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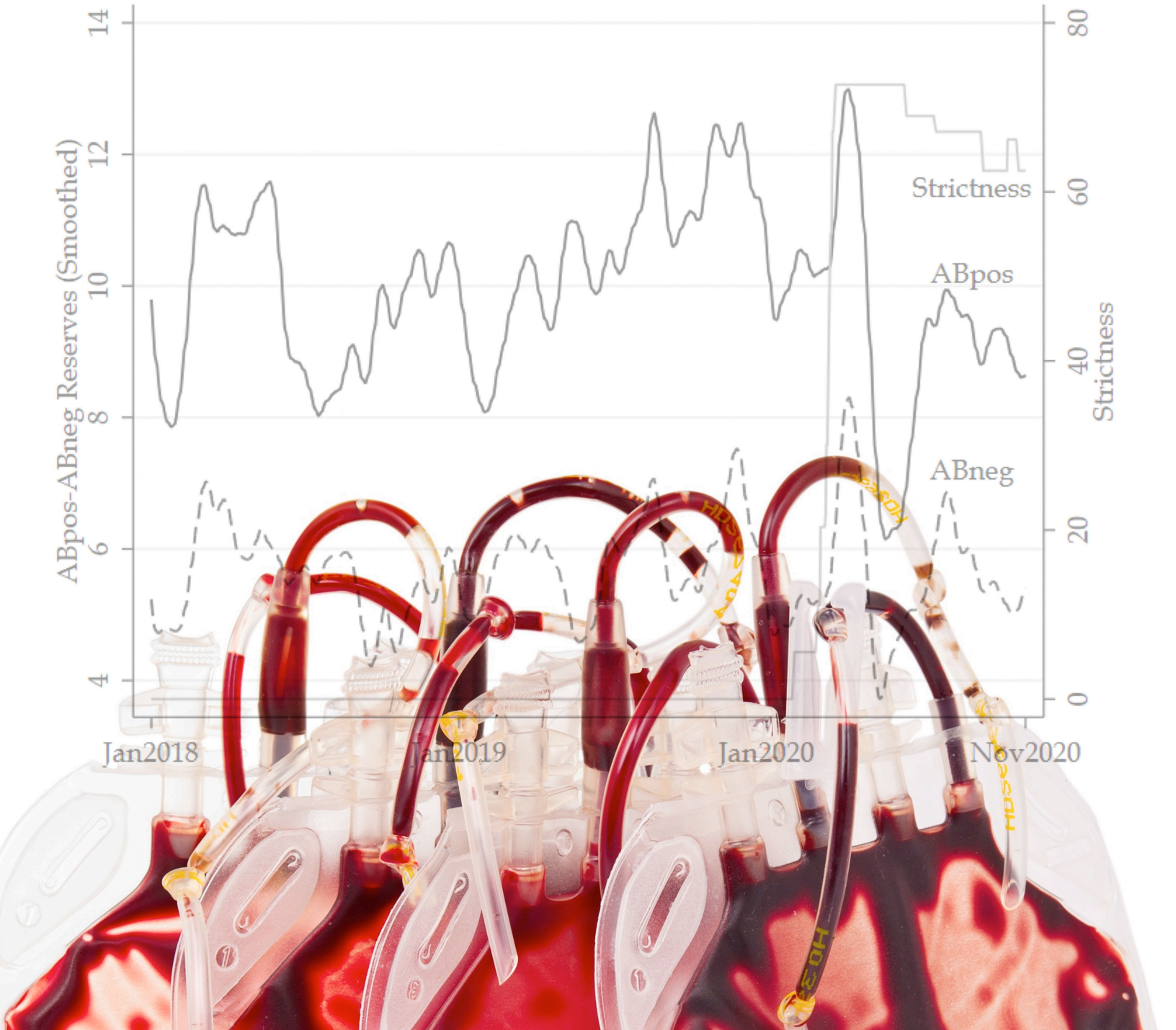

Journal of Blood Service Economics

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Dear Reader:

I would like to welcome you to the inaugural issue of the *Journal of Blood Services Economics.* I hope that you will immediately benefit from the content in this issue, and that it inspires you to contribute to future editions through articles, and/or, letters to the editor.

The *Journal of Blood Services Economics* is a publication of Commonwealth Transfusion Foundation and is not associated with or controlled by any other organization. We do not accept advertising so that our content remains free of even the appearance of bias. All articles in this – as well as future editions – are peer reviewed. We are in the process of establishing a permanent editorial board and welcome any volunteers.

While we have chosen *Economics* as the focus of the journal, we view the discipline to broadly include any topic that affects the economic health of the U.S. blood system. This not only includes the bottom line of blood centers that comprise the U.S. blood system, but also sustainability of the supply as well. After all, blood shortages have negative economic effects on the entire healthcare system.

Commonwealth Transfusion Foundation (CTF) is a private, non-operating foundation headquartered in Richmond, Virginia. It is not affiliated with, nor controlled by any other organization. Rather, CTF is governed by a Board of Directors from across many disciplines including hospital and transfusion management. CTF does not conduct any fund-raising activities and, does not accept contributions. Instead, operations and grants are funded by earnings on its investment portfolio.

In addition to grants, CTF conducts its own exempt Direct Charitable Activities to advance the art and science of transfusion medicine. Many private foundations like CTF are increasingly relying upon Direct Charitable Activities as they provide a high level of assurance that funds are being used to further the charitable purpose of the foundation. This journal is an example of a CTF Direct Charitable Activity.

We invite you to visit Commonwealth Transfusion Foundation's website at www.CTF.life to learn more about CTF.

Regards,

Robert Carden, PhD
Editor in Chief
President and CEO
Commonwealth Transfusion Foundation

COMMENTARY

Why Are Blood Centers Not Celebrating their Success in Meeting the Blood Needs of the United States?

A Response to the U.S. Department of Health and Human Services Adequacy of the National Blood Supply Report 2021

Dr. Dan Sutter, Charles G. Koch Professor of Economics, Troy University.

Introduction

The U.S. Department of Health and Human Services (HHS 2021) recently released a report on the blood industry, *Adequacy of the National Blood Supply*. This report to Congress was mandated by Section 209 of the Pandemic and All-Hazards Preparedness and Advancing Innovation Act of 2019. Prepared by HHS staff and industry experts based on presentations, submitted evidence, interviews, and existing research, the report depicts an industry in dire need of significant Congressional assistance despite outstanding performance to date. These two sentences in the Executive Summary set the tone of the report:

> This loose network of blood centers has served our country well in the past, ensuring the safety and availability of blood needed everyday for more than 6,000 hospitals throughout the country. However, the continued availability of a robust blood supply faces significant threats and challenges in the current environment. (HHS, p.1)

According to this report, an industry which has performed well for decades needs funding from Congress to maintain its donors (Recommendations 3.2 and 3.3), ensure the quality and safety of the blood it supplies (Recommendation 5.1), prepare for potential emergencies (Recommendation 4.2), and develop new products (Recommendation 6.1).

The report reconciles the excellent record of performance to date and looming disaster without significant Congressional assistance through a series of threats or potential disruptions which have yet to befall the industry. The specific threats involve donors, disaster, and data. This paper will review the evidence offered for each in turn.

The report identifies inadequate prices for blood paid by hospitals as the underlying cause of the specific perils (HHS, p.2, 4-5). The low recent prices for blood are a consequence of new technology reducing the amount of blood needed for transfusions, or "appropriate changes in medical practice that reduced blood utilization" (HHS p.4). The reduction has been around 30 percent and appears to be permanent (HHS, Figure 5, p.17), resulting in excess capacity among blood centers. Yet this does not reflect a fundamental flaw in the market or a market failure. Markets respond to decreases in demand by reducing the quantity supplied, so blood centers should deliver less blood (and consequently receive less revenue) and some centers may cease operations entirely (or exit the industry).

The HHS report echoes the warning from Klein et al. (2017) of a "crisis" in an industry with a great performance record. Klein et al. observe that, "blood supplies nationwide have proved remarkably resilient even in the face of train wrecks, terrorist

attacks, and natural disasters." And yet they then contend, "The U.S. blood pipeline is now in danger of disruption," (p.1485) and similarly cite inadequate revenues as the industry's underlying problem.

A car that has run smoothly for years may always fail to start one morning. Satisfactory past performance of a market does not prevent future problems. This paper assesses whether the HHS report has identified fundamental problems or failures in the market for blood or if the feared contingencies are like monsters under the bed. We review the evidence for the three sets of contingencies identified and do not find a challenge the market should not be able to meet. And we find the primary underlying cause, insufficient revenue, to be the expected market response to a decrease in demand. We do not believe that a convincing case for market failure requiring extensive government intervention has been made.

Dwindling Blood Donors

The first threat is an aging population of blood donors. As documented (HHS, Figure 1), the age distribution of blood donors changed between 2001 and 2017 from a modal donor age of 41 to 45 years to 55 to 60 years. As the largest group of donors continues to age, they will become unable to continue to donate. The implied threat is clear: the industry has too few young donors to replace the aging cohort and requires Federal assistance in recruiting new donors.

We find this concern overblown for three reasons. First, recruiting donors is perhaps the core component of the normal operation of blood centers. This concern essentially implies a lack of a core competence on the part of blood centers. Businesses that have survived for years must understand the basics of their industry. An extensive academic literature on the motivations of blood donors exists, and the industry also conducts its own market research. To claim that successful businesses need help with a core function requires a high standard of evidence, one not met here. Indeed, the evidence shows that each of the seven youngest age cohorts in the age distribution presented by HHS (Figure 1) contributed at least 5 percent of 2017 platelet donations. The industry is still attracting younger donors.

Second, the economics of investment offers insight on the "aging" donor population. Recruiting new donors and increasing contributions from existing donors requires resources and yields benefits in the future; in other words, it is an investment. This investment should not be undertaken too long before needed as time is money. Energy economics offers a parallel. As M. A. Adelman repeatedly emphasized, proven reserves are an economic good which must be produced; resources must be expended to prove the existence and quantity of recoverable reserves in an oil field. This investment is never undertaken too far in advance of when the oil will be used (Adelman 1995). Reserves

will not grow too large but will not dwindle away either. The blood supply is currently sufficient and younger donors are being identified. We should not expect significant investment in ramping up donations from younger donors until the large cohort of donors is near retirement.

Third, changes in technology and innovation have potential to reduce the demand for blood products. For example, McKinsey and Company report that self-driving vehicles could eliminate as much as 90% of all automobile accidents in the Unites States (Ramsey, 2015).

Compensated donations in the plasma industry may at some point undermine unpaid donations for whole blood, as HHS suggests. The tradition of blood donation in America goes back to World War II, and was portrayed as a patriotic act (Slonim, Wang and Garbrino 2014). Young people who grow up in an environment where some firms pay for donations may be unwilling to give their blood away for free. The monetary compensation of plasma donors touches on the issues of intrinsic versus extrinsic incentives and monetary versus nonmonetary compensation, which have been extensively researched (Benabou and Tirole 2003, Frey and Oberholzer-Gee 1997, Lacetera et al. 2012). The impact of paid donations on the quantity of quality of blood donations has also been widely investigated (Shaz et al. 2020, Domen 1995, Grabowski and Manning 2016). An examination of these questions is beyond the scope of this paper. We can note, though, that even should monetary payment for whole blood become necessary, this would not spell doom for the blood industry. The U.S. supplies 70 percent of plasma for the world supply and charges prices sufficient to cover the cost of paying donors (and earning profits on invested capital; Slonim, Wang and Garbrino 2014, Shaz et al. 2020). Furthermore, blood donors already receive nonmonetary compensation (gifts) and so the cost of securing voluntary donation is not zero. Even should payment for whole blood prove necessary in the future, this need not cause a crisis for the industry; prices should rise to cover long run cost.

Sustainability in the Face of Disaster

Inadequate preparation for a natural disaster or public health emergency is a second category of vulnerability cited by HHS as requiring government intervention. The report notes:

> Blood transfusions are critical to the American public during both emergency and non-emergency periods. (p.3)
> Natural hazards and emerging infectious diseases continue to pose threats to the availability and safety of the nation's blood supply. (p.12)
> To ensure the U.S. has an adequate blood supply in the case of public

health emergencies, Congressional funding and support is needed. (p.12)

Extreme events always have the potential to cause large increases in the quantity demanded or decreases in quantity supplied, creating temporary shortages. A temporary shortage of blood or blood products and can have serious consequences. This is a frightening prospect, but scary stories not closely tied to facts so not provide a solid basis for policy action. By contrast, the recent study by the Rand Corporation (Mulcahy et al. 2016) explored a variety of potential disaster scenarios and examined three in detail: a natural disaster, a terrorist attack, and a global pandemic. They assessed each as offering a high, medium or low threat to four different elements of the blood industry plus an overall risk score for the system as a whole. Simonetti et al. (2017) offer another example of a careful evaluation of emergency scenarios, and in their simulations the market does not experience shortages. HHS offers primarily concern over the availability of data (see below) and some facts about the supply chain which seemingly imply vulnerability.

HHS also ignores the performance of the blood industry during disasters and emergencies to date. The industry met demand for transfusions in the aftermath of Hurricanes Katrina and Sandy and the Oklahoma City and 9/11 terrorist attacks. Indeed, excessive donations have more frequently been the "problem" than a shortage. And the industry surmounted the enormous challenges of blood-borne pathogens of the HIV and Zika viruses.

The HHS report mentions in several places that the COVID-19 pandemic revealed the blood industry's inherent weaknesses. And yet the industry's response was successful. For example, HHS (Figure 11, p.35) reports blood collections and demand between January and June 2020, allegedly showing a surplus in March and a shortage in April. This is misleading. As Carden, Beard and Ford (2021) explain, a surge in collections occurred after U.S. Surgeon General Jerome Adams publicly appealed for blood donations on March 19; combined with restrictions on elective surgical procedures imposed by hospitals, this drove supplies to "unheard" of levels. The April "shortage" simply involved a rational market response to the surplus, drawing down this stock. Overall Carden, Beard and Ford (2021) find that the industry handled the changing conditions and fluctuations in demand and supply like the cancellation of mobile blood drives quite well.

The industry also met the need for convalescent plasma during the COVID-19 pandemic. HHS acknowledges this success while arguing that it demonstrates a need for "modernization" to allow adoption of "new technology." After stating that the pandemic "highlighted the magnitude of … shortcomings" (p.2), the report states:

A critical example of rapid modernization and innovation was the speed at which the FDA, BARDA, other HHS leaders and blood centers collaborated to produce COVID-19

convalescent plasma. … These innovation and technology responses require novel regulatory approaches that maintain safety and foster expansion of the blood donor base and the blood supply while reducing costs so that investments can be made in new and better blood components. (p.3)

The industry met an unexpected and substantial demand shock for a new blood product during a time of significant economic disruption. This represents a success rather than demonstrating a "critical need for remediation" (p.2).

Data Deficiencies

The inadequacy of data is a third category of potential disaster for the blood industry. As HHS puts it:

> At this time, there is no comprehensive source of data collection for the national blood supply. Such a system is needed to enable monitoring of trends, evolution of population health, and utilization of risk-based decision-making for new rules and regulations. A national data system that monitors the blood supply from vein to vein – or from donor to patient – is critical to our nations preparedness infrastructure and is essential to ensuring the adequacy of the blood supply in the case of public health emergencies. (p.41)

The report recommends that Congress fund the creation of a national data system (Recommendation 4.1).

The paucity of data presents an apparent paradox. The supply of individual components must be harmonized in various locations across the nation. A shortage at any place and time can lead to a life lost. If the quality of data in the industry is so low, how can hospitals and blood centers balance supply and demand so consistently well?

As HHS notes, the U.S. has a free-market blood supply (p.34). The economics of information resolves the paradox and reveals the call for centralized data as a call to centrally direct the industry. As economist Friedrich Hayek explained in his paper "The Use of Knowledge in Society," economic knowledge – or the data plus the information necessary to understand the meaning of numbers – is decentralized in any economy. "The peculiar character of the problem of a rational economic order is determined precisely by the fact that the knowledge of the circumstances of which we must make use never exists in concentrated or integrated form but solely as the dispersed bits of incomplete and frequently contradictory knowledge which all separate individuals possess." (1948, p.77) The fundamental economic challenge, "is a problem of the utilization of knowledge which is not given to anyone in its totality." (1948, p.78). There are two ways economic activity can be coordinated: planning or markets. As Hayek continues,

> Planning in the specific sense in which the term is used in contemporary controversy necessarily means central planning – direction of the whole economic system under one unified plan. Competition, on the other hand, means decentralized planning by many separate persons. (1948, p. 79)

Markets do not attempt to centralize knowledge. Instead decentralized decision making allows market participants to use the knowledge they possess. Markets coordinate activity by providing participants some additional knowledge, most prominently (though not exclusively) through prices. Prices do not convey all information, only enough to enable adjustments. Hayek notes that market participants can conserve on the use of a good when its price rises without understanding why the good is scarcer now than before.

Because knowledge is never centralized in a market, the sum total of knowledge at a time can never be measured. It is impossible to judge the adequacy of this sum directly, as the sum does not exist. The adequacy of knowledge is revealed in performance. "The continuous flow of goods and services is maintained by constant deliberate adjustments, by new dispositions made everyday in light of circumstances not known the day before, by B stepping in when A fails to deliver" (1948, p.83). The blood market unambiguously provides evidence of this coordination. Mulcahy et al. (2016, pp.86-96) mentions the adjustments the industry accomplishes regularly. For instance, blood is frequently shipped between regions to meet needs. Klein et al. (2017) acknowledge the existence of spot markets for blood. Shaz et al. (2020) describe what is effectively a national market for blood and its components. None of this would be possible without hospitals and blood centers knowing exactly which products were needed at each hospital each week and supplies available at blood centers. The numerous small adjustments needed to balance supply and demand would not occur if enough data did not exist in the system.

The U.S. blood market has the information architecture it requires to function. Aggregated national totals for transfusions of different types of blood need not be compiled in real time, or even in any aggregate statistics at all, for the needed blood products to be transfused to save lives. HHS observes this lack of data as a fatal flaw of the market. However, we would question how additional data would create action on the part of the transfusion industry. For example, would real time knowledge about blood products set aside for surgery along with blood products rolling out of manufacturing across the United States change recruitment and manufacturing strategies in the middle of the day? If not, then what is the value of real-time, vein to vein data?

To fill this critical data gap, public and private stakeholders must collaborate to design a comprehensive data infrastructure that ensures that the data supports the needs

of blood centers, hospitals, supply chain manufacturers, accreditors, regulators, payers, and other organizations throughout the blood community in times of public health emergencies. … This system must include implementation of a model for oversight by a public-private partnership, rooted in legislation, which in the event of a disaster with significant impact to the blood supply, *provides blood centers and hospitals with disaster-related governance, coordination, and communication, resources, and financial support to ensure blood transfusion needs are met for the American people*. (pp.41-42, emphasis added)

If the top-down planning of the market is contemplated, then as Hayek argues, information must first be centralized. The data structure may be inadequate for centralized governance, but enough information is processed and transmitted to allow the smooth operation of the existing *market*. Hayek offers a take-away perspective on such criticisms: "The common idea now seems to be that all such knowledge should as a matter of course be ready at the command of everybody, and the reproach of irrationality leveled against the existing economic order is frequently based on the fact that it is not available." (1948, p. 81)

Contracts and Revenue Adequacy

According to the HHS report, the underlying cause of the threats to the blood market examined in the previous sections, as well as other limitations like the lack of a national registry of ineligible donors or little research on safety improvements, is inadequate revenues for blood centers. This is described variously as "the inability to raise prices for services to hospitals," (p.2), a "dramatic loss of revenues, operating margins, and capital required to maintain and replace the current infrastructure and to invest in technology and innovation," (pp.4-5), "blood centers have not realized any significant increases in pricing of blood components, (p.27), and "the current financial approach to reimbursement/payment for blood components is inadequate" (p.66). The report proposes creation of a panel to propose changes to the funding model to increase revenues for blood centers (Recommendation 6.2). Yet given the extensive public-private partnership and Congressional funding the report envisions, and the potential to avoid Congressional appropriations to support blood industry operations if centers receive more revenue for the blood they supply, a more generous funding formula may well then be forced onto hospitals and insurers.

At one level this criticism of the reimbursement contracts is ridiculous. Market transactions are entirely voluntary. No party can compel another to participate, nor can they force acceptance of inadequate compensation on another. Prices in markets and the other terms of a contract emerge from bargaining between buyers and sellers, subject to the voluntary participation of each party. Unacceptable terms cannot be imposed

by a buyer on a seller, or vice versa. Economists know that under conditions of sufficient competition, prices get bid down to the suppliers' cost. And market prices will respond to changes in demand and supply.

As economists not working in the blood industry, we have not tried to negotiate contracts with hospitals. We will not, therefore, try to offer advice on negotiating better deals. But comparative statics in the supply and demand model offer an alternative perspective on low prices and inadequate revenues the HHS report decries. Innovations in transfusion technology have, as noted, reduced the demand for blood significantly, by an estimated by 25 to 40 percent (HHS, Figure 5; Mulcahy 2017). A reduction in demand leads to reductions in price and quantity, and the latter may involve a decrease in the number of firms. Textbooks gloss over how exactly this reduction occurs, but it clearly involves pain for the affected firms. The specificity of capital and investments, a point emphasized in transaction cost economics, will lengthen the adjustment process. Specific capital involves investments of different forms tailored for and largely only of value in one industry. Although many resources are reallocated to more productive uses when a firm goes out of business, specific assets represent largely nonrecoverable investments (Williamson 1985, pp.47-67, Rubin 1990, pp. 4-17). In the blood industry, a blood center will have built a reputation and knowledge of the local market, including the donor population and how best to reach them, financial donors, and the hospitals they serve. These investments cannot be easily redeployed to other types of businesses.

Because of asset specificity, a firm will accept a lower price to remain in operation than required to enter the market and begin operations. This means that the price may need to fall below long run average cost for some time to induce firms to exit the market. Contributing to the length of time (or amount of pain) required to produce this adjustment is a managerial inefficiency noted by Manne (1965): managers resist closing their business and putting themselves out of a job. The not-for-profit status of blood centers may also lengthen the adjustment process. In a for-profit-firm, investors or creditors not receiving an acceptable return on their investment counter managers' reluctance to close a business.

Technology has reduced demand for blood resulting in overcapacity in the industry. A period of prices below cost will be required to reduce industry capacity. Blood center operators will perceive their revenues inadequate, and competition will render efforts to negotiate higher prices fruitless. This does not threaten the long run viability of the industry. Once capacity declines, prices should rebound to cover costs again as we find it highly unlikely that hospitals would allow patients to die for lack of blood for transfusions. Hospitals will pay the price required for the quantity and quality of blood needed for normal operations. Claims that government should invest to ensure adequate reserve surge capacity for some potential emergency should be viewed as

self-serving and ultimately delaying the needed reduction in quantity supplied.

Conclusion

Physicists cannot prove that the Sun will rise tomorrow morning. We must simply wait and see what happens. Economists similarly cannot prove that a market will not break down next month. We can search for sources of recognized market failure and evaluate the track record. When observers wish to contend that a market which has worked well for decades is about to collapse, however, they should be held to a high standard of evidence.

HHS acknowledges the efficient performance of the blood market and yet contends that the market faces a grave danger of failing in the near future. We have critically examined three of the channels of failure offered by the report – donors, disasters, and data – as well as the underlying alleged problem of inadequate revenues. We believe that their evidence fails to meet even a modest standard. Klein et al. (2017) offered a similar criticism of the blood industry in 2017, labeling the situation a "crisis." The sky has not fallen on the industry in the past four years; indeed it proved robust to a major public health emergency with the COVID-19 pandemic. Economic systems inevitably face challenges, and the robustness of the system determines whether the challenges will produce failure. The blood market, like most markets, should be up to the challenges of the future.

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The Fundamental Economics of the Blood Service Industry in the United States: Summarizing the Structural Design and Market Dynamics

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Introduction

There is great complexity in the market for blood in the United States. Yet this intricate exchange is grounded in a basic yet important premise, only humans can manufacture blood. Individuals are the basis of the entire industry's supply base and are referred to simply as donors. These donors are typically individuals who donate whole blood or blood components after being screened, though not all donors of blood products are unpaid. In the plasma-derived medicinal products (PDMPs) industry, the norm is for donors to be compensated, even though the World Health Organization (WHO) has taken a position of strong advocacy to the contrary (Grabowski & Manning, 2016). Additionally, each donor's blood is categorized based on the presence or absence of two antigens ("A" and "B") and an Rh factor protein ("+" or "-") for a total of eight different blood types (American Red Cross, 2019). Other participants in the blood supply industry are blood centers, equipment and expendables suppliers, hospitals, clinicians, and payers (patients, insurance companies, etc.). The primary function of a blood center is to collect and supply blood to the community when and where it is needed. The term "blood center" is used to refer to an entire organization even if the organization has many physical locations, like the American Red Cross. Suppliers in this industry provide the equipment and expendables blood centers need to collect blood, like bags and needles, testing machines, etc., as well as services like blood testing and typing, inventory systems, and logistics services. Hospitals and clinicians acquire, store, match, and distribute blood to patients in need. The final actors are the payers. Patients, as well as government and private insurance groups, compensate hospitals for their services.

Additionally, federal governmental agencies participate in the blood supply system, primarily to ensure the safety of blood products and safety during the donation and transfusion process. The Food and Drug Administration (FDA), Centers for Disease Control (CDC), and the National Institute of Health (NIH) are just a few of the entities under the United States Department of Health and Human Services (DHHS) that have the authority to regulate and provide guidance. This industry also exhibits some self-regulation itself (Simon, 1996), in which organizations such as the American Association of Blood Banks (AABB) have their own set of standards. Blood centers and hospitals can become members through an accreditation process. These various self-regulating entities also work to ensure the safety of all involved uniform standards of quality.

The payment system for blood products is also extraordinarily complex. As a simplified explanation, blood centers are paid by hospitals, which are then paid by patients and/or insurance companies. Insurance companies repay hospitals through a diagnosis-related group (DRGs) payment system in the inpatient setting (Mulcahy, et al., 2016). DRGs are assigned based on diagnosis and procedures, and then hospitals are paid a prospectively-determined, fixed payment for each DRG (Mulcahy, et al., 2016). This

means that hospitals are paid a predetermined sum for every patient with the same DRG, regardless of the specifics of the case, like how much blood was used. Outpatient procedures in which only small amounts of blood products are used are billed differently, with blood and blood products being reimbursed separately and not rolled into a procedure payment (Mulcahy, et al., 2016).

Hospitals pay blood centers under a contract-based consignment model, meaning that the hospitals receive the blood but do not pay the blood center until the unit is used (Mulcahy, et al., 2016). Delivery frequency, payment mechanisms, disposition of unused products, and the blood prices themselves are determined by long-term contracts between hospitals and blood centers (Mulcahy, et al., 2016; Slonim, Wang, & Garbarino, 2014). This means that prices can only change through contract renegotiation (Mulcahy, et al., 2016; Slonim, Wang, & Garbarino, 2014). Though a flexible market price may normally be most desirable to capture the most efficient prices based on current supply and demand forces, the purpose of long-term contracts in the blood market provides benefits to both blood centers and hospitals. For blood centers, there is consistency in a revenue source to cover fixed costs associated with staffing to maintain a healthy supply of volunteer donors. For hospitals, it is the premium paid for the assurance of consistent supply, quality, and service. Within this long-term pricing relationship, there are numerous other functions, which includes a reasonable inventory of blood to support unexpected demand requirements from the hospitals.

As previously mentioned, the blood centers have long-term, mostly three- and five-year contracts with hospitals that establish pricing and supply, among other specifics (Mulcahy, et al., 2016; Slonim, Wang, & Garbarino, 2014). In a normal contract situation, both parties in the deal have an incentive to make sure that the contract is written and enforced efficiently (Rubin, 1993). Sellers want to make sure that contracted prices cover their costs, and buyers want the contracted prices to be as low as possible. The existence of risk within the market adds another element that must be factored into contract negotiations with blood centers currently bearing the risk. If there is an element of risk in a market, someone must bear it; thus, the blood centers do it. Bearing the risk acts as another cost under normal competitive circumstances, thus the bearer of risk is compensated for doing so. For efficient risk-bearing, it is imperative that a blood center carefully evaluates its costs to charge a higher price that covers both the costs related to collecting as well as the costs related to risk-bearing. The higher price for blood gives hospitals an incentive to consider if they should prefer to pay a lower price per unit of blood and bear the risk themselves. If the blood center bears the risk, then one can expect the price of blood to be higher and if the hospital bears the risk, then one should expect the price of blood to be lower. Under a consignment model, the price of blood per unit paid by the hospital should be higher to reflect the fact that the blood center bears the risk.

Though there is some capacity to accommodate unexpected demand, the blood market still experiences issues with supply and demand shocks. Supply shocks affect potential donors or collection sites, with the most common issue being pathogen-related threats that limit the ability of some people to donate blood (Slonim, Wang, & Garbarino, 2014). Anyone with a disease or that may have been exposed to a pathogen is ineligible to donate, which negatively affects the supply of blood. Natural disasters can also affect the supply side if blood centers or collection sites are damaged (Slonim, Wang, & Garbarino, 2014). Demand shocks would be anything that causes a surge of injuries, such as natural disasters or terrorist attacks. The blood system has historically been able to accommodate these shocks because the injury-causing event is often matched with a surge of blood donations from those not directly affected (Mulcahy, et al., 2016; Slonim, Wang, & Garbarino, 2014). Slonim et al. (2014) say that, along with shocks, there is often supply and demand imbalances in this market. As previously noted, donations spike after disasters to fulfill increased demand, but they often spike too high, resulting in hundreds of thousands of units that must be discarded because blood only lasts for twenty-one to thirty-five days (Mulcahy, et al., 2016; Slonim, Wang, & Garbarino, 2014). On the other hand, there are often shortages during the winter and holiday season when people are less interested in donating (Slonim, Wang, & Garbarino, 2014).

The Dominant-Firm Competitive Fringe Model and the Blood Market

Though multifaceted, the blood market, in terms of its functionality and efficiency, has not been given much attention by economists. Though commonly referred to as the "gift of life" for its irreplaceability in its medical application, blood, from an economic standpoint, is a pharmaceutical product. Thus, it is an exchangeable good that, in theory, is distributed through a market and subject to the same economic forces as in all other markets. Yet, upon closer inspection of the blood market, it is clear that this interchange of buyers and sellers is quite unique with long-term and fixed-price contracts, limited buyers, limited blood sellers, a volunteer supply of the industry's raw material (blood), extensive government regulations, numerous supply chain and spatial constraints, limited product shelf life, and many other exchange factors impacting the market.

The blood market essentially operates under the dominant-firm competitive fringe model used in several subsects of economics. This market dynamic has sometimes been referred to as an incomplete monopoly or imperfect competition (Schenzler, Siegfried, & Thweatt, 1992). For a market to fit this model, three assumptions must hold. First, there

is one large firm with a lot of market power, referred to as the dominant firm (Kahai, Kaserman, & Mayo, 1996). In general, if a firm has market power, it means that the firm can manipulate the market price of a good through various actions. The second assumption is the rest of the market is composed of smaller firms, the competitive fringe, that take the dominant firm's price as given (Kahai, Kaserman, & Mayo, 1996). Finally, the product is homogenous (Kahai, Kaserman, & Mayo, 1996).

Taking a closer look at these assumptions, a firm is said to have a lot of market power if it supplies a large portion of the product and therefore has a lot of buyers. If a single firm supplies a large percentage of the buyers, especially relative to competing firms, then decisions that this firm makes affect the market as a whole. The firm with a lot of market power is the dominant firm because its decisions affect the market as a whole; it can raise prices over marginal cost or artificially reduce supply, and the whole market is affected (Schenzler, Siegfried, & Thweatt, 1992). A dominant firm is the one that supplies a large percentage of the product.

The second assumption is that the competitive fringe will take the dominant firm's price as given. Though it sounds odd at first, it makes sense when you consider the three possible scenarios for the smaller firms. Small firms could set their prices higher than the dominant firm, but they would usually lose their buyers to the dominant firm. Alternatively, small firms could set their prices lower than the dominant firm. Even if this is an economically viable option, they have such small market shares that they will not steal away any significant number of buyers. The smaller firms' last option is to follow the pricing scheme of the dominant firm. The other two options are not economically rational, so this is the best choice for the smaller firms. Thus, the competitive fringe will follow the price of the dominant firm because, ultimately, they have no other options.

The World Health Organization (2019) reported that a total of 117.4 million blood donations were collected annually by about 13,000 blood centers in 173 countries. Although the global blood bank market is projected to climb up to $40 billion in 2024 (Market Study Report, 2019), the U.S. blood bank outlook is unpromising. In fact, the U.S. blood revenue dropped to $1.5 billion in 2014 compared to $5 billion before 2008 (Brown K. , 2017). The plunge continues as the number of U.S. blood transfusions has dropped by 33% to 11 million units over the past five years (Market Study Report, 2019).

In the U.S. blood market, The American Red Cross (Red Cross) is the dominant firm, while smaller blood centers comprise the competitive fringe that follows the lead of the dominant firm. The Red Cross was founded in 1881 and is the largest relief agency in the United States (American Red Cross, 2017). The organization established the first civilian blood service in the United States after World War II and remains the industry leader. Its biomedical services include activities associated with the collection, processing, testing, and distribution of whole blood, blood components, and tissue at 36 local blood service

operations, national testing laboratories, a biomedical research facility and related national support functions. In fiscal 2018 (year-end June), the organization generated $3.7 billion in revenue and gains, with its net assets totaling $1.6 billion (American Red Cross, 2018a).

The Red Cross blood program began in 1940 and supplies an estimated 40% of the nation's blood supply (American Red Cross, 2018b). In 2018, the organization provided blood for patients in over 2,500 hospitals and transfusion centers throughout the United States. The organization now works with more than 58,000 blood drive sponsors each year to hold over 145,000 blood drives, providing several locations for people to give blood, including mobile blood donation centers. In 2018, 2.7 million people donated 4.7 million units of blood, providing 6.5 million blood products for patients requiring transfusions.

The remaining 60.0% of the blood supply in the United States is provided through various independent blood centers, with these being nonprofit in terms of operational business structure. These independent operations form the membership of America's Blood Centers (ABC). Currently, ABC has 47 member organizations that vary in size and associated market share. The two largest nonprofit blood centers in ABC are Vitalant and OneBlood.

Vitalant was previously known as Blood Systems Inc. (BSI) and changed its name to Vitalant in 2018. Headquartered in Scottsdale, AZ, the Vitalant network includes 10 blood center brands, a research institute, and a specialty laboratory that serves communities in 40 states. According to its website, the organization identifies with 127 donation centers and hosts around 30,000 mobile blood drives each year (Vitalant, 2019). During the current period, the organization has significantly expanded by adding new blood centers to increase its collection capabilities. In 2014, Vitalant (then BSI) added two new centers; Bonfils Blood Center in Denver and LifeStream in Los Angeles. In 2015, four additional blood centers joined the network: LifeShare in Ohio, Community Blood Services in New Jersey, Lifeblood in Tennessee, and BloodSource in California. In 2016, five more leading blood centers became a part of the organization. Through a series of small and large acquisitions, Vitalant has continued to grow into one of the largest blood service and transfusion providers in the country (Vitalant, 2019). According to the organization's latest available annual report (Vitalant, 2017), Vitalant led a number of different research projects funded by the National Institutes of Health, the US Department of Defense, the Bill and Melinda Gates Foundation and other private funding sources. Most notable research included a large-scale study on the Zika virus and the accrual of 14,000 donors to study the storage stability of red blood cell samples in 2016.

According to its website, OneBlood is a nonprofit organization servicing over 200 hospitals throughout Florida, Georgia, Alabama, and South Carolina (OneBlood, 2019).

This organization currently employs more than 2,000 individuals and operates over 200 buses to collect blood at various partnering institutions such as schools, corporations, and religious organizations. In total, the buses collect 80.0% of the organization's blood supply, with the remaining 20.0% collected at donor centers. OneBlood merged with the Blood Alliance in 2015. That year, it distributed over 1.0 million blood products. In 2016, the organization launched its mobile application, Donor Space. IBISWorld forecasts that OneBlood will generate $339.7 million in revenue in 2019, accounting for 2.9% of the industry's total yearly revenue.

Vitalant and OneBlood, who both have a large market share for the remaining independent blood centers, have partnered with the American Red Cross (the dominant firm) to form Creative Testing Solutions (CTS), which is the largest nonprofit blood donor testing laboratory organization in the United States. According to their website, "in 2019, CTS will test over 10 million donor samples, which is 75.0% of the U.S. blood supply, in six high volume laboratory facilities located in Charlotte, Dallas, Phoenix, Portland, St. Louis and Tampa" (2019). The potential impact of CTS on the overall pricing of the blood market is worthy of closer examination in future research as testing is one of the required fixed costs associated with "manufacturing" each unit of blood. For example, economies of scale could be used to both lower the prices of testing for these owners, who collectively control well over 50% of the blood supply market, while simultaneously generating additional revenue from the testing services offered to other independent blood centers utilizing their services. With control of such a large market share of testing, this could potentially distort the foundations of fair competition under free-market functionality assumptions as testing is a required factor of blood production.

Conclusion

In summary, the longstanding free-market based economic foundations of blood service industry, have proven to be adequate in meeting the needs of United States. Though there are clear market problems associated with the dominant firm model, there have been many proposed ways to address some of the inherent problems in the blood market. However, none of the proposed solutions target the contractual inefficiencies that stem from the market structure. Though some of these solutions are plausible and may correct some small problems, none help to reestablish the competitive and efficiency-driven incentives, and most policy recommendations move the market even further away from the economic gains. For example, Mulcahy et al. (2016) propose four solutions that involve government subsidies. The first proposition is a blood technology supplement plan in which money is given out to hospitals to encourage blood-related technological improvements. The second plan only differs from the first in that the money is given to blood centers. A third possible solution suggests subsidies to hospitals that

use a lot of blood products, such as those with trauma centers. Finally, one solution calls for grants that will go directly to blood centers. However, none of these plans address the problems identified in this section of the research paper, namely the distorted incentives between the blood centers and hospitals that result in less efficient, competitive contractual outcomes. These plans are not ideal because they even further distort the monetary decisions between blood centers and hospitals. These solutions merely add funds that change the profit and loss and efficiency considerations and move them farther away from a free market.

From a firm/blood center level, the predominate non-profit business structure has served the blood supply industry well for many decades. The blood service industry embraces the non-profit mission and still holds closely its history of commitment to community service and providing "the gift of life" to those in need. Also, of importance at the firm level is the ability of blood centers to compete but doing so within an environment of cooperative, collaborative market driven system, which also reinforces the adequacy of the non-profit industry structure.

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Examining Pricing Trends in the Pharmaceutical Industry: How Effective is the Blood Services Industry in Comparison?

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Overview of the Pharmaceutical Industry: Increasing Costs and Profits

In 2017, $3.5 trillion was spent on healthcare nationwide and costs continue to increase. Healthcare accounts for the single largest share of the U.S. economy at nearly 18% of the gross domestic product (GDP). As a key component one sector that is under great scrutiny is the pharmaceutical industry, which is dominated by large pharmaceutical companies. According to a 2019 report from the Kaiser Family Foundation, one in 4 Americans have difficulty paying the cost of their prescription medications. In response to the ever-rising costs of medicine and concurrent rise in profits of large pharmaceuticals, the *Journal of the American Medical Association* (JAMA) published an issue focused on drug pricing on March 3, 2020. According to Ledley, et.al. (2020), from 2000 to 2018, 35 large pharmaceutical companies reported total revenue of $11.5 trillion, gross profit of $8.6 trillion, earnings before interest, taxes, depreciation, and amortization (EPITDA) of $3.7 trillion, and net income of $1.9 trillion. Using regression modeling, the research compared these 35 large pharmaceuticals to 357 S&P 500 companies over the same time period and found that profits of the large pharmaceuticals were significantly greater—such as having a gross profit margin of 76.5% to 37.5% for the other companies. Based on the various opinion pieces and original research from the issue, it becomes clear that the development of new drugs along with keeping generic drugs from competing with their brand name offerings continue to drive profit margins higher.

The average cost for prescription drugs for Americans is approximately $1,200 per person per year - the highest in the world (Langreth, 2019). Even though the lawmakers are trying to pressure pharmaceutical companies to lower prices, 60 drug companies started the year of 2019 by increasing list prices on 300 drugs (Luhby, 2019).

High pharmaceutical prices are largely found in specialty drugs. In 2013, Gilead Sciences debuted its hepatitis drug Sovaldi at $84,000 for a 12-week treatment (Langreth, 2019). Nostrum Pharmaceuticals quadrupled the price of nitrofurantoin, an antibiotic to treat bladder infections, from $474.74 to $2,393 a bottle (Keown, 2018). Most notoriously, Martin Shkreli raised the price for the antiparasitic drug Daraprim in 2015 from $13.5 to $750 per pill - a 5,000% hike (Klitzman, 2018). In the insulin market controlled by three major brands - Humalog, Apidra and Novolog, prices had been increased by nearly 300% from 2002 to 2013 (Prasad, R., 2019; Advisory Board, 2018). An EpiPen used for allergy treatment costs about $1 a dose. However, a two-pack of the pens was priced at $608.61 in 2016, a hike of 500% compared to its price at $93.88 in 2007 (Johnson, 2016b).

Besides the specialty drugs, Americans are also paying many times more for many common prescription drugs than their Canadian counterparts. For example, Brilinta 90mg costs $5.64 per pill in the U.S., whereas it is sold for $1.67 in Canada; Humalog Insulin 100 units/ml is priced at $252.13 per capsule in the U.S., but only $91.30 per capsule

in Canada (Belk & Belk, 2017). Price gouging scandals have ignited strong reactions across the country. In December 2018, U.S. Senator Elizabeth Warren (D-Mass.) introduced the Affordable Drug Manufacturing Act to address the increasing prices of prescription drugs in an attempt to lower the cost of generic drugs through competition, which was spearheaded by the Office of Drug Manufacturing (Warren, 2018). In January 2019, Sen. Bernie Sanders and Reps. Cummings and Ro Khanna introduced legislation to allow the government to negotiate down the prices for Medicare (Lovelace & LaVito, 2019). The debate on this issue intensified when the U.S. Congress held a hearing on prescription drug prices. Executives from the top seven pharmaceutical companies were summoned to the capital on February 26, 2019. Instead of committing themselves to lower the prices, the pharmaceutical companies blamed pharmacy benefit managers (PBMs) and insurers and simply offered their ideas to reform the healthcare rebate program (Advisory Board, 2019).

Brand Name Monopoly

As one of the "most profitable industries" in the U.S., the pharmaceutical industry depends on continued research and development (R&D) efforts, as well as the patent system, to maintain and protect its high profit margins (Axene Health Partners, 2019). The high cost of this R&D has been cited as a major reason to justify high drug prices, and the patents have kept competition at bay. Wolfe (2018) noted that American pharmaceutical companies spent $64.6 billion in R&D in 2016, accounting for 11.2% of total sales, which was far greater than the 4.1% average for all industries. To cover risks associated with failures, the lobbying company PhRMA reported that its member pharmaceutical companies spent a record of $71.4 billion on R&D in 2017, about 21.4% of their total sales (Dunn, 2018). In fact, one single FDA-approved drug may cost as much as $2.6 billion (Ellis, 2019) to develop and bring to market. This number, based on the study by the Tufts University Center for the Study of Drug Development Research, has been used as the benchmark figure, although the methods used were not transparent (Harris, 2017). However, Kesselheim, Avorn, and Sarpatwari (2016) noted that there was no association between R&D costs and product pricing even though R&D input was constantly used as a justification for higher prices. By further investigating this mysterious claim, Prasad and Mailankody (2017) discovered that the development cost of a single cancer drug in 2017 had a mean of $648 million, ranging from $157 million to $1.95 billion and an average of $720 million, ranging from $336 million to $1.1 billion.

In the pharmaceutical industry, patents and exclusivity are two types of protections used to shield competitions. Patents are a property right granted by the United States Patent and Trademark Office anytime during the development of a drug and can encompass a wide range of claims. After new drugs are approved by the FDA, pharma-

ceutical companies can then manufacture and distribute the drugs at high prices with regulatory exclusivity and patents. Those companies will continue to sell the brand name drugs until the patents expire. Exclusivity refers to certain delays and prohibitions on the approval of competitor drugs available under the statute that attach upon approval of a drug or of certain supplements. Normally a patent gives a company a span of 20 years to capitalize on its innovation. Exclusivity varies from 6 months to 7 years (Food and Drug Administration, 2018a). Unfortunately, pharmaceutical companies have found ways to step up their monopoly game through the so-called "evergreening" strategy – applying for new patents on existing drugs and extending their exclusivity (Amin, 2018b). Amin also pointed out that 74 percent of new patents in the past ten years were awarded to drugs already being sold in the market. Out of the 100 best-selling drugs, 80% extended their exclusivity at least once, and 50% extended their patents more than once. Humira, a TNF blocker medicine that can lower the ability of the immune system to fight infections, has been made available to patients since 2002. The drug is covered under 247 patent applications in the U.S., with 50% applied during 2012-2016. Other companies follow suit to prolong their monopolies. Among the 12-top selling drugs, on average, each drug has applied for 125 patents, extending their patent protection to 38 years per drug (Amin, 2018a).

Generic Drugs

According to the Food and Drug Administration (2018b), 90 percent of all U.S. prescriptions filled are for generic drugs. As an equal substitute for its brand-name medicine, a generic drug shares the same characteristics and provides the same medical benefits to patients, though at a much lower cost. Without the need for recovering R&D costs, generic medicines are typically priced 80-85% lower than their branded counterparts. By taking advantage of the lower prices associated with generic drugs, the U.S. healthcare system saved $1.67 trillion from 2007 to 2016 (Food and Drug Administration, 2018c). The generic drug industry sales reached only $104 billion in 2017 (Rowland, 2018).

Even though generic drugs tend to be less expensive, the prices keep climbing, especially when in short supply (Schencker, 2019). The legal and competitive challenges imposed by drug companies make it difficult for generic-drug manufacturers to gain access to reference drug samples for testing and development. By abusing restricted distribution programs such as Risk Evaluation and Mitigation Strategies (REMS), drug companies can also block the purchase of active ingredients to deter the manufacture of generic drugs (Wechsler, 2018). Brill (2014) noted that nearly 40 percent of all new FDA generic drug approvals were subject to REMS, and the cost associated with REMS misuse reached $5.4 billion annually. Furthermore, the FDA (2017) noted that it takes two

generic drugs to reduce the price to 52% of the original brand-name drug, five generic drugs reduce the price to 33%, and 15 generic drugs reduce the price to 13%. Generic drugs are necessary to improve affordability, improve access to healthcare, create fair competition, and improve availability.

The government can do much to make generic drugs even more available. To begin with, the FDA can now improve the cumbersome process of approving new generic drugs under the Generic Drug User Fee Amendments (GDUFA) passed in 2012. Besides approving new generic drugs, the FDA also published a list of off-patent, off-exclusivity drugs without an approved generic in order to promote transparency and encourage competition (2018d). However, the FDA's efforts alone may not be enough to address inadequate competition in the generic drug market. For example, the FDA has approved more than 1,600 generic drug applications since January 2017, but about 43 percent of the approved alternatives are still not available on the market as of January 2019 (Lupkin & Hancock, 2019). As these problems linger, the U.S. government decided to intervene. In February 2019, U.S. senators Amy Klobuchar and Chuck Grassley proposed the bipartisan Creating and Restoring Equal Access to Equivalent Samples (CREATES) Act to allow Americans to import prescription drugs from Canada and to end the practice in which pharmaceutical companies block cheaper generic drugs from entering the market (Klobuchar, 2016). Meanwhile, U.S. Rep. Peter Welch introduced Fair Access for Safe and Timely (FAST) Generics Act to allow Americans to import low-cost insulin from Canada and other countries for people with diabetes (Rathke, 2019).

Generic Drugs Competition and Price-Fixing

Ironically, it is not specialty drugs alone that have acerbated the healthcare system; generic drugs have also played along. Pharmaceutical giants such as Pfizer, Novartis, Allergan, and Mylan manufacture both brand name and generic drugs. Their first action has typically been to block competition by withholding reference drug samples and thereby control the generic drug market. A total of 39 companies were called out by the FDA in May 2018 for such offenses. The above-mentioned big companies all made the list (Meagher, 2018).

Their next action has been to "determine" the drug prices by the generic drug makers. At industry conferences, company-sponsored dinners, cocktail receptions, and golf courses, executives from generic drug companies had been sharing sensitive information and playing their "fair share" scheme in the generic drug market (Rowland, 2018). In 2016, a federal lawsuit was filed by 20 states accusing six generic drug makers of illegal price-fixing. Orchestrated by Heritage Pharmaceuticals and tagged along by five other companies, the prices of an antibiotic and a diabetes medication were inflated and manipulated to reduce competition. One form of doxycycline saw a price jump of

more than 8,000% from $20 per bottle in October 2013 to $1,849 per bottle in April 2014 (Associated Press, 2016; Kodjak, 2016; Thomas, 2016). The price of many other generic drugs has soared in previous years as well. The U.S. Government Accountability Office (GAO) revealed that 45 generic drugs have seen a price jump of 100 percent or more. Alarmingly, a 500-milligram dose of the antibiotic erythromycin was priced at $8.96 in 2015, an increase of 3,600% more than its price of $0.24 in 2010. And the price of the antidepressant Clomipramine HCL rose more than 2,000% in a single year (CBS/AP, 2016).

The fight against the systematic and pervasive collusion continued in 2017 as 45 states and the District of Columbia expanded price-fixing accusations against 18 drug makers and 15 medicines (Freifeld, 2017). The investigation further exploded to include at least 47 states, 16 companies, and 300 drugs in 2018 (Rowland, 2018). Two former executives from Heritage Pharmaceuticals pleaded guilty in January 2017 and agreed to cooperate with a Justice Department criminal probe (Bartz, 2017).

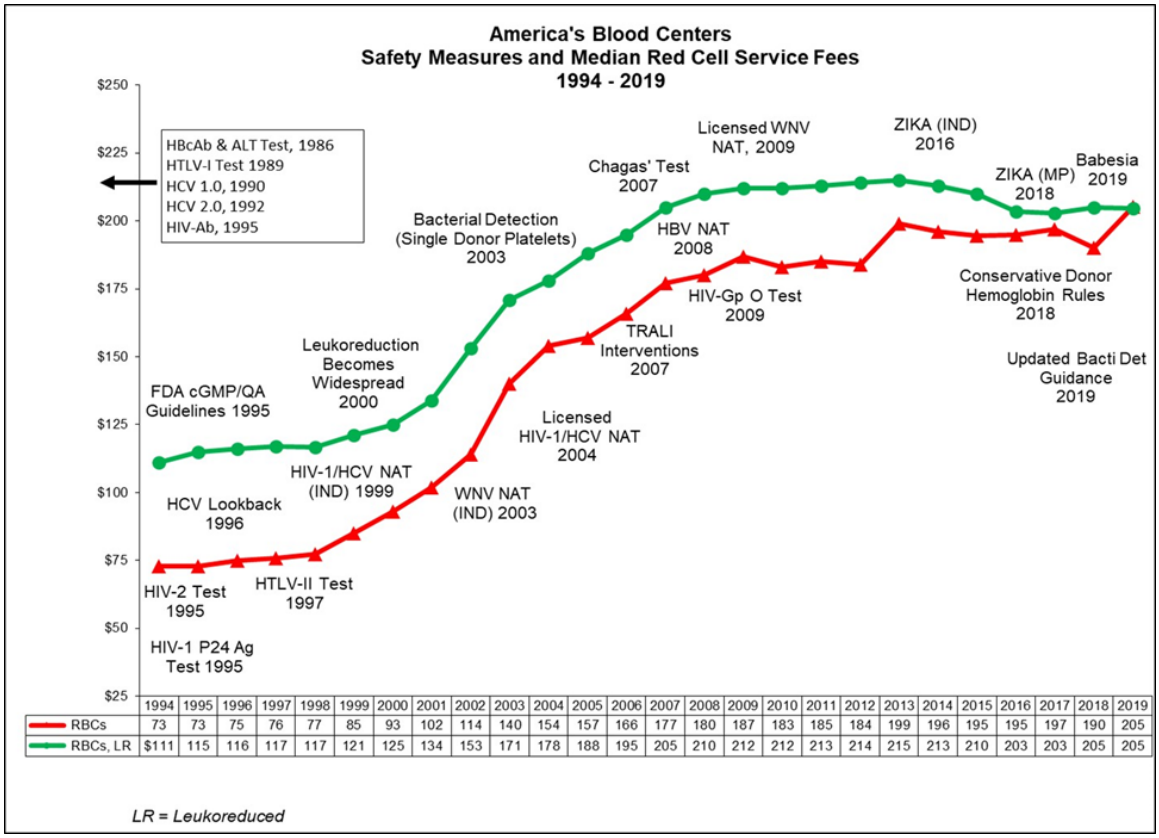
Pricing in the Blood Industry: Meeting Demand and Controlling Costs

As presented in the introductory overview of the economics of the blood service industry, there are inherent concerns about the accuracy of pricing based on unique structural factors such as the dominant position of the American Red Cross and its influence on pricing, increased consolidation of blood centers, producing a pharmaceutical product based purely on volunteer supply, increasing buying power of hospitals due to mergers/acquisitions, greater utilization of group purchasing organizations, blood centers and hospitals utilizing long-term contracts with fixed prices, emergence of sophisticated supply chains allowing blood to move across the country, testing costs, and numerous other market factors. Yet, unlike a standard commodity market, where changes in prices are the signals which indicate changes in demand or changes in the conditions upon which goods can be produced, blood pricing uses contract pricing intended to provide greater stability to both the buyer and seller due to many of the factors mentioned above, with the most important being there is no substitute for blood. But with fixed pricing, blood centers are not able to "float" prices, which most accurately reflect market conditions that would warrant price adjustments based on current supply and demand factors. Besides the role of pricing in the operational efficiency of the overall market, it is important to note that prices influence behaviors and practices of the firm. For example, blood centers do not charge hospitals variable prices based on blood type. Thus, O negative blood, "the universal donor" is the preferred blood because of its flexibility and safety, yet O negative donors are rare at only 7% of the population. Accordingly, based on typical market forces, O negative blood, with its very inelastic demand and limited supply, should be priced higher than A positive blood, which is more readily available (35.7% of

the population) with higher elasticity of demand and limited use. Yet, by not charging variable prices based on market forces, there is no disincentive to the use O negative blood when A positive blood will suffice, thus the market will not impact behavior of the user or pay the blood center a higher price for providing the rare unit.

According to data provided to the research team by America's Blood Centers, utilizing results from the Health and Human Services 2017 National Blood Collection and Utilization Survey (NBCUS), from 1994 to 2019 median RBC service fees have increased from $73 to $205 per RBC and $111 to $205 per RBC leukoreduced. As presented in Figure 1, significant testing requirements to increase safety had a major influence on the price increase. Yet when adjusting the RBC $73 price in 1994 for inflation ($126 in 2019) prices have increased cumulatively by 38.5% in 25 years, an average annual increase of 1.54%. For leukoreduced RBCs, when adjusted for inflation, prices have only increased by 6.5% over the 25-year period, an average increase of .26% annually—basically flat pricing.

Figure 1. RBC Pricing and Safety Measures



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
RBCs	73	73	75	76	77	85	93	102	114	140	154	157	166	177	180	187	183	185	184	199	196	195	195	197	190	205
RBCs, LR	$111	115	116	117	117	121	125	134	153	171	178	188	195	205	210	212	212	213	214	215	213	210	203	203	205	205

Source: America's Blood Centers, 2020

Though inefficiencies do exist in the blood marketplace and the subsequent prices resulting from it, it is clear from the literature that blood centers do continue to provide adequate supply to the U.S. market, even during unforeseen disasters. The ability of the longstanding blood market model has demonstrated time and again It can meet the challenge of crisis and this Is very well presented in the Rand Report in 2016. Yet, many past and recent "state of the Industry" type reports produced on behalf of blood Industry associations (see Sutter and Edwards response in this publication) continue request the need for intervention from government to keep supply available to meet demand during a disaster.

According to the latest 2017 National Blood Collection and Utilization Survey (NBCUS), published in a special issue of *Transfusion* (Volume 60, Issue S2, March 2020), red blood cell (RBC) collections have been on the decline since 2008. During the latest period of examination (2015-2017), collections declined 3.0% along with a 6.1% decrease in RBC transfusions. Also, between 2015 and 2017, the median price paid per unit paid by hospitals decreased $4 from $211 (2015) to $207 (2017) for leukoreduced RBCs and also decreased the same $4 from $204 (2015) to $200 (2017) $4 for nonleukoreduced RBCs. The concluding results from the latest survey suggests the decline in blood collection and use will likely continue. These trends are presented in Table 1.

Table 1. Median Service Fees Collections and Transfusions, 2001–2017

Red Blood Cells (Full Service)

Year	NON-LEUKO-REDUCED	LEUKO-REDUCED	TOTAL COLLECTIONS	AVAILABLE SUPPLY (COLLECTIONS LESS REJECTIONS)	TRANSFUSIONS	OUTDATE
2001	102	134	15,320,000	15,076,000	13,898,000	880,000
2002	114	153				
2003	140	171				
2004	154	178	15,288,000	15,019,000	14,182,000	503,000
2005	157	188				
2006	166	195	16,174,000	16,023,000	14,650,000	401,000
2007	177	205				
2008	180	210	17,286,000	17,159,000	15,014,000	447,000
2009	187	212				
2010	183	212				
2011	185	213	15,721,000	15,619,000	13,785,000	370,000
2012	184	214				
2013	199	215	14,237,000	13,395,000	13,180,000	306,000
2014	196	213				
2015	195	210	12,591,000	12,028,000	11,349,000	600,000
2016	195	203				
2017	197	203	12,211,000	11,545,000	10,654,000	177,000

Source:
HHS NBCUS Bieniel survey https://www.hhs.gov/oidp/topics/blood-tissue-safety/surveys/national-blood-collection-and-utilization-survey/index.html

Conclusion

Based on this review, pharmaceuticals continue to experience price increases in nearly all types of product lines. What is also alarming is the inability to meet demand requirements for many generic drugs, which have very thin margins in comparison to new to market products. Yet while blood centers operate on thin margins, much like generic drugs, and despite decreasing demand and increasing manufacturing costs of blood, the blood service industry has met the regular and emergent needs of the United States--in fact, consistently over supplied the market. Even more impressive, the industry has met demand with very slight price increases over the past 25 years. Though this is an admirable accomplishment and demonstrates the macrolevel market dynamics, this Is all built on the behaviors of the Individual blood centers building the national supply. As such, leadership of blood centers must continue to innovate and manage with free market foundations at the forefront of the organization. Blood center executives must not lose sight of innovation and diversification possibilities to achieve greater economic success and assist in the sustainability of traditional blood collection activities. If blood center managers would embrace the tenants of running a profitable enterprise the way they support delivering the "gift of life", the noble mission of blood centers would only be enhanced and Its sustainability more certain.

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Innovation, Entrepreneurship and Strategic Planning within Non-Profit Blood Centers: Case Analysis through Interviews with Blood Center Executives

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Introduction

To properly evaluate the blood center industry beyond macro-level considerations, it is imperative to understand the operations of the firm and its role in success or failure in meeting market needs. This section of the report seeks to provide a better understanding about essential areas of organizational leadership required to succeed—all within the construct of the not-for-profit structure. The nonprofit business model has served the blood supply industry well for many decades. The blood service industry still holds closely its history of commitment to community service and providing "the gift of life" to those in need. Also, of importance is the ability of blood centers to compete but doing so within an environment of cooperative, collaborative market driven system (Mulcahy, et al., 2016; Kim and Kim, 2016: Salamon, 2012). To be able to better understand the competitive, innovative, and entrepreneurial environments in which blood centers must operate, six chief executives from various sized blood centers were interviewed at length. The questions asked of these CEOs focused on three core areas: innovation, entrepreneurship, and strategic planning (see Appendix A). A summary of the information and insights provided by their responses is below.

Innovation

Each executive was asked to respond to a series of questions regarding innovation in the Blood Supply industry. This included specific innovations, as well as the type of innovation (process, quality, marketing, etc.) that they each feel have been the most influential in improving the stability of the industry, pricing and profit structures, quality of products, etc. Their answers were remarkably similar in many ways, and most described the following specific innovations:

- (Quality) Pathogen detection, which is a method of testing blood donations for specific pathogen antibodies, began with the testing for Hepatitis B contamination in 1970 and has grown to include numerous other pathogens. These innovations have been sequential rather than abrupt and continue to evolve as additional tests for specific pathogens becomes available. That said, it was noted by several CEOs that their view of this type of change has been abrupt at times, especially when the FDA mandates additional testing in response to critical issues in the supply of blood, such as happened recently with additional mandated testing for the Zika virus.
- (Quality) Nucleic acid testing (NAT), which is also a screening technique to reduce transmitted infections through transfusions of donated blood. However, where pathogen detection techniques test for pathogen antibodies, NAT testing works

by detecting the actual DNA material of known bacteria and viruses. This method takes less time and can detect pathogens much sooner after donor exposure than pathogen detection, allowing for both safer products and increased product shelf life.

- (Product/Marketing) Apheresis is a process in which a donation is collected from a donor, one or more component parts are separated out for further processing, and the remaining blood components are returned to the donor's circulation system. This process is key to the success of many plasma collection centers because donors who donate plasma can typically do so much more frequently than those who donate other whole blood. As a result, this innovation has brought about additional challenges to donor management for the blood supply industry.
- (Marketing) The use of mobile blood collection centers, called "bloodmobiles," permits the on-site collection of donated blood products from individuals as schools, churches, companies, etc. This was seen by several of those interviewed as innovative when first introduced. This should be viewed as an abrupt innovation rather than incremental.
- Information System improvements. Specifically, the development of several capabilities was seen as key innovations:
    - (Process/Marketing) Applications for handheld devices that allow donors to enter information prior to visiting for their donation appointment, avoiding paperwork and the need to re-key information into donor databases, are becoming the norm. Of the CEOs interviewed, all indicated they had adopted this innovation.
    - (Process/Marketing/Management) Software to support data analytics regarding donors and potential donors is becoming more prevalent. Specifically, the ability to identify specific trends, clusters, traits, etc., of donors is becoming critical to donor management efforts.
    - (Management) There has been significant recent advancement with regard to Executive Support Systems (ESS) meant for the blood supply industry. Software and device apps have recently been developed that provide real-time information to management teams regarding the status of donation goal attainment, supply levels, hospital needs, and much more. It was noted that, while some organizations have developed dedicated apps for this, others send management teams printable status outputs on demand and/or on a daily basis. However, it was also noted that the industry as a whole is moving toward decision-making based on real-time data, and the need for experts in data analytics who can build usable systems is a real, present, and growing issue.
    - (Management) Blood Ordering Supply System (BOSS) is a system recently developed by hospitals to improve inventory management efforts. This is

similar to the executive support systems mentioned earlier, except that the focus is on maintaining blood supplies and stocks at hospitals rather than on the supply-side management of donors and donation processing activities.

- (Marketing/Management) Improved forecasting methods, which allow blood centers to forecast the routine needs of hospitals more accurately, has recently been improved through the use of improved data analytic algorithms, available software, and limited data sharing with other organizations. However, a number of issues make accurate forecasting challenging, including unforeseen demand increases from certain types of surgeries being performed, normal seasonal variations in donor activities that are still not fully understood, as well as demand surges due to unexpected disaster and emergency response efforts.

- (Quality/Process) Automated handling of blood donations after collection is becoming more prevalent, especially with regard to sample testing. In addition, the CEOs that discussed this in more detail mentioned that these automation practices often add costs that are not recovered through increased prices. Automation is seen as a necessary step to reduce processing time and improve product quality and consistency.
- (Cost reduction) An industry-wide commercial liability insurance company was recently formed, which provides insurance for most organizations in the industry but has recently been working on other types of insurance (fleet vehicle insurance in particular). This has resulted in significant savings for the entire industry.
- The formation of three industry association organizations, each with its own unique function in the industry, was seen by several CEOs as innovative.
  - (Pricing) Group purchasing of expendables (needles, bags, gloves, etc.), which results in standardized and much cheaper costs throughout the industry, is handled by a single trade association, Blood Centers of America.
  - (Regulatory) Policy discussions with government agencies (primarily the FDA) on issues of policy and lobbying activities (primarily at the national level) on issues related to the blood supply industry as a whole, is now mostly handled by a single trade association, America's Blood Centers.
  - (Management) There is an operations and benchmarking group, American Association of Blood Banks, comprised of industry executives who meet regularly to discuss and share best practices in their own organizations, which seems to be the primary mechanism by which most major innovations are diffused throughout the industry. These CEOs also benchmark their organizations against others but are careful to avoid sharing any pricing information due to anti-trust laws. It was noted by one CEO that innovations are typically not shared between blood collection centers in close geographic

proximity to each other because these are seen as more direct competition than those at a distance.

When asked about the types of innovation initiatives originating in their own blood centers now or in the recent past, most executives responded that most innovations do not typically originate from the blood centers themselves but rather from equipment vendors, hospitals, and regulatory bodies (i.e., the FDA). The specific innovation examples they gave have already been mentioned, though one executive did discuss efforts to change FDA policy as an innovation itself. However, this was undertaken by blood centers in the industry through one a trade organization formed specifically for such purposes. Furthermore, they also characterize most of the innovations they have seen as incremental in that they have been slow, steady, and continuous improvements over past practices over a longer period of time. However, there have been a few non-incremental innovations that were adopted with short notice, but it was clear that the primary source of these has been regulatory in nature. All those interviewed pointed to the recent mandate by the FDA that all donated blood must be tested for the Zika virus in 2016, which mandated that all donated blood be tested for the virus before use, as an example.

When asked if blood centers in the blood supply industry have strong R&D divisions, no R&D division at all, or if they pool their resources into a separate but shared R&D organization, most replied that they knew of no R&D function at all in any blood center and that the only R&D functionality they were aware of were in the organizations that supplied their equipment and supplies. One executive, however, replied that New York Blood Center may have an R&D function and that Vitalant, a network of blood centers, has a robust R&D function but, otherwise, the industry competitors generally have no R&D at all. When asked what roles they see the numerous trade associations in the industry having on the innovation process, most replied that there is essentially not one, other than what has been mentioned already in the form of sharing best practices, benchmarking, group purchasing, and policy/legislative lobbying. These trade groups appear to have little, if any, formal R&D functionality related to the blood product deliverables themselves.

When asked about the role that intangible assets (patents, copyrights, etc.) play in the blood supply industry, it was commonly stated that these types of assets essentially don't exist in the industry, with the only exceptions being the patents held by equipment vendors and the trademarks held by larger competitors (namely, the American Red Cross).

Entrepreneurship

When asked if they see the culture of the blood supply industry as more or less risk-averse compared to other healthcare-related industries, all indicated they believed that they were considerably more risk-averse. They also indicated that the pharmaceutical industry, in general, is much more willing to risk large and long-term investments in an attempt to increase future profits. They also believe that the amount of entrepreneurial freedom enjoyed by each CEO in the blood supply industry varies quite a bit among organizations primarily as a result of the makeup of their governing boards. All reported that their profit margins are extremely small and shrinking, with one executive revealing that the typical profit margin for blood products is less than 1%. As a result, many of the organizations in the industry are diversifying into other areas in the hopes of increased profits as a matter of survival. Several of them reported that some organizations are selling blood products at a loss by surviving on the profits of these other endeavors. When asked about the types of diversification their companies, or their competitors, are undertaking, nearly all referred to some blood collection centers diversifying by providing testing services for other companies. One executive gave a few additional examples, which included their company's effort to create a software development company, which provides the company with their software at a much lower cost but also licenses the software out to other companies as another revenue stream. Several executives mentioned organizations that have diversified into cellular therapies (bone marrow and peripheral stem cell processing, donated lymphocyte processing, etc.) as well. Another executive mentioned that they also had a revenue stream from renting extra building space to other non-industry organizations. However, no CEO mentioned any diversification into other healthcare-related industries.

By all accounts, the blood supply industry is heavy with nonprofit organizations, which suggests that they are driven by factors other than financial profit. When asked why this might be the case, all executives were clear. The driving purpose of their existence is a sense of serving the local community, both in terms of what drives donors to donate as well as why the organizations (and their individual employees) do what they do. When discussing this, it became clear that any effort to pool donations with those from outside the local community as a routine business practice (i.e., the "Dairy Farm Model") will, in all likelihood, be detrimental to the willingness of donors to continue donating. Furthermore, the idea of serving the local community permeates most marketing materials, corporate cultures, and even relationships with customers (the donors and hospitals). In most organizations, actual patients whose lives were touched (saved) by donated blood are used in marketing materials. One organization has even gone as far as to be able to identify specific donors that have helped save the lives of specific

patients and bring them together each year, along with their employees, at a banquet. Other than serving the community, no other reasons for existing as a nonprofit were given, though it was also noted that the profit margins across the industry simply cannot support any other business model at this time.

When asked if executives in this industry, as a general rule, also have extensive experience in other healthcare-related industries (hospital supply manufacturing, pharmaceutical manufacturing, patient care, insurance, etc.) or if their experience base is typically limited to the blood supply industry alone, all gave essentially the same response. The majority of the executives either came from non-healthcare industries (i.e., the military, automotive manufacturing, retail, etc.), or they worked their way up through the ranks of organizations in the blood supply industry itself. There were no examples given of any executive coming from any healthcare organizations other than those participating in the blood supply industry.

Strategic Planning

When asked about the major strategic challenges they feel the blood supply industry faces for the future, a number of different answers were common among the CEO responses given, which included:

- Donor related issues
    - There is a declining sense of community in geographic terms, which has resulted in a declining community passion for donating. This seems to be addressed by most organizations with marketing materials rich in the use of local lives saved through locally-donated blood.
    - Donors are increasingly unwilling to spend the time to donate. Converting to paperless donor screening has saved about 10 minutes from each donor's time investment when donating.
    - Recent regulatory changes make it increasingly difficult to collect from certain key donor groups. In particular, these include donors who have recently separated from the military, are foreign nationals, have traveled internationally, or who are among the younger donors (i.e., older teenagers).
    - A number of generational issues are becoming problematic. Key among these is the fact that millennials increasingly demonstrate a "what's in it for me" attitude toward donating. In addition, older generations that historically have been strong donors have aged to the point where they are now

those who need the most donated products.

- One executive pointed out an issue regarding the plasma industry in that many blood centers are simply being "crowded out." In short, the routine business practice in the plasma industry is that the donors are paid for their donations. These donors can also donate much more frequently than whole blood donors. As a result, plasma centers are often established in locations where large numbers of people are willing to donate for small amounts of money, such as near low-income areas, near colleges and universities, etc. The result has been that this is now affecting the blood supply industry because many of their donors are giving plasma instead.

- Survival of the business model
  - In short, because profit margins are almost non-existent, most CEOs interviewed responded similarly in that something will eventually have to change, though they do not know what that change will look like. As a result, there has already been an increase in mergers among smaller blood supply centers. Others are being forced to diversify in order to create revenue streams to permit them to operate their blood collection activities at a loss. Most of these diversification activities, however, are related to other aspects of the blood supply industry, such as testing, software licensing, marketing activities, etc.

  - When asked if they believe that the industry's nonprofit model will continue into the near future, all similarly stated that it probably would. Their reasons were also similar in that they agree that the demand for blood products will not soon disappear and that they believe the government and industry will adjust accordingly. Again, the form of that adjustment is not yet apparent. When asked if, in their opinion, there has been an increase in the number of organizations in the blood supply industry investigating diversifying into related industries, a "not to my knowledge" response was commonly given. All those interviewed were asked if there was an increased possibility that organizations in the industry would change to a for-profit model, and most said they did not believe that is the case. However, while one executive did mention this before the question was asked, the responses of all were similar. There would need to a paradigm change across the entire industry for this to occur. Specifically, the entire industry would need to change nearly simultaneously, and that this would likely result in an upward shift in blood product prices to improve margins.

When asked if their own organizations have considered strategic diversification into other healthcare-related areas not related to the blood supply industry, all said that they had not. Furthermore, they all said that, to the best of their knowledge, no other organization was considering diversifying into any healthcare-related industry not related to

theirs. Furthermore, while all of the executives agree that the blood supply industry's business model is likely unsustainable beyond the near future, none could provide any insight into what changes were coming, though most mentioned the likelihood of government intervention and the possibility of paying donors for donating similar to what the plasma industry is doing. One CEO noted government subsidies to blood centers as one possible part of the solution.

Summary of the Findings from Interviews

While the industry is rich in well-developed nonprofits, this research has revealed that it has some unique traits that will likely limit the generalization of its business model to other industries. These include:

- There is a strong reliance on concepts involving "community" at all levels of the industry, from the time when blood is taken from the donor to when it is used to save the lives of others. Removing this theme from the process would likely be detrimental to the entire industry, especially in terms of donor management.
- The unique characteristics of blood product sales transactions are unlike any other healthcare industry. Specifically, blood products are not sold until used, similar to a consignment model, but pricing is set by negotiated contracts in advance rather than by the manufacturers (i.e., the blood centers). Contracts, therefore, must account not only for the pricing for consumed units of blood products; they must also address issues related to units of blood products that are not used.
- The shelf lives of blood products are extremely short when compared to nearly all other products bought and sold in the healthcare industry, which makes maintaining product stocks challenging. In addition, a number of issues compound the problem:
    - The supply of donors, for a number of reasons, continues to dwindle.
    - The payers are separate industry participants from the suppliers and consumers of the products.
    - A number of different factors create surges in demand for blood products.
- The blood centers themselves produce nearly no profits at all that can be reinvested into R&D or other fixed-cost activities. As a result, leadership in the industry is more risk-averse when it comes to spending what little profits they have. The only significant R&D activity in the industry is that that is performed by the equipment and expendable product manufacturers. Entrepreneurship activities by blood center CEOs are, therefore, typically limited to the blood supply indus-

try itself, or to cost-saving activities in which the chances for success are high.

- Blood centers, with very few exceptions, are typically small nonprofit entities who are too small to have any significant voice when dealing with outside organizations. To address this, which can also be seen as a lack of any notable economies of scale, these organizations have formed a number of separate nonprofit trade associations. While no one blood center has much of a voice, these trade associations allow the blood centers to have a much louder collective voice. This permits the small blood centers to remain responsive to the local needs of the communities that they serve, have significant surge capacity when needed, provide for self-regulation through common standards, but still have strong economies of scale when necessary to deal with other organizations. However, while this model has numerous advantages, it has taken decades to develop and could be difficult, if not impossible, to duplicate in for-profit industries.
- Intangible assets (trademarks, patents, etc.) have almost no role in the blood supply industry. This means that nearly all innovations are unprotected from diffusion across the industry. Indeed, the blood centers themselves have created a trade association that permits them to share their best practices amongst themselves, as well as benchmark themselves against all other blood centers, which would be unheard if the industry was similar to others in which the product manufacturers viewed themselves as direct competitors. That is, while there are certainly some bits of information that are not shared with each other, most of the blood centers are very local (again, the idea of serving their community), so sharing information with competitors is not as much of a problem as it can be in nearly all other healthcare industries.
- The availability of raw materials for manufacturing (i.e., blood donations) is much more dynamic than in other industries where raw materials are simply materials purchased from suppliers and shipped to manufacturers. Donors are real people, and there are a number of issues that increasingly affect their willingness and ability to donate. Coupled with the fact that the raw materials for this industry are not acquired through enforceable contracting, the industry's primary source of raw material is not only in a constant state of change, it is often unpredictable and, therefore, unreliable.
- While most healthcare industries are typically viewed as heavily regulated when compared to non-healthcare industries, the blood supply industry seems to be even more so, especially with regard to donor management. In fact, few other industries are forced to deal with the prospect that each unit of raw material (i.e., a single blood donation) is different from all others, comes from a supplier (i.e., a donor) who is unique from all others, and has the potential to transmit disease to the very customers they are meant to help. In fact, if these differences are not accounted for and appropriate testing performed correctly, people can die. Collectively, these issues are unlike few others in the healthcare industry.

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Appendix A

Interview Questions for CEOs

(Greeting, introduction, etc.) We are conducting research into the successes of the blood supply industry in an effort to determine what factors of success can be applied to other healthcare industries (especially generic drug manufacturing).

A. Regarding Innovation (modifications to existing products, processes, and other phenomena)

1. What innovations in the blood supply industry do you feel have been the most influential in improving the stability of the industry, pricing and profit structures, quality of products, etc.?
2. What types of innovation initiatives do you see blood centers undertaking (now or in the past)? (Examples include innovations to processing techniques, marketing efforts, pricing strategies, organizational structures, etc.)
    a. Do you see these changes as typically incremental (i.e., they build on previous innovations), or do you believe they are usually one-time innovations that only bring temporary advantages?
    b. Do most of the competitors in your industry have strong R&D divisions, no R&D at all, or do they pool their resources into a separate shared R&D organization?
3. What roles do you see the numerous associations and groups in this industry having on the innovation processes within individual organizations?
    a. Are innovations undertaken by one organization in the blood supply industry typically shared with other organizations in the industry?
    b. In your opinion, how strong a role does trade secrets (i.e., patents, copyrights, etc.) play in the blood supply industry compared to other healthcare-related industries?

B. Regarding Entrepreneurship (taking risks in order to increase profits)

1. Do you see the culture of the blood supply industry as more or less risk-averse than other healthcare-related industries?
2. Do the CEOs in your industry typically enjoy the same levels of entrepreneurial freedom that one might find with CEOs in other health-care industries?
3. By most accounts, the blood supply industry is heavy with nonprofit organizations, which suggests that they are driven by factors other than financial profit. Can you provide any insight as to why this might be the case?
4. I note that many executives in your industry participate in or have experience with one or more of these industry associations. How do these relationships typically influence both the industry itself and the organizations they work for?
5. Do these executives, as a general rule, also have extensive experience in other healthcare-related industries (hospital supply manufacturing, pharmaceutical manufacturing, patient care, insurance, etc.), or is their experience base typically limited to the blood supply industry alone?

C. Regarding Strategic Planning in General (i.e., long-term executive planning processes)

1. What major strategic challenges do you see for the blood supply industry as a whole in the future?
2. The blood supply industry has been operating on a nonprofit model that has done very well over the years. Do you believe that this will continue into the foreseeable future?
3. In your opinion, has there been an increase in the number of organizations in the blood supply industry that have been investigating the possibility of diversifying into related industries (i.e., manufacturing or the wholesale supply of hospital expendables, pharmaceuticals, medical equipment, etc.)?
4. Has your organization considered strategic diversification in this manner? (Why or why not?)
5. Are you aware of any organizations in your industry that have considered diversifying into non-blood related products, especially with regard to manufacturing or supplying pharmaceuticals?

(Follow-up and closing) Do you have any other thoughts or insights that might improve our research process? That is, did we overlook anything important? Would it be okay for us to follow-up with you, should we have any additional (brief) questions?

The COVID-19 Pandemic and the U.S. Blood Supply: Revisiting RAND's "Toward a Sustainable Blood Supply in the United States"

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Abstract:

We review the accuracy of the predictions of the RAND Corporation study, *Toward a Sustainable Blood Supply in the United States: An Analysis of the Current System and Alternatives for the Future (2016),* regarding the consequences of a global pandemic for the U.S. blood supply system. We surveyed a large sample of U.S. blood centers, representing around 77% of the blood supply, to solicit information relevant to the areas of concern identified in the RAND analysis. The responses, combined with detailed information on blood reserve stocks of the Blood Centers of America and estimates of the severity of Covid-19 public health measures, allows us to evaluate the accuracy of the RAND predictions. Although several consequences of the Covid-19 pandemic were not foreseen by RAND, most forecasts of pandemic effects on the blood supply chain were accurate, suggesting that the RAND approach could be useful in planning for future pandemics.

The COVID-19 Pandemic and the U.S. Blood Supply: Revisiting RAND's "Toward a Sustainable Blood Supply in the United States"

Introduction

In 2015, the United States Dept of Health and Human Services (HHS) commissioned the RAND Corporation to study the resilience and sustainability of the U.S. blood supply. The resulting study, *Toward a Sustainable Blood Supply in the United States: An Analysis of the Current System and Alternatives for the Future* (2016, hereinafter the "RAND Study"), was both controversial and influential[1]. The study was conducted during a period of profound disruption in the blood industry: changes in medical practice had significantly reduced blood product demand, while consolidation among hospitals weakened the bargaining positions of blood suppliers. The RAND Study was comprehensive, and it included an extensive analysis of the probable effects of three categories of disasters for the performance of the U.S. blood system. The third category of disaster considered by RAND, "Global Pandemic," was identified in the study as potentially posing a profound threat. Along with untold misery, the current Covid-19 pandemic presents us with an opportunity to revisit the RAND analysis and compare the predictions it presented with the reality we now face. Such a comparison is the purpose of this article.

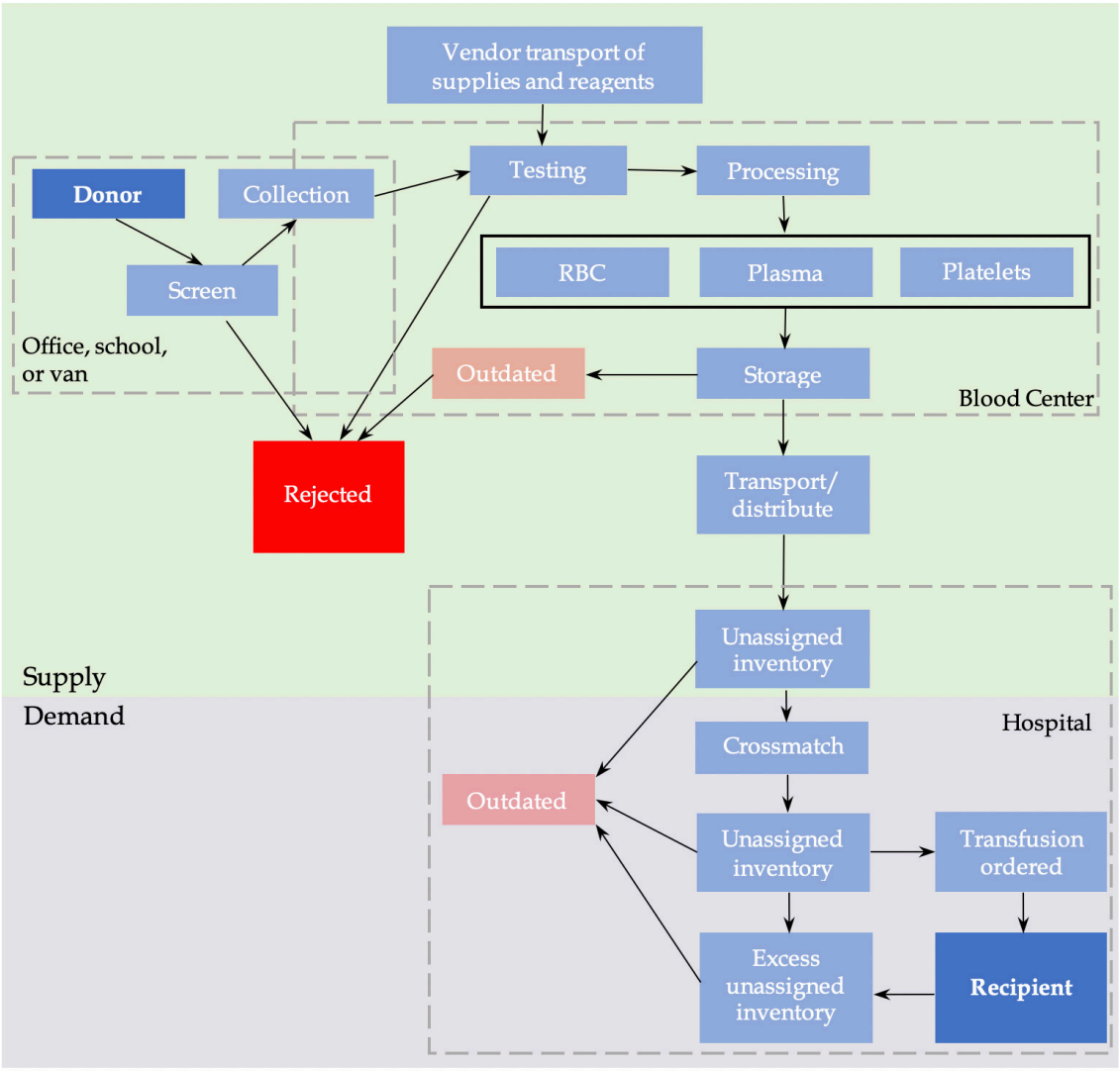
To evaluate the intermediate-period effects of the pandemic on blood centers and the blood supply, we conducted a detailed survey of the experiences of blood centers as reported during the period July 1, 2020 –July 28, 2020. Participants were drawn from the population of U.S. blood centers excluding hospital-based collection programs and military programs. Anonomous Survey responses, data on the daily levels of blood inventories for the Blood Centers of America (BCA) member network and publicly available data representing the strictness of pandemic public health measures, allowed us to evaluate the accuracy of all the primary conclusions reached by the RAND researchers. We find that although the RAND analysis failed to identify several significant developments, it was largely accurate in its predictions.

Blood System Components Evaluated by RAND

The RAND Study evaluates risks to the blood supply chain using "influence diagrams" which illustrate the components and critical nodes which connect blood donors to transfusion recipients. Although the blood supply system is very complex, the RAND analysis focuses on certain key components of the chain and evaluates the risks of disruption to these components arising from pandemics and other disasters. The primary

critical nodes of the system are blood centers, which coordinate resources to obtain blood from donors, and hospitals, which use blood and blood products in patient care. The abilities of these nodes to function adequately depend, in turn, on the continued availability of both appropriate human resources and supplies and other material support. The RAND model of the blood supply system, presented as Figure 7.2 in the study, is reproduced below in Figure 1.

Figure 1. Blood Supply Chain



Interviews with blood bankers, physicians, and numerous other specialists led RAND (Ch. 7) to focus on seven critical areas of concern: (1) donors; (2) reserve stocks; (3) suppliers and vendors; (4) blood center personnel and equipment; (5) critical infrastructure; (6) transportation services; and (7) blood product demand. The risks of disruption to each of these factors is then evaluated considering the likely impacts of a pandemic. Table 1 summarizes the risk factors considered by the RAND researchers and their assessments of the degree of risk in each.

Table 1. Summary of Risk Factors for Global Pandemic

Factor	Risk
Donors	High
Blood center reserve stocks	High
Vendors to Blood Centers	High
Blood center personnel and equipment	High
Critical infrastructure	Medium
Transportation	Medium
Demand	Low

Source: RAND Study (2016), Table 7.8.

Donors

Although blood donation is an altruistic act, the willingness to donate is never-the-less impacted by the costs of doing so (RAND Study: 87-8). In a pandemic, these costs may rise substantially. First, concerns over personal safety and exposure to the pathogen could dissuade many from donating. Second, potential donors may find it necessary to care for children or ill family members, limiting their ability to travel to a blood center. Third, mobile blood drives could be curtailed or eliminated entirely due to public health concerns and the closure of schools, colleges, and other traditional collection sites. Estimates are that mobile drives account for 60% to 80% of blood collected[2]. Finally, if the pandemic reaches critical proportions in some areas, government rules may limit the ability of donors to travel to collection sites (RAND Study: 91). As a result of these factors, RAND determined that risks to donation were **high**.

Blood Reserve Stocks

The *RAND Study* suggested that, at least in the early days of a pandemic, effects on reserve stocks are likely to be low. The primary intermediate-term risks to blood stocks will be significantly affected by the ability to test donated blood for the pandemic patho-

gen, and the degree to which infection rates vary geographically. In the case of the Zika virus, for example, lack of screening tests for the virus, and its concentration in Puerto Rico, combined to allow sufficient exporting of blood from the mainland to Puerto Rico, which suspended collections (RAND Study, 95). As time passes, reduced donation will put substantial pressure on reserves, and uniformly high rates of infection would render exporting blood impossible. Thus, RAND determined that the pandemic risk to reserve stocks was **high**.

Suppliers and Vendors

Blood collection and processing requires a continuous supply of specialized products such as collection bags, reagents, and so on. The RAND Study notes that many blood centers maintain relatively small inventories of these products, reflecting the goal of cost reduction through "just-in-time" practices (RAND Study: 95). Further, RAND notes that, in many cases, these critical supplies are available from a few, or even a single, supplier (RAND Study: 95). Therefore, disruptions in collection supplies due, for example, to high levels of employee illness among the supplier workforce, cannot be accommodated through depletion of blood center supply inventories or alternative supply sources, so RAND determines the pandemic risk to collection product supplies is **high**.

Blood Center Personnel and Equipment

Blood centers use numerous skilled workers to schedule donors, screen donors, collect blood, operate apheresis machines, test blood for diseases, document all blood products collected, discard unusable collections, and so on. The RAND Study notes that some skilled workers, such as phlebotomists, are in very short supply even during normal times (RAND Study: 98, 106). The dangers a pandemic poses for blood center employees mirrors the dangers posed for the general population: workers become ill, must care for children or sick family members, and fear infection due to their extensive interaction with the public. RAND notes that nearly one half of health care workers surveyed in the New York City area said they were unwilling to go to work during the SARS outbreak (RAND Study: 99). Thus, RAND determined that the risks of a pandemic to blood center personnel was **high**.

Critical Infrastructure

Critical infrastructure includes the electric grid, the internet, the road system, water supplies, waste disposal, and the like. As with any organization, blood centers rely on these services to operate. Loss of electrical service for any extended period, for example, would render blood stocks unusable. The RAND Study suggests that the primary

risk a pandemic poses to the critical infrastructure arises from widespread sickness among essential personnel, and concludes this risk is of **moderate** severity.

Transportation

Blood centers rely on local and national transportation providers to ship blood to hospitals, laboratories, and other blood centers, often at daily frequencies. The primary threat of pandemic towards the transport system is employee illnesses. Further, the RAND Study notes that the transport and delivery systems are likely to face increased demands during a pandemic, potentially exacerbating the effects of a diminished labor force (RAND Study: 105). RAND characterizes the pandemic transportation risk as **moderate**.

Demand

The RAND Study argues that blood supply, not demand, is likely to be the focus of concern during a pandemic. Further, blood product demand can be managed, though at a cost, by postponing elective surgical procedures and instituting other practices to limit blood use in hospitals. Unlike a terrorist attack or earthquake, a pandemic is unlikely to lead to spikes in short-run blood needs. Thus, RAND rates the risk of demand shocks due to pandemic to be **low**.

Evaluation of the RAND predictions

To obtain timely data on the effects of the Covid-19 on U.S. blood banks, an anonymous survey instrument was created by Blood Centers of America (BCA) and the authors. BCA is the largest blood supply network in the United States. Its members and associates collect and supply over 50% of the blood used in the United States. BCA sent the survey to 47 blood centers representing an estimated 96% of the U.S. blood supply (excluding hospital based and military collectors and manufacturers). Centers surveyed included both BCA and non-BCA members. Thirty-four centers responded to the survey, a response rate of slightly over 72%. Using data from National Blood Collection and Utilization Study (NBCUS) for 2019 and the 2019 collections self reported by the surveyed centers , we estimate that the 34 respondents represent approximately 77% of the 2019 U.S. blood supply. The data was collected anonomously by BCA and provided to the researchers; no identies, locations, or other identifiers of the respondents were obtainable .The survey was conducted between July 1 and July 28, 2020, using the Select Survey ASP Advanced.

Responding blood banks differed widely in size, with 41% (14 of 34) collecting less than 50,000 total red cells in 2019, while 7 of 34 (21%) collected more than 200,000 units, and three collected more than 500,000 units. About half the responding blood banks (16 of 34) are managed by CEOs with a business background, while clinicians lead a similar number (16 of 34).

The survey was divided into 22 main questions, with many further subdivided into specific areas of concern. Respondents were afforded opportunities to make additional comments to amplify their answers, or to indicate areas of concern not included in the survey instrument. The survey and aggregated responses are presented as an Appendix.

Responses to the questionnaire described above, combined with detailed data on daily blood reserve stocks within the BCA membership, allow us to evaluate the accuracy of the RAND analysis on the likely effects of a pandemic on the blood supply system of the United States. As shown below, most RAND predictions were prescient, suggesting that the RAND Study methodology succeeded in identifying the primary challenges faced by blood banks. Several consequences of the pandemic were not foreseen by the RAND researchers, however, and these are highlighted below.

Donors

The RAND analysis described the risks to donation as **high** and responding blood bankers concur. Almost two-thirds (65%) of respondents agreed that "getting enough donors to meet demand" (Q 1.3) was a major concern, while all others indicated they were "somewhat concerned." *No* blood bank indicated "no concern." 88% of blood banks identified the need to find new means of collection as a major concern (Q 1.9), with all others saying they were somewhat concerned. In response to these challenges, blood banks instituted multiple new programs to secure donations, with the large majority turning to social media advertising (88%), online social networking (91%), and alternative "non-traditional" locations for small "pop-up" drives (71%) (Q 3.1-3.9). Other efforts included small neighborhood drives (41%), increased traditional advertising (47%), Covid-19 testing for donors (55%), and donor recruitment via geo-tracking technologies (32%). Five of the responding blood centers even added new fixed sites (Q 3.2).

Blood Center Reserve Stocks

RAND rated the risk to reserve stocks as **high** but noted that these risks were unlikely to manifest in the early days of the pandemic (RAND Study: 95). For the intermediate- and long-term, RAND suggested reserve stock risks would increase, pointing to the possible inability of blood banks to test donated blood for the relevant pathogen, and the likelihood that a truly widespread infection would make it difficult or impossible to

export blood across regions. Over time, the collapse in donations could be expected to substantially reduce reserve stocks. While survey respondents did point to transportation problems, the FDA did not require screening of donors as there were no reported cases of transfusion-transmitted Covid.[3]

Some blood centers did offer Covid tests for donors as an inducement, however (Q 3.8). On the other hand, blood demand can be reduced during a pandemic by postponing elective surgeries (RAND Study: 70). Consistent with the RAND expectation, there was a nationwide reduction in the level of elective surgeries, thus reducing blood demand[4].

We can evaluate the effect of the Covid-19 pandemic on blood reserves directly using the blood reserve data for the BCA membership. Reserve days are calculated for each center by dividing units on hand on the survey date by average units supplied per day in the prior year. These figures are then averaged to produce the illustrated reserve series. Reserve data is for BCA members and is not limited to members responding to the survey.

Figure 2: O-Neg Reserves (Smoothed)

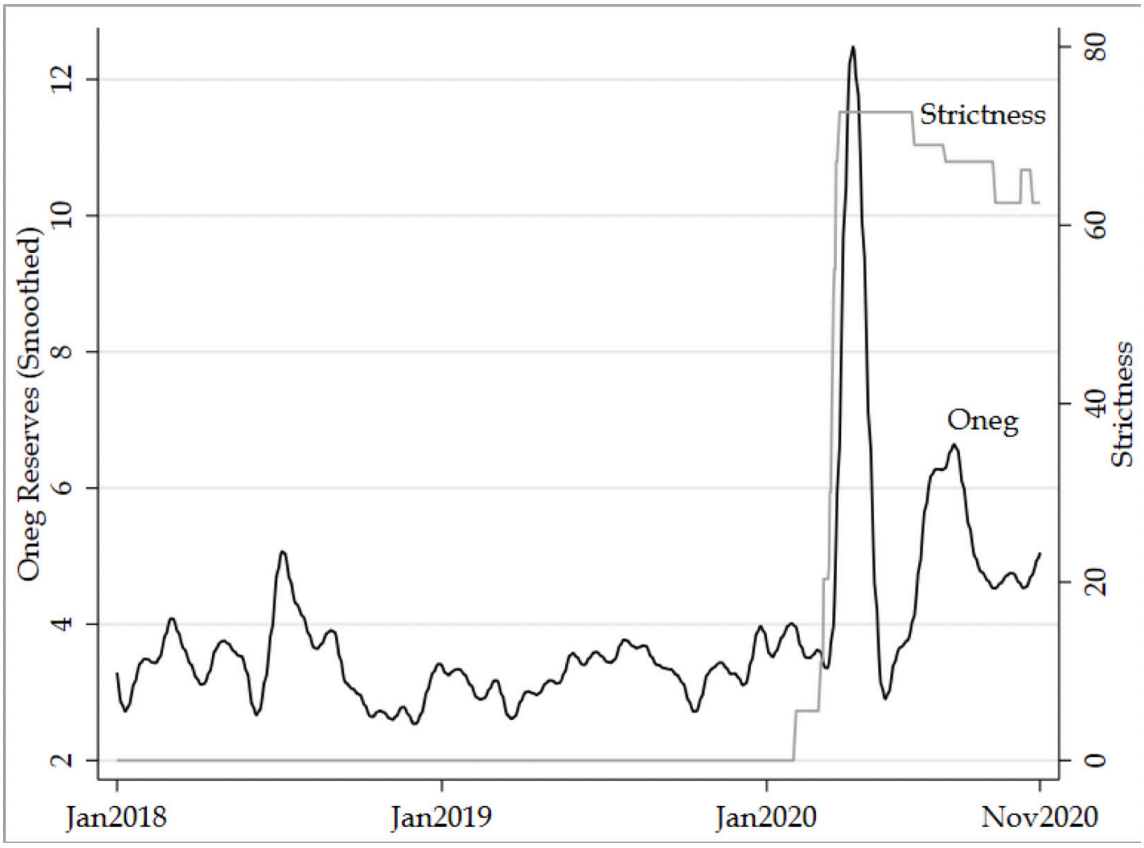


Figure 2 displays (a mildly smoothed) trend of the average numbers of days of blood in reserve reported by BCA members for the O-negative blood type for the period January 1, 2018 through November 3, 2020[5]. Also illustrated in the figure is an index constructed to represent the "strictness" of public health measures imposed in the United States in response to the pandemic. As described in Petherick, et al., (2020), the strictness index is based on seven indicators reflecting policies such as school closures and travel bans. This composite strictness measure is a simple average score of the seven indicators measured on an ordinal scale, rescaled to vary from 0 to 100. The scale of the index is indicated on the right-hand vertical axis. During the sample period, the strictness index for the U.S. first exceeded 50 on March 16, 2020 and peaked at 73 on March 23, 2020.

Inspection of Figure 2 reveals the consequences of the pandemic (and the nation's shelter-in-place policies) for blood reserves. When the pandemic hit, and public health measures were rapidly put in place, reserve stocks of O-negative *surged* to nearly an unheard-of thirteen-day supply on April 6, 2020. This occurred for two reasons. First, many U.S. hospitals instituted the almost complete suspension of elective surgical procedures during that time in broad anticipation of a tidal-wave of Covid-19 hospitalizations.[6] Second, and most importantly, United States Surgeon General Jerome Adams made a broad public appeal for blood donation, especially by younger donors, on March 19, 2020.[7] BCA reserve stocks of O-negative RBCs rose from 3.9 days on March 19, to 8 days on March 25, to 11.9 days on March 30, to 13.5 days on April 6.

The combination of a positive public response to the Surgeon General's plea and the large reduction in elective medical procedures created the surge in reserves shown in Figure 2. In particular, the large spike is primarily the result of a surge in donations since even an almost complete elimination in blood sent to hospitals would not cause reserves to rise at such a rate. (For example, if the average daily reserve of blood of some type is 4 days, then even a reduction in usage to zero for a day, with continuing donation levels, would cause reserves to rise only to about 5 days.) In the short run (during the latter part of March 2020) reserve stocks were more than adequate: O-negative RBCs were plentiful. Over time, however, the effects of the pandemic on donations begin to tell, despite the low demand for blood, and by June 2020 reserve stocks of O-negative had fallen back close to pre-pandemic levels. Since restrictions on elective surgeries persisted at many hospitals during this time, the large falls in donations did not lead to critical shortages. Later, reserve stocks rose to around five-day's supply, which is slightly above the 2018 and 2019 averages (3.4 and 3.3 days, respectively).

Figure 3: Average of All Blood Reserves (Smoothed)

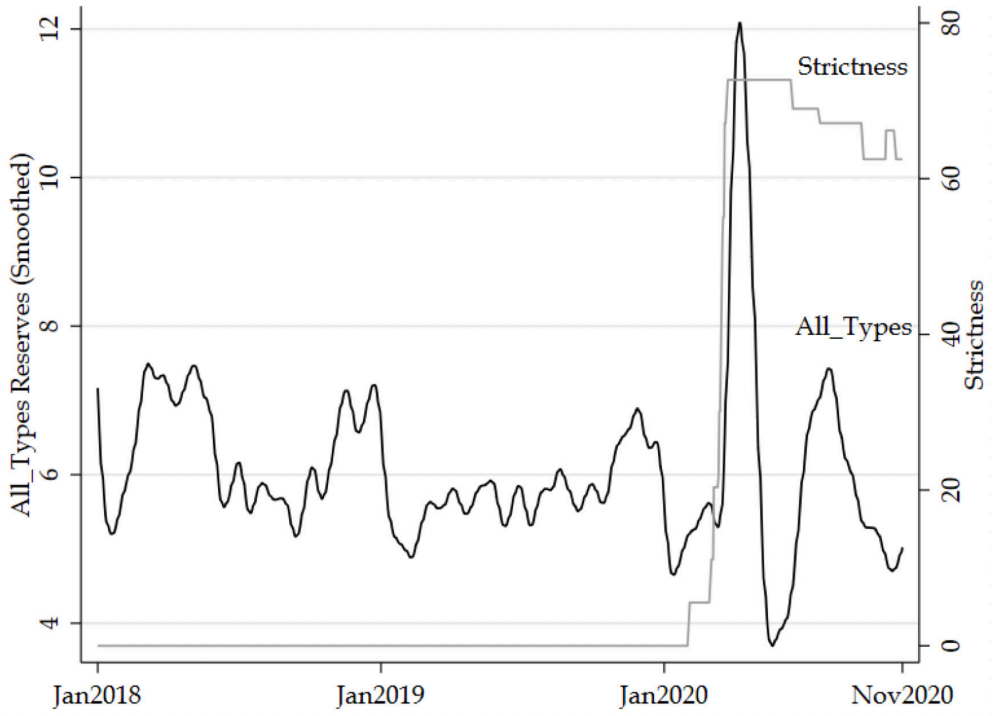
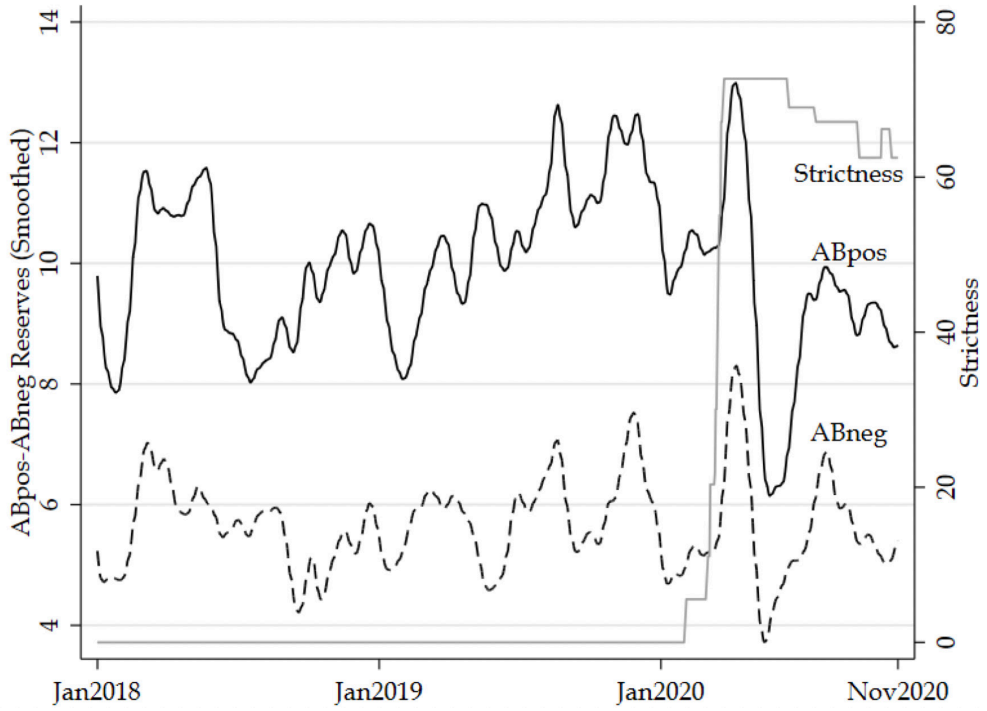


Figure 3 repeats our analysis using the simple average of reserve stocks of red cells across all blood types. We note a pattern strikingly like that found for O-negative RBCs: the implementation of strict public health measures, combined with the Surgeon General's request, led to a short-lived surge in reserve stocks which then gave way to substantial declines in May and June 2020, before recovering somewhat and exhibiting normal levels of reserves by the beginning of July 2020.

Figure 4 examines reserve stocks for AB-positive and AB-negative blood types. Again, the effect of the pandemic on reserves replicates our findings above: the onset of serious public health measures and the national plea for donations leads initially to a spike in reserves, while over the next few months reserves fall to levels below those seen pre-pandemic. After around 4 months, reserves return to pre-Covid-19 levels.

The BCA reserves data highlights the effects of two compounding forces on blood supplies. First, suspensions of elective procedures reduced the demand for blood by hospitals, which would increase stocks if such suspensions were maintained. More dramatically, the U.S. government responded to the risks of reduced blood donations with a universal and dramatic appeal by the Surgeon General. This effort was so successful that blood stocks surged to levels previously unseen, although ironically these spikes occurred at a time of reduced demand.

Figure 4: AB Reserves (Smoothed))



The RAND study did not contemplate the use of a public appeal for donations when faced with a pandemic, and the social benefits which resulted from Dr. Adams' appeal are unknown. Evidently the extraordinary circumstances surrounding the Covid-19 epidemic motivated the public to greatly increase donations over a short period in late March 2020. Longer-term, analyses of stocks of AB +/- and all types taken together follow the predictions of the RAND study: by November 2020, reserves were somewhat lower than the immediate pre-pandemic averages. O-negative RBCs appear to be a mild exception, with reserves in November 2020 appearing at least equal to those immediately pre-pandemic.

Suppliers and Vendors

Due to minimal inventories of crucial supplies, and the dependence of blood banks on a few vendors, RAND identified the supplies risk to be **high** (RAND Study: 97). Supplies can be problematic for several reasons. First, the supplier workforce, like any group, could see serious levels of infection, crippling production. Even in the absence of this, vendors rely on the transportation network to deliver supplies in a timely fashion. Finally, although not specifically discussed in the RAND Study, essential supplies may remain available but at a substantially higher cost.

Survey questions 1.10 and 5.1 address these issues. By Q 1.10, all responding blood banks were either somewhat concerned (62%, 21 of 34 responses) or very concerned (38%, 12 of 34 responses) regarding increased supply costs; none were unconcerned. Given the substantial reduction in blood collection over the sample period, such price increases were not caused by increased demand by blood banks. Rather, either supplier costs rose, or else suppliers found alternative market opportunities to be more profitable than the sale of blood collection consumables, thus substantially reducing their supply.

Some evidence for this interpretation is provided by the responses to survey question 5.1, which focused broadly on transportation problems. When asked if they had experienced problems "obtaining supplies," 56% (18 of 32 responses) reported that was a minor problem, while 34% (11 of 32 responses) described the issue as of moderate importance. No blood bank reported they faced a major problem and about 10% (3 of 32 responses) reported no problem obtaining supplies.

Table 2. Cross Tabulation, Supplies and Vendors

	Q 1.10: Concerned about increase in supply costs?			
Q 5.1: Problems with obtaining supplies?	No Concern	Somewhat Concerned	Major Concern	Total
No Problem	0	3	0	3
Minor Problem	0	12	6	18
Moderate Problem	0	5	6	11
Significant Problem	0	0	0	0
Total	0	20	12	32

Responses to these questions are cross-tabulated in Table 2. Naturally, blood banks that experienced minor or moderate problems obtaining supplies were more likely to be concerned about rising prices.

Blood Center Personnel and Equipment

Blood bank employees are as likely to become infected as anybody else, and the RAND Study emphasized that rampant illness could deprive blood centers of specialized workers, such as phlebotomists, who were already in short supply prior to the pandemic. Thus, RAND considered the pandemic risks to personnel to be **high** (RAND Study: 99-100).

The survey separated employee risks into financial and non-financial components. In the first case, loss of center income may lead to employee furloughs or terminations

(Q 1.1, 7.1-7.8, 9, 10). In the second case, employees may not come to work due to fear of infection, sick family members, or childcare duties (Q 11, 12). Blood centers responded to these problems in a variety of ways, including the use of remote work, employee screening, additional PPE and hazard pay (Q 1.7, 1.8, 9, 10, 14).

The financial consequences of the pandemic for blood banks were a moderate (41%) or major (12%) concern for the survey respondents. Of the respondents, 35% surveyed were somewhat concerned about having to furlough employees, while 12% saw it as a major issue. About 18% of respondents furloughed recruitment staff, the highest rate of any category. By contrast, medical staff and employees in manufacturing or the reference lab were seldom laid off. Although many blood banks report financial stress, most appear to have been quite reluctant to furlough employees. These decisions were influenced by blood bank participation in the Payroll Protection Program (PPP) of the U.S. government which provided highly concessionary loans to employers who agreed not to reduce staff. Fifty-six percent of blood banks report participating in the PPP (Q 9). This, combined with the large reductions in collections, suggest that staffing shortages were not a serious problem during the survey period.

Non-financial effects of the pandemic on staff were more notable. Fully two thirds (68%) of responders reported difficulties with employees not coming to work. Reasons cited for the absenteeism include childcare obligations (86%), other family care obligations (59%), employee Covid-19 exposure outside of the workplace (64%), and employee concern about exposure at work (64%). The very large role played by childcare needs seen here is consistent with the conclusions of employment experts and economists for the entire economy.[8 9 10]

Blood banks utilized a variety of strategies to manage employee risks during the period under study: 88% allowed remote work for at least some employees for whom that was feasible (Q 14.2), while all but one blood bank reported supplying additional PPE as a response to the risk of infection on the job (97%, question 14.3). A little less than a third (27%) introduced hazard pay (Q 14.4).

The RAND Study did not consider the possibility of remote work, which is a more recent phenomenon. However, 41% of blood banks expressed concerns over reduced productivity arising from telework (1.7). More generally, 38% were moderately concerned, and 44% were very concerned, about decreased worker productivity due to social distancing and other pandemic issues.

On balance, the Covid-19 pandemic did not result in serious problems arising from personnel shortages. However, the pandemic led to greatly reduced collections, reducing the need for staff. Most blood banks were able to maintain staffing levels at almost pre-pandemic levels, although concerns over the productivity effects of remote work and social distancing protocols were common. When staff failed to come to work, their reasons mirrored those of the labor force generally.

In contrast to an event such as a major terrorist attack or an earthquake, a pandemic is unlikely to seriously affect functioning of critical infrastructure in the short term. Fortunately to date there have been no reports of serious infrastructure problems due to Covid-19, and the RAND Study rated this risk as **moderate** due primarily to the threat of infection among infrastructure workers. No blood bank in the survey reported problems with infrastructure. (Question 2 and Question 23 permitted an open-ended response for general concerns and no respondent indicated problems with infrastructure.)

Transportation

The main threats to the transportation network arising in a pandemic are widespread illness among transport workers and, as RAND noted, increased stress on the network arising from expanded demands for its services. The RAND Study classified transport risks as **moderate**.

The evidence for transportation problems is nuanced. For example, while one half of blood banks report no problems sending samples to laboratories for testing, 50% report difficulties ranging from the minor to the significant (Q 5). Although no blood bank found obtaining supplies a significant problem, fully 90% reported either minor or moderate difficulties. When asked to describe their transportation problems, blood bankers most frequently mentioned commercial flight cancellations, which affected the shipping of blood and blood products. Several respondents switched to commercial shipping services like UPS and Federal Express, but they also noted these options are far more expensive than shipping on commercial flights. One respondent mentioned interstate shutdowns in some states early during the pandemic affected both patients and donors while another noted the lags in normal testing needs due to the focus of testing sites on antibody testing. These responses must be evaluated in light of the significant drop in collections experienced by the blood banks during the period under study. As donations fell, the need for supplies and transport also diminished to some extent.

Demand

RAND rated demand risks from pandemics as **low**, and this conclusion is certainly borne out by the Covid-19 experience. Unlike a terrorist attack or an earthquake, a pandemic does not generate mass traumatic injuries requiring large amounts of blood. Further, as RAND also noted, blood demand can be substantially reduced in the short term by forgoing elective surgical procedures (RAND Study: 70). The primary short-run demand risk for blood banks is that blood demand will fall so substantially that financial viability may be impacted. In the Covid-19 experience, drastic demand reductions allowed critical use blood supply to continue despite the fall in donations. Financially,

blood banks benefited from special circumstances such as the PPP and the sales of convalescent plasma, thus somewhat mitigating the reductions in income.[11] [12] [13] Nevertheless, 79% of respondents were somewhat or very concerned about the ability of their hospital customers to pay them for blood products (Q 1.6).

Conclusion

Although the Covid-19 pandemic represents a profound risk to the health care system, risks to the nation's blood supply system, though significant, have proven largely manageable. At least four factors appear to have supported this outcome. First, according to the FDA there were no reported cases of transfusion-transmitted, and the FDA did not require Covid screening of donors. Had Covid been transmissible in blood products, circumstances would have been far more difficult. Some blood centers did offer Covid tests for donors as an inducement, however. Second, unlike mass casualty events such as earthquakes, the Covid-19 pandemic did not require large amounts of blood for patient treatment. Third, the suspension of many routine and voluntary surgeries greatly reduced the demand for blood. As a result, blood stocks remained adequate in most respects, even months into the epidemic. Finally, the plea by the U.S. Surgeon General for mass blood donation on March 19, 2020, resulted in very large short-lived surges in blood reserves. Unfortunately, these surges coincided with periods of reduced blood demand. The analyses presented here allow us to reach several conclusions which may inform our responses to future disasters of this sort.

- The RAND Study, *Toward a Sustainable Blood Supply in the United States: An Analysis of the Current System and Alternatives for the Future* (2016), was of varying accuracy in its predictions regarding the probable effects of a pandemic. Blood demand can be managed in the short run, greatly reducing the risks of serious shortages. The grave public concern attending the Covid-19 pandemic made a public appeal by the Surgeon General for blood donations very effective. The RAND analysis did not predict the large surges in reserves at the onset of the pandemic, but these surges arose primarily due to a general appeal for donations by public health authorities, which is an exogenous event. In retrospect, the wisdom of such appeals is unclear in the context of the pandemic during which blood demand was low. It is possible that substantial amounts of collected blood had to be discarded in the weeks after the severe onset of public health restrictions. As of this writing, we have been unable to locate a reliable data set in order to test this hypothesis. It is also unknown how the large surge in collections in late March 2020 affected collection supplies going forward.
- Difficulties in obtaining donations, predicted in the RAND analysis, were borne out by the experiences of the survey respondents. This will presumably repeat in future pandemics although, as recent experience shows, the consequences for

the blood supply may be somewhat mitigated by reductions in demand. Postponement of elective surgeries is not costless, however.

- Collection supplies, and the costs of consumables, were areas of concern for almost all blood banks, although the large decrease in blood donations mitigated the need for supplies. RAND judged the supplier risks to be **high**, but the actual consequences for blood collection appear minimal.
- Staffing problems, rated a **high** risk by the RAND analysis, do not appear to have limited collections to levels below blood demand by hospitals. However, a large majority of blood bankers reported staffing problems, especially absenteeism due to illness or fear of infection. Many blood banks turned to remote work for some employees, an outcome not anticipated by the RAND Study. Numerous blood centers reported concerns about employee productivity under remote work and other pandemic-related labor practices.
- Blood banks reported only moderate difficulties due to problems with transportation, and failure of critical infrastructure did not occur during the survey period. These results roughly accord with the RAND determination that such risks are **moderate** rather than severe.
- As predicted by the RAND analysts, the risk arising from blood demand was **low**.

The COVID-19 pandemic continues as of this writing, so it is too early to draw final conclusions on its effect on blood banks. One issue not directly addressed by RAND in the context of a pandemic is the *financial* consequence. Blood banks universally reported financial concerns, and many availed themselves of the PPP assistance provided by the U.S. government. Additionally, collection of convalescent plasma to treat Covid patients has become a large source of revenue for many blood centers, although this is unlikely to continue. It is probable that, in the absence of significant publicly-funded interventions, the financial consequences of the Covid pandemic for blood banks would have been far worse. The ultimate pandemic-driven financial effects on blood banks remain to be seen.

Appendix: COVID 19 Survey

Conducted by: Blood Center's of America (BCA)
Respondents: 34
Launch Date: July 1, 2020
Closed Date: July 28, 2020

Note: In order to protect anonymity, all comments have been removed. As a result, the numbering of the questions includes omissions since comments were presented as numbered questions.

1. Going forward, how concerned are you about the following.

		No Concern	Somewhat Concerned	Major Concern	Response Total
1	Ability to pay bills/salaries (Financial welfare)	47% (16)	41% (14)	12% (4)	34
2	Having to furlough or layoff employees	53% (18)	35% (12)	12% (4)	34
3	Getting enough donors to meet demand	0% (0)	35% (12)	65% (22)	34
4	Potential for second way	0% (0)	32% (11)	68% (23)	34
5	CCP reimbursement	24% (8)	59% (20)	18% (6)	34
6	Hospital ability to pay	21% (7)	64% (21)	15% (5)	33
7	Decreased productivity due to employees working remotely:	59% (20)	41% (14)	0% (0)	34
8	Decreased productivity due to social distancing and other pandemic related issues:	18% (6)	38% (13)	44% (15)	34
9	Need to find new means of collections as schools and businesses limit mobile blood drives:	0% (0)	12% (4)	88% (30)	34
10	Increase in supply costs:	0% (0)	62% (21)	38% (13)	34
11	Increased competition from other blood centers for hospital contracts:	29% (10)	53% (18)	18% (6)	34
12	Increased competition from other blood centers for donors:	15% (5)	42% (14)	42% (14)	33
13	Increased competition from plasma centers for donors:	21% (7)	38% (13)	41% (14)	34
14	Other – please comment below	77% (10)	8% (1)	15% (2)	13

3. In order to deal with cancelled mobile drives due to COVID-19, has your center implemented or have plans to implement any of the following?

		Already Implemented	Not Implemented, but Considering	No	Response Total
1	Extended fixed site hours	65% (22)	26% (9)	9% (3)	34
2	Added new fixed sites	15% (5)	33% (11)	52% (17)	33
3	Found non-traditional locations for small pop-up drives	71% (24)	15% (5)	15% (5)	34
4	Developed small neighborhood drives	41% (14)	38% (13)	21% (7)	34
5	Increased traditional advertising	47% (16)	18% (6)	35% (12)	34
6	Increased social media advertising	88% (30)	3% (1)	9% (3)	34
7	Increased online social networking	91% (30)	0% (0)	9% (3)	33
8	COVID 19 testing for donors	55% (18)	24% (8)	21% (7)	33
9	Door recruitment via geo tracking	32% (11)	29% (10)	38% (13)	34

5. Did you experience any problems (as defined by you) due to COVID 19 related transportation issues?

		No Problem	Minor Problem	Moderate Problem	Significant Problem	Response Total
1	Obtaining supplies	9% (3)	56% (18)	34% (11)	0% (0)	32
2	Sending testing samples to labs	50% (16)	19% (6)	22% (7)	9% (3)	32
3	Other transportation issues	50% (15)	30% (9)	13% (4)	7% (2)	30

7. As a result of COVID 19 issues, did you furlough or lay off any of the following staff?

		Yes	No	Response Total
1	Admin /clerical	15% (5)	85% (29)	34
2	Recruitment	18% (6)	82% (28)	34
3	Collections	9% (3)	91% (30)	33
4	Manufacturing	3% (1)	97% (32)	33
5	Reference Lab	3% (1)	97% (32)	33
6	Quality control/compliance	12% (4)	88% (30)	34
7	Drivers	12% (4)	88% (29)	33
8	Medical Staff	6% (2)	94% (31)	33

9. Did your organization apply for support from the federal Paycheck Protection Program?

Yes	No	Response Total
56% (19)	44% (15)	34

10. If Yes, did PPP permit you to restore furloughed/laid off staff?

All Staff Restored	Most Staff Restored	Some Staff Restored	Other, Specify*	Total
25% (5)	5% (1)	0% (0)	70% (14)	19

11. As a result of COVID 19 issues, has your center experienced any problems with employees not showing up for work?

Yes	No	Response Total
68% (23)	32% (11)	34

12. If you answered Yes, what are the most commonly cited reason? Check all that apply.

	Response Total	Response Percent
Taking care of children	19	86%
Taking care of other family members	13	59%
Employee exposed to Covid-19 outside of work	14	64%
Concern over exposure to Covid-19 in the workplace	14	64%
Other, please specify.*	6	27%
	Total Responses	**22**

14. As a result of COVID 19, has your center implemented any of the following?

	Yes	No	Response Total
Taking employees temperature before each shift	88% (29)	12% (4)	33
Allow remote or teleworking (work form home)	88% (29)	12% (4)	33
Supplied additional PPE	97% (32)	3% (1)	33
Implemented hazard pay	27% (9)	73% (34)	33
		Total Responses	**132**

16. In order to deal with canceled mobile drives due to COVID-19, has your center implemented or have plans to implement any of the following?

		Not Helpful	Somewhat Helpful	Very Helpful	Response Total
1	AABB	21% (7)	59% (20)	21% (7)	34
2	ABC	6% (2)	21% (7)	73% (24)	33
3	BCA	3% (1)	3% (1)	94% (32)	34
4	FDA	15% (5)	64% (21)	21% (7)	33
5	FEMA	75% (24)	22% (7)	3% (1)	32
6	HHS	38% (12)	47% (15)	16% (5)	32
7	State Government	48% (16)	33% (11)	18% (6)	33
8	Local Government	44% (15)	35% (12)	21% (7)	34
				Total Responses	**265**

17. Do you charge different service fees for red blood cells based on type? For example, charging more for O negative than for A positive

Yes	No	Response Total
18% (6)	82% (28)	34

18. If no to question #17, have you considered doing so?

	Response Total	Response Percent
Yes, and remain open to the idea	15	50%
Yes, but have rejected the idea	7	23%
No	8	27%
	Total Responses	**30**

19. Do you charge different service fees for FFP/FP24 based on type? For example, charging more for AB plasma than for O plasma.

Yes	No	Total Response
21% (7)	79% (27)	34

20. If no to question #19, have you considered doing so?.

	Response Total	Response Percent
Yes, and remain open to the idea	11	39%
Yes, but have rejected the idea	413	14%
No		46%
	Total Responses	**28**

21. Size of your blood center based on total red cell collections during calendar year 2019 (or most recent 12 months).

	Response Total	Response Percent
< 50,000	14	41%
50,000 – 100,000	9	26%
100,000 – 150,000	2	6%
150,000- 200,000	2	6%
200,000 – 500,000	4	12%
> 500,000	3	9%
	Total Responses	**34**

22. Which best describes the President/CEO of your blood center?

	Response Total	Response Percent
Physician	4	12%
Medical Technologist	11	32%
Other clinical specialty	1	3%
Business background	16	47%
None of the above	2	6%
	Total Responses	**34**

Footnotes

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