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ORIGINAL RESEARCH

Blood conservation strategies at United States hospitals during the COVID-19 pandemic: Findings from a multi-institutional analysis - International Society of Blood Transfusion survey

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Abstract

Background: Due to the coronavirus disease 2019 (COVID-19) pandemic, the transfusion medicine community has experienced unprecedented blood supply shortages since March 2020. As such, numerous changes to everyday practice have occurred with a specific emphasis on blood conservation. We sought to determine the strategies used to mitigate blood shortages and promote blood conservation during the pandemic.

Methods: An anonymous, 37-question survey was developed using Research Electronic Data Capture and distributed via e-mail to transfusion medicine specialists across the US obtained via publicly available databases.

Results: Amongst surveyed [41.1% response rate (51/124 institutions)], 98.0% experienced a product shortage, with the greatest number reporting red blood cell (RBC) shortages (92.0%). This led to 35.3% of institutions altering the composition and/or number of blood product suppliers, including a 100% increase in the number of institutions acquiring blood from organizations that connect hospital transfusion services with blood collection centers (e.g., Blood Buy) compared to before March 2020. Prospective triaging of blood products was the most common blood conservation strategy (68.1%), though 35.4% altered their

RBC exchange or transfusion program for patients receiving chronic RBC transfusion/exchange. As a result of these changes, 78.6% of institutions reported that these changes resulted in a reduction in blood product usage, and 38.1% reported a decrease in product wastage.

Conclusions: Most hospitals experienced the effects of the supply shortage, and many of them implemented blood conserving measures. Conservation strategies were associated with decreased blood utilization and waste, and future studies could evaluate whether these changes persist.

1 | INTRODUCTION

Transient disruptions in the blood supply are commonplace; however, the sustained multifactorial interruptions to both demand for blood as well as supply of blood observed throughout the coronavirus disease (COVID-19) pandemic are without historical precedent. As severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) spread worldwide, the transfusion medicine community initiated conservation plans to proactively address potential prolonged blood shortages, and sought to understand the implications of reductions in elective surgeries and other medical procedures. The literature at the time suggested a number of blood conservation strategies to mitigate the clinical impact of these disruptions to both supply and demand for blood.^{1,2}

Cohn et al. defined the severity of blood shortages from a blood center perspective as: mild, or affecting 25% or less of a supplier's expected inventory; moderate, or affecting 50% of a supplier's expected inventory; and severe, or a 75% or greater reduction of a supplier's expected inventory – any of which may impact hospital blood supply, especially for products that are almost always in limited supply such as blood group O, Rh-negative red blood cells (RBCs).¹ The authors also described numerous possible mitigation efforts, ranging from auditing product orders to canceling procedures based on the severity of the situation.¹ Notably, National Healthcare Safety Network Hemovigilance Module data showed decreased blood product utilization in early 2020 but a trend toward baseline utilization in June 2020, and a single hospital study demonstrated approximately normal usage by the end of the year.^{3,4} However, as of June 2022, blood product utilization is generally lower than pre-pandemic levels but certain products – such as Rh-negative RBCs – remain at below-ideal levels of inventory.⁵ Indeed, in early 2022, the American Red Cross declared the first ever “blood crisis” with the worst blood shortage in more than a decade,⁶ with some blood centers reporting less than a one-day supply of certain blood types.⁷

Evidence has shown that the number of blood donations in the United States (US) was decreasing as of

2019,⁸ which in conjunction with the challenges faced by both donors and blood collection facilities secondary to the COVID-19 pandemic, have contributed to the persistent blood shortages across the US. To address this issue, and attempt to increase the pool of eligible blood donors, certain donor screening measures were relaxed by the Food and Drug Administration in April 2020, and once more in May 2022.^{9–11} While these regulatory changes have come at a crucial juncture, they alone are insufficient to ameliorate the blood crisis. The search for blood conservation techniques has led to a heightened interest in patient blood management (PBM) programs amongst various stakeholders.^{2,12,13} Similarly, a newfound emphasis has been placed on both hospital-based donor centers (HBDC) as well as alternative blood suppliers, such as the cloud-based bidding model employed by BloodBuy,^{14,15} as it may become increasingly difficult for institutions with large blood usage to rely on a single supplier to support their needs.

Given the complex evolution of the US blood supply during the COVID-19 pandemic, we sought to characterize changes in transfusion practice in response to ongoing blood shortages. To assess the impact of the COVID-19 pandemic on blood conservation strategies and transfusion practice in the United States, we performed a multi-institutional survey. We also queried institutions for details regarding patient blood management programs and staffing changes since March 2020.

2 | METHODS

An anonymous 37-question survey (Supplemental material) was constructed using Research Electronic Data Capture (REDCap). The questions were developed by the authors who include transfusion medicine service and blood donation medical directors through an iterative process of consensus over a period of 2 months. The survey was piloted amongst 20 transfusion medicine specialists at 10 different institutions to improve validity and reliability, and feedback obtained was used to enhance the survey content and structure. The questions address

multiple categories, including institution demographics, the composition of blood suppliers, patient blood management programs, strategies to prevent or mitigate blood shortages, hindrances to implementing blood conservation policies, blood transfusion utility protocols, under-transfusion, and medical technologist staffing shortages.

Publicly available email contact information for US-based transfusion medicine specialists, including physicians, nurses, medical laboratory technologists, and specialists in blood banking, was collected via an online search. Sources utilized to obtain contact information included the Association for the Advancement of Blood and Biotherapies (AABB), the Society for the Advancement of Blood Management (SABM), and Pathology Outlines. Additionally, a free language search using key words including “blood bank,” “transfusion medicine,” and “patient blood management,” was utilized to identify healthcare facilities likely to perform blood transfusion procedures. An approximately equal number of institutions from the four US Census-defined regions were included to reduce geographic bias. However, our cohort primarily consisted of large academic medical centers, with this sampling method representing one inherent study limitation. This is because smaller, non-academic hospitals’ medical directors are often not members of AABB, SABM, or other professional organizations, and their institutions are often not hospital members. Thus, email contact information was heavily skewed to large academic institutions across all regions. Individual REDCap survey links were distributed between March 22 and May 24, 2022, to 1 individual at each of the 124 institutions. Up to 6 weekly reminders were sent to non-respondents. These personalized links prevented duplicative responses from the same individual and the same institution. Survey responses were automatically uploaded within the database.

Study data were collected and managed using a secure electronic web-based data capture tool, REDCap, hosted at Yale School of Medicine.^{16,17} This survey was exempt from institutional review board approval as it did not involve human subjects research and did not include any responses containing identifiable private information.

3 | RESULTS

3.1 | Responding institution details

A total of 51 unique institutions responded to the survey (response rate of 41.1%, 51/124). 50 of the 51 respondents were located at an academic/university affiliated hospital, and most respondents’ institutions were large Level I trauma centers that treat both pediatric and adult

patients (Table 1). One respondent did not indicate their institution type or trauma level. Eight responding institutions (15.7%) have a hospital-based blood donation center.

3.2 | Blood product management

Most institutions (98%, 50/51) have experienced a shortage of blood products at some point since March 2020, most commonly RBCs and platelets (Figure 1). 39.2% of responding institutions reported experiencing a nadir in their blood type O RBCs of <1 day supply, while 35.3% reported a nadir of a 1–2 day supply.

Given these significant constraints, 89.4% (42/47) of responding institutions reported that they have implemented various changes to prevent or mitigate blood shortages since March 2020, including both blood bank-specific and institution-wide changes (Figure 2). Notably, two strategies undertaken included canceling or delaying elective procedures (62.5%, 30/48) and altering the RBC exchange or transfusion program for patients undergoing chronic transfusion or exchange therapy (35.4%, 17/48).

Of the approximately 90% of institutions implementing changes to conserve blood, 9.5% (4/42) incorporated policies or procedures to monitor patient outcomes, including monitoring via monthly and quarterly quality improvement and quality and safety meetings, passive reporting, and active surveillance following transfusion via massive transfusion protocols (MTPs).

Notably, 78.6% (33/42) of institutions reported that their changes resulted in a reduction in blood product usage, while 38.1% (16/42) reported that their policies resulted in a reduction in blood product waste.

Prior to March 2020, 60.8% (31/51) had a patient blood management (PBM) in place, which increased to 64.7% (33/51) as of May 2022. Of these PBM programs, 9.1% (3/33) were accredited by the AABB and/or the Joint Commission. PBM certifications issued by SABM were not queried.

3.3 | Blood product acquisition

In the year before March 1, 2020, three of the eight responding institutions with an onsite hospital-based blood donation center supplied 1–25% of RBCs used by the institution, two supplied 26–50%, and three supplied 51–75%. Since March 1, 2020, the proportion of RBCs supplied by onsite HBDCs remained approximately the same at five institutions, while the percentage of RBCs supplied increased at two and decreased at one institution. In the year prior to March 1, 2020, three onsite

TABLE 1 Survey respondent demographics

Institution type	Trauma designation		Beds	Population served		Onsite blood collection establishment	US region ^a	
	No. (%)	Level		No. (%)	Adults (≥ 18 years of age)		No. (%)	No. (%)
Academic medical center/ university hospital	50 (98)	Level I	>900	21 (41)	Adults (≥ 18 years of age)	Yes	8 (16)	Northeast
State, community, or city hospital	0 (0)	Level II	751–900	0 (0)	Pediatrics (<18 years of age)	No	42 (82)	South
Federal government/ military facility	0 (0)	Level III	601–750	14 (27)	Both	Unknown	1 (2)	Midwest
Private, nonprofit	0 (0)	Level IV	451–600	4 (8)	Unknown			West
Private, profit	0 (0)	Level V	301–450	10 (20)				
Other	0 (0)	Not a trauma center	150–300	1 (2)				
Unknown	1 (2)	Unknown	<150	0 (0)				
			Unknown	1 (2)				

^aBased on US Census regions.

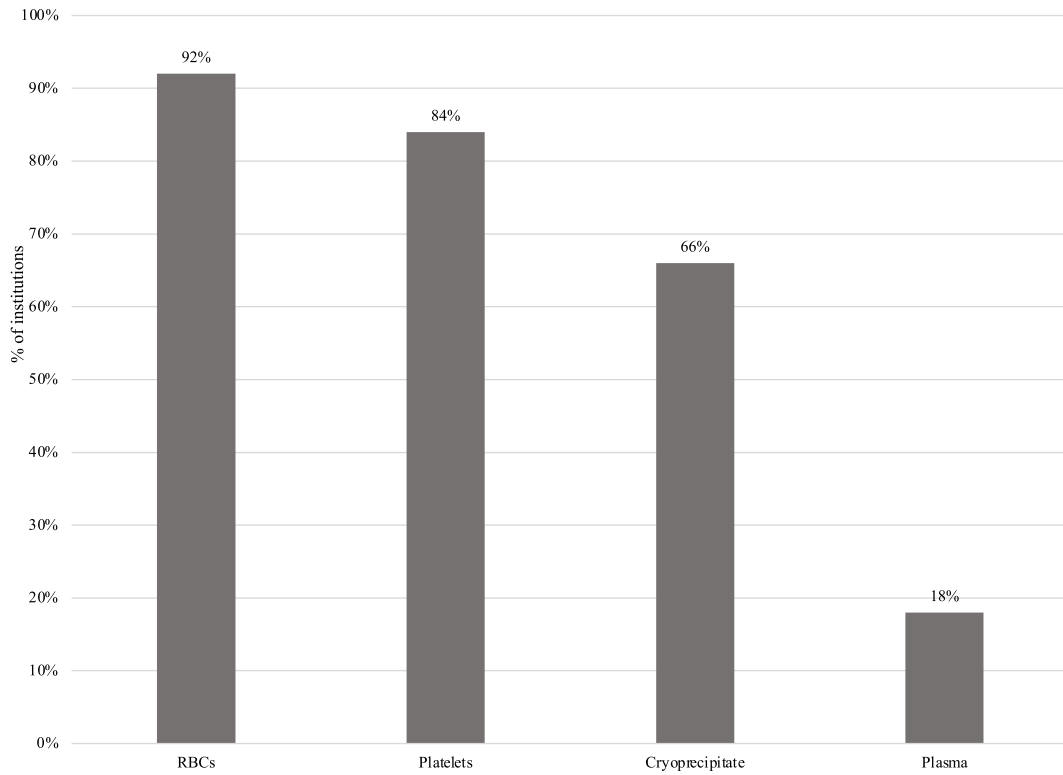


FIGURE 1 Percentage of institutions that have experienced a particular blood product shortage since March 2020

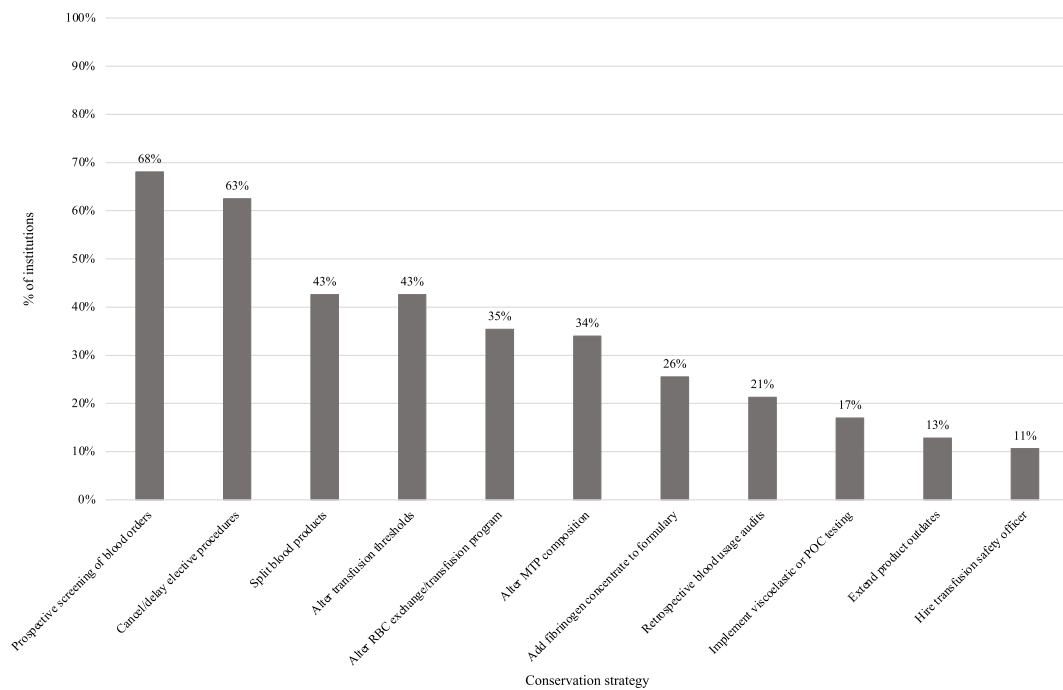


FIGURE 2 Percentage of institutions that implemented a particular blood conservation strategy

HBDCs provided 1–25% of platelet products used by the institution, four provided 26–50%, and one provided 51–75%. Since March 2020, the percentage of platelet

products supplied by the HBDCs remained the same at five of the eight institutions and increased at three institutions.

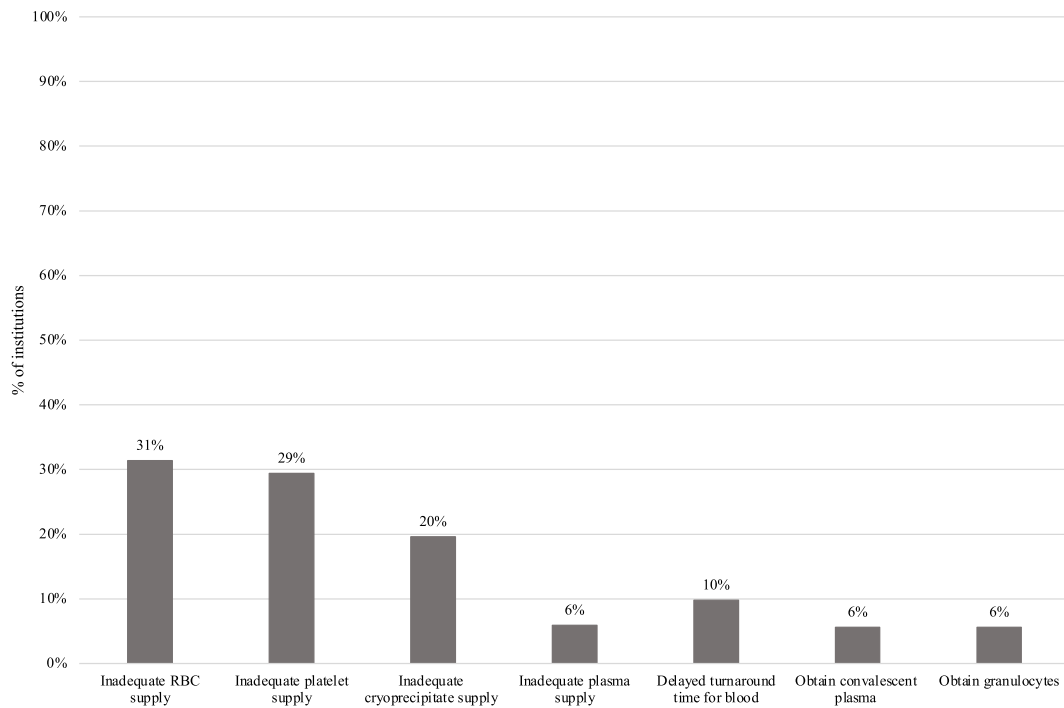


FIGURE 3 Reasons that institutions altered the composition or number of blood product suppliers

As of May 2022, 50 institutions (1 non-response) acquire blood products directly from an external blood supplier, of which 31 receive blood from more than one external collector. Three institutions currently purchase blood from a for-profit specialty supplier (e.g., Secure Transfusion Services), two of which did not prior to March 2020. Similarly, 16 institutions currently acquire blood from organizations that connect hospital transfusion services with a network of blood collection centers (e.g., Blood Buy), a 100% increase (from 8 institutions) compared to prior to March 2020.

Since March 2020, 35.3% of institutions (18/51) have altered the composition or number of blood product suppliers, with the majority (94.4%, 17/18) increasing the number of suppliers. Institutions reported various reasons for altering their blood suppliers (Figure 3), predominantly related to blood supply issues, though one institution reported changing to acquire convalescent plasma, while another sought Apheresis Granulocytes.

3.4 | Blood transfusion futility protocols and undertransfusion

Prior to March 2020, none of the responding institutions had a futility protocol in place, while 23.4% (11/47) had implemented a protocol as of May 2022. A futility protocol is intended to prevent large-volume transfusion in patients where use of blood products would be medically

futile, or transfusion would be unlikely to improve the patient's acute outcome.^{18,19} Given the implications of futility protocols, survey respondents indicated that various individuals are involved in these protocols, and institutions utilize multiple parameters to decide when to enact the protocol (Figure 4).

Of the 51 responding institutions, only 2 (3.9%) have a formal means for assessing undertransfusion, both of which use retrospective blood utilization audits, while 42 (82.4%) do not, 5 (9.8%) were unsure, and 2 (3.9%) did not respond. Several respondents reported that they are skeptical such an entity exists, and therefore do not define or assess patients for undertransfusion. Of the retrospective blood audits, one institution reviews all patients with hemoglobin <7 g/dL, and in the absence of transfusion, vital signs are assessed for evidence of symptomatic anemia. Another institution analyzes inappropriate transfusions of plasma in the setting of undertransfusion/inappropriate dosage (i.e., single unit FFP transfusions). Institutional definitions for undertransfusion include:

- Evidence of a patient having an adverse outcome that could have been avoided with appropriate transfusion.
- The requested dose/volume of blood is not sufficient to reach therapeutic goals in specific situations.
- Failed RBC exchange goal or requirement for more transfusion (e.g., simple transfusion goals not met) that results in delay of care or potential harm.

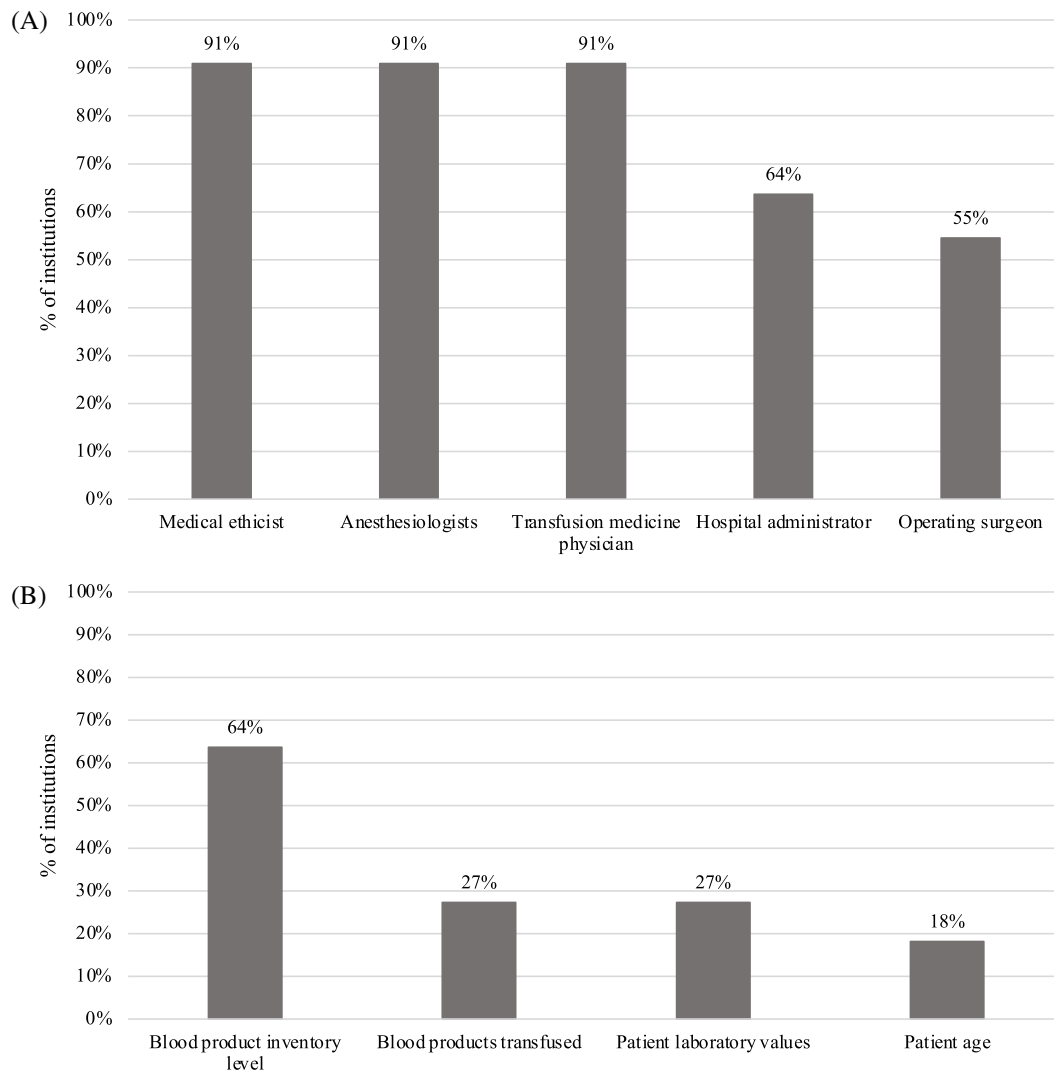


FIGURE 4 Transfusion futility protocols. (A) Proportion of institutions with involvement by specific individuals and (B) proportion of institutions that use specific parameters to initiate the futility protocol

3.5 | Blood bank and medical technologist staffing

The majority (76.5%, 39/51) of institutions reported encountering issues with adequate blood bank staffing, 56.4% (22/39) of whom indicated 5–19% staffing turnover, 28.2% (11/39) saw 20–49% staffing turnover, and one institution reported 50–75% staffing turnover since March 2020.

Numerous factors contributing to staffing issues were suggested, including a lack of applicants (89.7%, 35/39), staff leaving for jobs at other institutions (74.4%, 29/39), staff retiring (46.2%, 18/39), institutional budget constraints (41.0%, 16/39), and a shortage of staff due to illness or quarantine (38.5%, 15/39). Notably, 15.4% (6/39) of institutions reported staffing issues due to a lack of staff secondary to COVID-19 vaccination mandates,

while 2.6% (1/39) reported staff were leaving for jobs that allowed them to work from home.

4 | DISCUSSION

Our group achieved a 41% response rate, higher than recently published literature regarding transfusion medicine experiences during the COVID-19 pandemic.²⁰ Our findings highlight numerous blood conservation strategies in US hospitals, as 98% reported experiencing a blood product shortage during the pandemic. This statistic is likely unsurprising to most practicing transfusion medicine physicians, with high utilization products such as RBCs and cryoprecipitate, as well as high-utilization short shelf-life products such as platelets being the components in short supply.

Most blood-conservation strategies implemented relied on transfusion medicine staff, with prospective triaging the most common. The goal of triaging, including prospective auditing of all blood product orders, consultations, and blood supplier notifications, is to ensure that blood products are administered to patients in a fair and ethical manner and to whom existing evidence indicates that they are most likely to benefit from a blood transfusion. This has previously been shown to lead to a cost reduction and reduced transfusion with prospective monitoring of platelet, cryoprecipitate, and plasma transfusions, although this may not be scalable to all clinical scenarios, especially in small practices.^{19,21} Although some changes, such as delaying outpatient procedures or altering chronic transfusion schedules are likely only practically feasible in the short-term, addition of point-of-care testing to assess transfusion requirements and efficacy or incorporation of fibrinogen concentrate to hospital formularies may have long-term impacts.

Many of the efforts leveraged to both conserve products and reduce waste were largely dependent on blood bank medical technologists and medical laboratory scientists, an already stressed workforce. This additional burden may have contributed to staffing turnover, and/or have been exacerbated by understaffing. These staffing issues are of particular interest and likely reflect stressors of contemporary culture, though survey data show that stress levels and burnout were at exceptionally high levels amongst laboratory staff prior to March 2020.²² In the United States, approximately 25 million jobs were vacated in the second half of 2021, and the most recent monthly quit rate from the US Department of Labor Bureau of Labor Statistics was 3.0% in April 2022.^{23,24} The American Society for Clinical Pathology (ASCP), which conducts laboratory staff vacancy surveys every 2 years, recently published results of the 2020 vacancy survey, demonstrating the effects of COVID-19 on laboratory staffing mainly through furloughs, staff departure, and early retirement, while experiencing workload increases.²⁵ Laboratory staff salaries have also been rising, a trend present in 2019 survey data, and in the authors' experiences, this appears to be leading to an exodus in some lower-compensation labs, as supported by our survey finding showing nearly 75% of separating staff moving to other institutions.²² Laboratory personnel undoubtedly have similar societal pressures such as caring for children or taking time off for quarantine, which may make at-home career opportunities more attractive, though as evidenced by our survey results, there may be limited work-from-home options for this workforce.²⁶ Additionally, one of the notable findings from our results was that 15% of institutions encountered staffing issues secondary to COVID-19 vaccination mandates, a phenomenon that has previously been studied.²⁷⁻²⁹

While the number of institutions with PBM programs remained steady, the total number of accredited PBM programs remains low, suggesting a lag in accreditation and/or lack of interest, though we specifically queried only those whose programs have been accredited by AABB and/or The Joint Commission, and did not include certifications issued by SABM in our analysis. Furthermore, we acknowledge that while the benefits of PBM certification are numerous, as it involves reducing adverse patient outcomes and waste while reducing costs, the process of obtaining and maintaining PBM certification is not without challenges.³⁰ These include acquisition of support from hospital leadership, implementing the necessary resources, provision of continuous education and quality assurance, and significant upfront costs.³⁰ On the other hand, the number of transfusion safety officers increased, suggesting that this position may be easier to implement and may have been considered more likely to have a more immediate impact on blood auditing. However, given the significant number of institutions that reported decreased blood usage and decreased wastage, hospital administrators may be amenable to implementing formal PBM programs in the coming years.

As blood is a finite resource, the means of blood component acquisition appear to have changed significantly in the past 2 years. Hospitals in urban settings may have access to multiple blood suppliers, although we were unable to specifically assess whether the need for additional products or specific components such as COVID-19 convalescent plasma may have driven hospitals to obtain products from outside of their immediate region. Specifically, BloodBuy, a for-profit blood product marketplace, has shown a 100% increase in utilization amongst our respondents. Thus, pandemic-related shortages drove a change in the blood supply strategy and economy for 8/51 (16%) of respondents, and could herald a larger shift in the blood marketplace in the US. Notably, the number of HBDCs amongst respondents did not change in our study, although the number has steadily declined over the last few decades.¹⁴ Despite the challenges associated with implementing and maintaining a HBDC, the COVID-19 pandemic has highlighted many of their benefits, including their inherent flexibility and control of the local blood supply, allowing hospitals to compensate for unexpected supply decreases from larger organizations.^{14,31} Thus, this realization may contribute to a slowing or potentially reversal of the trend of the decreasing number of HBDCs.

Prior to the COVID-19 pandemic, none of the surveyed hospitals had transfusion futility protocols in place. In patients with non-survivable injuries or bleeding not amenable to surgical intervention, transfusion medicine physicians and other hospital representatives have been forced to intervene in dire inventory scenarios, but

otherwise continue to provide products. In hospitals considering futility protocols, it has been shown that profound acidosis (pH <7.00), elevated lactate (≥ 10 mmol/L) and advanced age (≥ 65 years) were associated with increased mortality for patients undergoing massive transfusion;³² however, there were many outliers in that analysis which prevented a reliable predictive algorithm from being developed, and thus it remains impossible to reliably predict mortality even amongst the massively transfused. As evidenced by our respondents, futility protocols are generally felt to require a group consensus and would optimally include an institution's clinical ethicist as well as other stakeholders who may form a transfusion triage team.^{33,34} The inclusion of transfusion futility protocols in modern practice represents a grim reality of sustained blood shortages.³⁵

In addition, we assessed institutions' interpretation of undertransfusion, as this may be a new concept for many blood bankers. Undertransfusion is of particular importance as it is considered both a transfusion complication and error. In fact, the AABB assembled a group of researchers to define undertransfusion hemovigilance codes in late 2020 which were recently published to increase its recognition.³⁶ Though definitions now exist when blood products are limited, undertransfusion remains difficult to assess outside of a laboratory setting, as health care providers typically make transfusion decisions without blood bank consultation. Moving forward, novel means of assessing undertransfusion may be developed along with implementation of hemovigilance definitions. Furthermore, enhanced awareness of this phenomenon is warranted, as evidenced by the skepticism voiced by many of the survey respondents.

The main limitations of our study are related to the nature of reporting in surveys, which may not reflect actual practice, and the modest response rate; although we do recognize that the response rate was significantly higher than similar surveys that have recently analyzed the transfusion medicine field in the context of COVID-19. To ensure quality of responses and reduce bias, surveyors were able to respond anonymously and were not provided with gifts or other incentives to participate. Therefore, we believe our respondents provided insightful information;³⁷ however, this survey is unlikely to be representative of all blood banks and all hospitals, as large, level I, academic hospitals were over-represented amongst survey respondents. This is presumably secondary to the methods used to obtain contact information, as large academic hospitals may be more likely to publish email contact information, and more likely to have an individual available to respond to the survey, than smaller hospitals. Additional studies are needed to assess how smaller, non-academic institutions have addressed blood product shortages and how effective these strategies have been in these environments. Furthermore, this survey

was US-based, and hospitals in other countries may have vastly different approaches to blood conservation, or may completely lack some of the options available in the US, such as adding or changing blood suppliers (e.g., countries with a single national blood supplier). Some countries may live in a state of permanent shortage or with no national blood supply infrastructure, and perhaps US-based institutions could learn from them about managing such circumstances with aplomb (and they may serve as a cautionary tale for a stable, national system for blood is necessary). Thus, future research comparing blood conservation strategies in the US to other countries could likely be informative.

Based on our survey results, most hospitals experienced blood shortages during the pandemic with the majority utilizing blood conservation strategies. Blood conservation has led to sustained reduction in transfusion and component wastage, and as such, many of these practices may persist even if the blood supply should increase.

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CONFLICT OF INTEREST

Jeremy W. Jacobs has no disclosures and denies any conflicts of interest. Laura D. Stephens has no disclosures and denies any conflicts of interest. Eric A. Gehrie is a consultant to Grifols Diagnostics and reports stock ownership in Refactor Health. Garrett S. Booth denies any conflicts of interest but reports that he has received payments from Grifols Diagnostic Solutions, Inc. that are unrelated to the contents of this submission. Brian D. Adkins has no disclosures and denies any conflicts of interest. Jennifer S. Woo has no disclosures and denies any conflicts of interest. Dawn C. Ward has no disclosures and denies any conflicts of interest. Yara A. Park has no disclosures and denies any conflicts of interest. Matthew S. Karafin denies any conflicts of interest but reports that he is a consultant for Westat, Inc. Elizabeth Abels has no disclosures and denies any conflicts of interest. Elizabeth S. Allen has no disclosures and denies any conflicts of interest.


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SUPPORTING INFORMATION

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

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