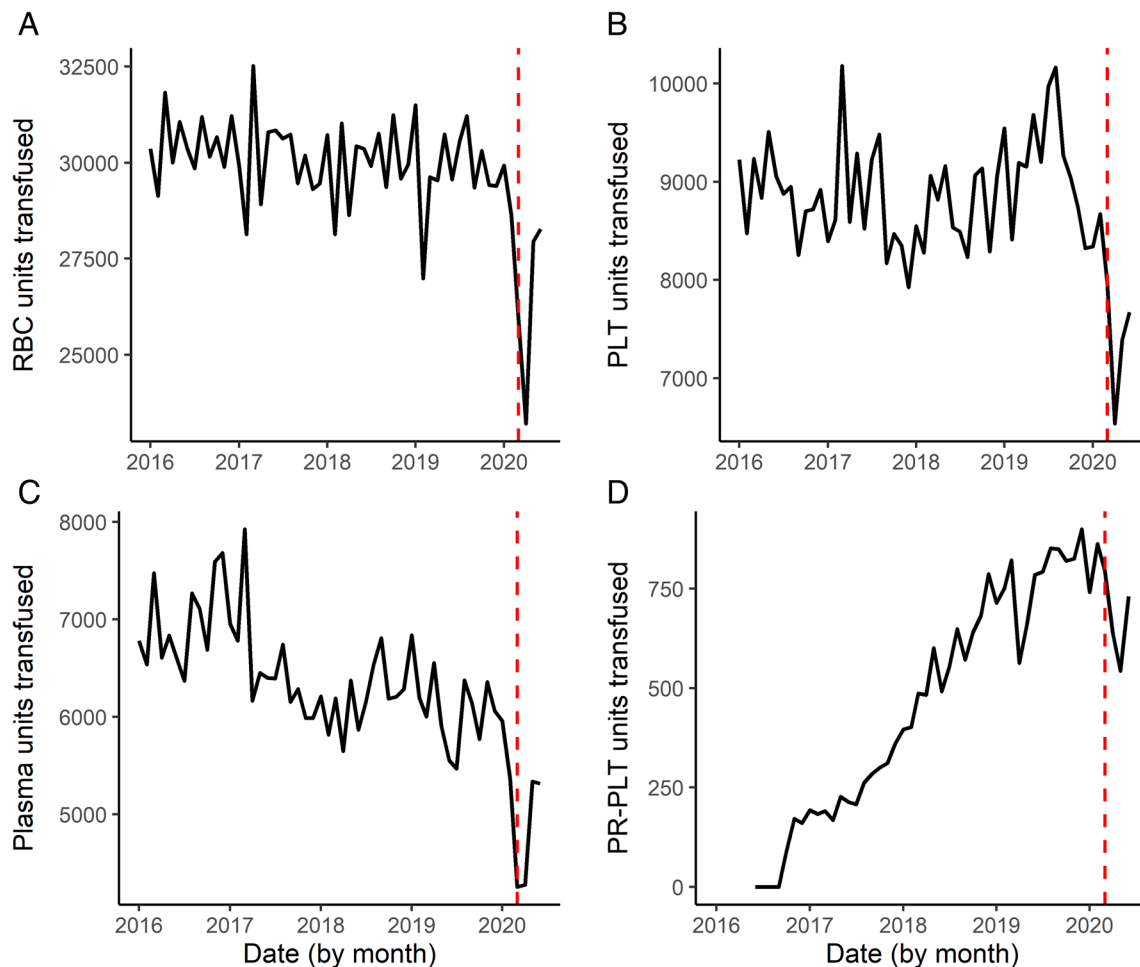


FIGURE 1 Monthly transfused blood components, stratified by type, reported to the National Healthcare Safety Network Hemovigilance Module during January 2016–June 2020. Dotted red line shows date of Centers for Medicare & Medicaid Services notification (March 2020) recommending delaying nonessential medical procedures. PLT, platelets; PRT-PLT, pathogen reduction treated platelet

the average number of components transfused shows a higher proportion of plasma (12%) were discarded than platelets (7%) and RBCs (3%).

The observed monthly number of discards by component type relative to the timing of the CMS recommendation that delayed nonessential surgery is shown in Figure 2. A sharp rise in platelet discards occurred beginning in March and peaked in April 2020 (Figure 2B). Beginning in May 2020, discards declined, trending toward historical baselines for all components.

3.3 | Modeled impact of COVID-19

3.3.1 | Blood utilization

Results of the interrupted time-series analysis with generalized estimating equations adjusting for quarter of the year and surgical volume tercile are shown in Table S1.

Estimated percent changes in blood utilization after adjustment for quarter and surgical volume are shown in Table 3. There was a statistically significant decline in the use of RBCs and platelets (-9.9 [95% CI: $-14.2, -5.5$], $p = <.001$) and (-13.6% [95% CI: $-23.2, -3.0$], p value = $.014$), respectively. Following the CMS notification and abrupt changes in utilization, the trend in RBC use returned toward baseline, increasing by 5.7% (95% CI: $4.1, 7.3$) per month. For blood utilization, there was no statistically significant interaction between annual inpatient surgical volume tercile and the binary CMS notification variable.

3.3.2 | Blood discards

Estimated percent changes in blood discards after adjustment for quarter and surgical volume are shown in Table 4. There was a statistically significant increase

TABLE 2 Discarded blood components among facilities reporting to the National Healthcare Safety Network Hemovigilance Module during January 2016–June 2020

Component type	Monthly units of blood discarded, mean (95% confidence interval)
Red blood cells	852 (829–878)
Platelets	584 (567–601)
Pathogen-reduced-platelets ^a	19 (18)
Plasma	766 (754–778)
Annual surgical volume	
Low (0–1050)	88 (83–94)
Medium (1051–3663)	473 (459–488)
High (≥3664)	1641 (1573–1711)
Health and Human Services region (%) <i>n</i> = 72	
Region 1 (<i>n</i> = 60)	1686 (1613–1742)
Region 2 (<i>n</i> = 2)	41 (34–43)
Region 3 (<i>n</i> = 1)	8 (5–10)
Region 4 (<i>n</i> = 2)	42 (37–45)
Region 5 (<i>n</i> = 4)	249 (233–257)
Region 6 (<i>n</i> = 1)	0
Region 7 (<i>n</i> = 1)	17 (15–19)
Region 8	-
Region 9 (<i>n</i> = 1)	147 (131–157)
Region 10	-

^aPathogen-reduced apheresis platelets represent a subset of all platelet components used.

in discards of RBCs (30.2 [95% CI: .25, 69.1], $p = .047$) and platelets (60.4% [95% CI: 18.9, 116.3], p value = .002), respectively. Following the CMS notification, discards trended towards baseline decreasing-16.4% (95% CI: -24.6, -7.3; $p < .001$) for platelets and -12.7% (-19.4, -5.3, $p = .001$) for RBCs, per month. For blood discards, there was no statistically significant interaction between annual inpatient surgical volume tercile and the binary CMS notification variable.

4 | DISCUSSION

Findings from this analysis of facilities reporting to the NHSN HM during the early U.S. pandemic suggest COVID-19 impacted blood utilization and discards. Consistent with observations of a reduction of healthcare utilization,^{5,6} the use of RBCs and platelets declined, while RBCs and platelets were also discarded in greater numbers than historical trends. While the impact of the pandemic on blood utilization appears to have been

transient, disruptions to transfusion services likely contributed to significant economic impacts on blood collection organizations and transfusing facilities. Given the lability and short shelf life of RBCs and platelets, future pandemic planning, including further potential healthcare responses to the COVID-19 epidemic should anticipate perturbations of both blood supply and demand. These findings highlight the difficulty in planning for disasters of this magnitude. Furthermore, these findings underline the importance of pandemic preparedness in establishing command infrastructure to communicate across all levels of the blood component supply chain to rapidly respond to evolving needs.^{8,10}

Studies have shown public health emergencies and disasters have resulted in disruptions of blood transfusion services. Previous pandemics, including SARS and H1N1 pandemic influenza, were associated with a reduction in blood utilization secondary to declining healthcare utilization.^{15–17} Similar to those previous pandemics, the present findings point to dramatic declines in nonessential surgeries and hospital admissions as the most plausible reasons for the abrupt decline in blood utilization and the associated increase in discards during the early COVID-19 epidemic among facilities in our study.^{5,18} Declines in blood utilization during the COVID-19 pandemic were also reported in other countries, including Singapore (>15%) and Saudi Arabia (>20%).^{19,20} Early in the pandemic, school and workplace closures in the United States were associated with a precipitous drop in the number of donors and blood collection events, which reduced the supply nationally; however, this was offset by declines in blood utilization due to reductions in surgical and nonsurgical medical procedures.^{8,9,20}

Although facility surgical volume was shown to be an indicator for blood utilization, this study found no statistically significant changes in blood utilization or discards by facility surgical volume, suggesting small and large facilities may have been proportionally impacted.¹³ To date, >25 million COVID-19 cases have been identified in the United States; however, data indicate that hospitalized COVID-19 patients require fewer transfusions than other hospitalized patients.^{10,19,21} Although the COVID-19 pandemic resulted in declines in elective and planned medical procedures, blood collection organizations and transfusion services must continue to maintain appropriate blood supplies to ensure adequacy for patients with hematologic malignancies, acute bleeding, and trauma where blood products can be emergently required.⁹ However, ensuring an adequate supply is challenging given the unpredictability of emergent transfusion needs, as well as balancing the possibility of wastage and subsequent adverse economic impacts to blood centers or transfusing facilities.²² Surveillance of blood availability

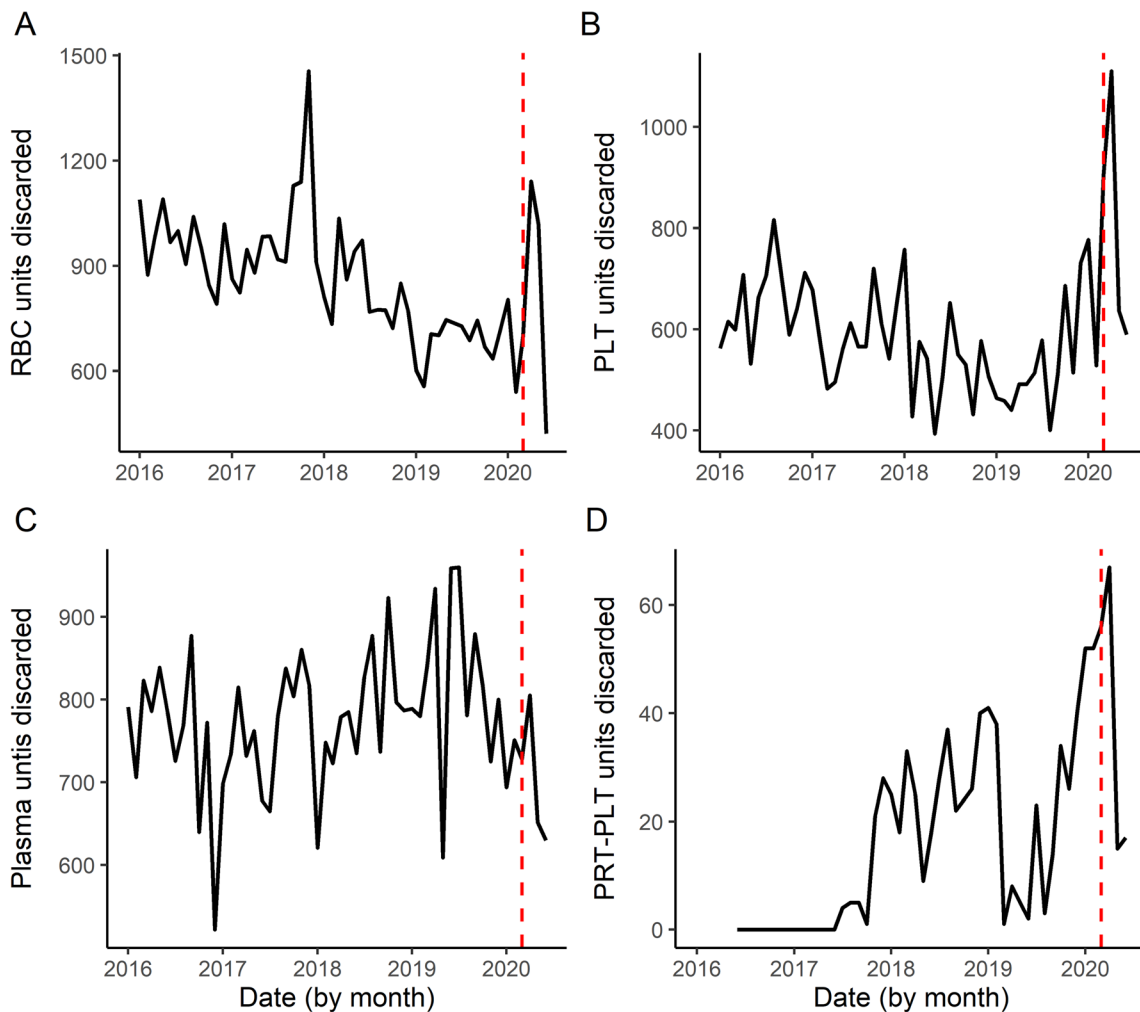


FIGURE 2 Monthly discarded blood components stratified by type, reported to the National Healthcare Safety Network Hemovigilance Module during January 2016–June 2020. Dotted red line shows date of Centers for Medicare & Medicaid Services notification (March 2020) recommending delaying nonessential medical procedures. PLT, platelets; PRT-PLT, pathogen reduction treated platelet

TABLE 3 Estimated change in blood component use following Centers for Medicare & Medicaid Services (CMS) recommendations to delay nonessential medical procedures

	Blood utilization					
	Red blood cells		Platelets		Plasma	
	% change (95% confidence interval [CI])	p value	% change (95% CI)	p value	% change (95% CI)	p value
Post-CMS notification ^a	-9.9 (-14.2, -5.5)	<.001	-13.6 (-23.2, -3.0)	.014	-2.2 (-25.4, 28.3)	.874
Trend after notification	5.7 (4.1, 7.3)	<.001	3.5 (-2.1, 9.4)	.23	10.8 (0.72, 21.9)	.035

^aPost-CMS notification represents the abrupt change relative to the delay nonessential medical procedures.

and use in near real time are facilitated by resources like the NHSN HM, but low participation limits its generalizability. Future research examining the creation of systems like NHSN for monitoring blood availability such as the one proposed by the HHS Advisory

Committee on Blood and Tissue Safety Availability may provide a crucial resource during emergency and non-emergency periods.

These findings are subject to the following limitations. The data reported represent a subset of facilities

TABLE 4 Estimated change in blood component discards following Centers for Medicare & Medicaid Services (CMS) recommendations to delay nonessential medical procedures

	Blood discards					
	Red blood cells		Platelets		Plasma	
	% change (95% confidence interval [CI])	p value	% change (95% CI)	p value	% change (95% CI)	p value
Post-CMS notification ^a	30.2 (.25, 69.1)	.047	60.4 (18.9, 116.3)	.002	1.2 (−24.1, 34.9)	.93
Trend after notification	−12.7 (−19.4, −5.3)	.001	−16.4 (−24.6, −7.3)	<.001	−3.1 (−14.1, 9.4)	.62

^aPost-CMS notification represents the abrupt change relative to the delay nonessential medical procedures.

reporting to the NHSN HM and may not be generalizable to all transfusing facilities in the United States. Additionally, most geographic regions were not represented in the present sample. However, the facilities included in this study still collectively transfused, on average, >500,000 components annually. Similarly, a small number of pediatric facilities were included in these analyses thus limiting the conclusions and generalizability. The data used in this analysis included approximately 4 months following the initial and subsequent CMS recommendations. Further assessments are required to understand the impact on blood utilization and discards more completely. Although the timing of the CMS notification provided a plausible association for the change in blood utilization and discards, other policies and interventions may have also impacted the changes that were observed here. For example, during the pandemic, some facilities and organizations made recommendations to conserve blood.²³ The impact of these policies on the current finding cannot be independently assessed.

5 | CONCLUSION

These findings indicate that in addition to disruptions in healthcare services and blood collection, the initial COVID-19 pandemic period resulted in significant wastage of collected RBCs and platelets. Given the resource intense undertaking of blood donor recruitment, component manufacturing, and implementation of blood safety measures, and the significant cost of blood products, blood discards likely had adverse economic impact on blood collection organizations and transfusing hospitals. Under these economically challenging circumstances, blood collection organizations and transfusing hospitals are still required to ensure availability of blood products in emergencies, even if elective and planned procedures and inpatient admissions are suspended. These findings highlight the need for additional planning and preparedness measures to ensure a

safe and adequate blood supply during pandemics such as COVID-19.

ACKNOWLEDGMENTS

The authors thank facilities that participated in the NHSN Hemovigilance Module and reported these data.

CONFLICT OF INTEREST

The authors have disclosed no conflicts of interest.

ORCID

Ian Kracalik  <https://orcid.org/0000-0003-3233-9466>

Sanjida Mowla  <https://orcid.org/0000-0001-9305-9228>

Matthew R. P. Sapiano  <https://orcid.org/0000-0001-6938-6683>

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Kracalik I, Mowla S, Katz L, Cumming M, Sapiano MRP, Basavaraju SV. Impact of the early coronavirus disease 2019 pandemic on blood utilization in the United States: A time-series analysis of data reported to the National Healthcare Safety Network Hemovigilance Module. *Transfusion*. 2021;61:S36–S43. <https://doi.org/10.1111/trf.16451>