Blood Transfusions: Limitations and Solutions

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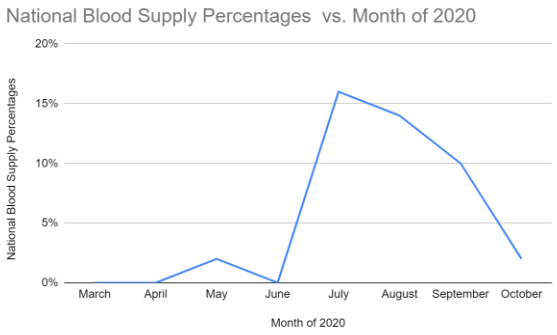
Rachel Nall, a medical freelance writer for Healthline Media, explains how infants are born with approximately 270 milliliters of blood in their bodies (Nall, 2017). As children grow older and bigger, the amount of blood they possess and the probability of accidents and illnesses increases.The red liquid that courses through veins and pumps throughout the body is necessary for human survival. It is essential in delivering oxygen to the brain, thus, supporting life. Nall reports that losing 40%, or 2,000 milliliters, of blood results in death (Nall, 2017). Fortunately, medical processes have been developed and tested to save lives in critical situations. The most common procedure is a blood transfusion. A blood transfusion is when blood from a donor or volunteer is introduced into the patient's bloodstream ("Blood Transfusion" [Mayo], 2022). The process resembles a blood test, where a needle is inserted in a vein, and blood travels through the cannula tube. The only difference is that the IV line sends blood into the body. The University of Rochester Medical Center (URMC) identifies that situations where blood transfusions are necessary are car crashes, surgeries, bleeding disorders, and cancer treatments ("Blood Transfusions in Adults," 2022). The procedure is crucial when accidents result in vast and rapid blood loss, and the urgency depends on the patient's state. Furthermore, the URMC describes how multiple components and types of blood vary based on the recipient and their condition(s). Plasma is the liquid part of the blood. It comprises proteins, water, hormones, and other substances. Red blood cells (RBCs), white blood cells (WBCs), proteins, and platelets are within the plasma. First, RBCs contain hemoglobin, allowing them to carry oxygen from the lungs to other body parts. Second, WBCs help fight off infections. Third, platelets aid in clotting and stop bleeding from wounds ("Blood Transfusions in Adults"). A patient's blood may lack some of these components, or their condition may call for a specific type of blood transfusion. For

example, a person with thrombocytopenia would need a platelet transfusion since their body is devoid of that element and they need it to survive. Moreover, there are four blood groups: A, B, AB, and O. These types represent the antigens that cause immune system reactions in blood cells. There are eight blood types since Rh is a specific antigen, and each group can be positive or negative ("Blood Transfusions in Adults"). Therefore, the type of blood used during the transfusion is crucial because a mix-up can harm the patient's immune system. Even when the correct blood types and components are used, transfusions can cause risks and side effects, explains NHS Inform, one of Scotland's national health information services. These include allergic reactions, incompatibility of cell antibodies, fevers, HIV, and hepatitis B ("Blood Transfusion" [NHS], 2023). Patient reactions, symptoms, and care will vary, and although these conditions are infrequent, they should not be dismissed since the safety rate of transfusions is not 100 percent.

One major problem of blood transfusions is blood unavailability and shortages. This presents both practical and moral issues regarding the medical procedure. First, the supplies necessary to help patients and save lives are not accessible. Second, as blood donations and reserves dwindle, the question of which patients should receive transfusions first arises. So, what factors are fueling these frequent shortages? Mayo Clinic credits the Covid-19 pandemic for blood shortages and a downward donation trend. At the height of the pandemic in 2020, social distancing and the cancellation of public events restricted donation opportunities. Across the United States, hospitals saw a shift from two-week inventories to two-day inventories within a short period (Stiepan, 2020). Moreover, NPR reports a 10% decline in blood drives since 2020 and a 62% drop in school/university blood drives (Treisman, 2022). Blood unavailability became common due to people's fear of the coronavirus and a concern for their safety. This fear included

coming into contact with blood drive volunteers and medical equipment within a perimeter of space. This causes donations to reduce since people are unwilling to attend blood events. Moreover, drives were canceled due to Covid, eliminating the middleman between donors and hospitals and negatively affecting patients who required blood transfusions. The following years were also affected, with people still concerned about their health and costs rising. In 2021, Judy F. Minkove, a senior writer at Johns Hopkins Medicine, interviewed Steven Frank, an anesthesiologist at Johns Hopkins (JHU), and he reported on the hospital's blood costs for that year. JHU spent one million dollars for its red blood cell supply and one million dollars for platelets each month (Minkove, 2021). Hospitals have extensive budgets and supply lists to ensure their patients receive the necessary care. However, spending too much on one component, in this case blood, can throw off this set monetary plan. As supply diminishes and the cost of blood increases, hospitals face the unfortunate circumstance of deciding which situations need the blood the most. A common example of this moral dilemma: Does a premature baby or a single mother in a car accident need the transfusion more? Doctors and healthcare professionals want the best treatment for all patients, but this hope cannot be ensured. Thus, blood unavailability negatively affects both doctors and patients, and donations are essential to provide transfusions to anyone, whenever and wherever he/she/them needs them.

Figure 1: ("Regional Blood Supply," 2020)



The line graph above depicts the percentages of American blood centers that had a 3+ day blood supply through 2020.

Another major issue regarding blood transfusions is the inadequate detection of infections in blood donations and supplies. These infections are rare nowadays due to improved technology and screening processes, but their existence should not be completely dismissed. If a recipient is infected, the effects are harmful and detrimental. A 2016 Annual UK Serious Hazards of Transfusion article, mentioned by a National Library of Medicine book, reports that bacterial transmission by transfusions accounted for 10% of transfusion-related deaths in the United States. There are two main categories for types of illnesses: bacterial and nonbacterial. One type of bacterial illness is septicemia, which can cause nausea, swelling, chills, unexplained bleeding, and fluctuating blood pressure. One type of nonbacterial illness is hepatitis B, which results in fever, nausea, abdominal pain, and yellowing skin (Buerger and Jain, 2022). These side effects on top of a patient's pre-existing condition/illness, can take a major toll on their health. Especially since both he/she/they and his/her/their doctor are looking at a transfusion as a viable option to save their life. Therefore, the frequency of transfusion-transmitted infections must reduce. But how are these infections caused? Infectious blood occurs due to the donor's health or anatomy. The Australian Red Cross describes how blood can be infected during the blood collection procedure due to bacteria in the donor's skin or pre-existing health conditions ("Transfusion-Transmitted," 2022). Skin is not specifically tested during screenings and this bacteria may not be easily detected since blood is tested for a set number and type of routine and expected diseases. Screening errors are not impossible and can overlook a donor's health eligibility. For example, if a donor has a condition that is not tested for, he may be falsely approved as a "healthy" donor, which in turn, negatively affects potential recipients. So,

although screening processes occur before donations and the collection centers are extremely sterile, the complete elimination of potential blood-borne diseases/illnesses is not possible. Another reason blood becomes infected is due to improper storage. The UK report explains how the temperature at which supplies are stored can greatly affect contamination. For instance, for five days, platelet stocks must be stored at 72 degrees Fahrenheit with agitation, a chemical process that ensures the platelets are oxygenated. The CDC also reports how the transmission of infections occurs in every 1 of 2000 platelet transfusions due to this cause. Moreover, errors in transportation, breakages, and improper handling can lead to exposure to contaminants (Buerger and Jain, 2022; "Disease and," 2022). If storage parameters are waved off, or the utmost care is not taken of these blood supplies, they can lead to the development of infections. The incorrect temperatures or locations can promote bacterial and fungal growth. Remember, this is the same blood that will be introduced to an unstable patient's bodily environment and immune system. This idea can be compared to groceries at home. It is fine to leave a pack of potato chips in the pantry due to its composition and makeup. However, a gallon of milk in the pantry leads to its spoiled state and can make people sick if consumed. Overall, detecting blood infections is vital to protecting patient health and improving the safety of blood transfusion procedures.

Once problems are identified, it is easier to develop possible solutions. Scientists, doctors, and experts are working towards reducing the duration and occurrence of blood shortages. One response involves harnessing technology and academics. In 2021, Stanford University announced the development of a mathematical model that posed an interesting solution. Accounting for blood thickness and flow rate, the experts explained how blood could be substituted with a similar element ("New Model," 2021). By understanding how blood works and is composed, substitutes can be made and distributed to hospitals and patients desperate for

transfusion supplies. In fact, as of 2023, blood substitutes, like hemoglobin-based oxygen carriers (HBOCs), are being clinically tested for human use. This new invention's main purpose is to function as hemoglobin and deliver blood to various bodily organs and systems. Advantages of this replacement include a longer shelf life, a reduced risk of infections, and lower financial costs, describes the Pacific Heart, Lung, & Blood Institute ("Synthetic and," 2023). This new technological advancement will help end the increasing demand for real blood by providing other options on the market. It will also help hospitals afford safe and necessary care for their patients. Moreover, the American Red Cross (ARC) proposes that greater community involvement will reduce blood shortages. In January 2022, 68% of hospitals across the United States only had a 3-day blood supply, and ARC estimates that 29,000 blood units are needed daily. Many patients and doctors were under tremendous stress regarding treatments. The renowned organization calls upon the public to make transfusions possible for all. Medical News Today mentions becoming screened donors, attending blood drives, and spreading awareness as viable and impactful ("American Red," 2022). When hospitals and entities cannot obtain blood through transactions or suppliers, they turn to the public and approved donors for help. Citizens who can donate blood must take it upon themselves to help patients in critical conditions and do their part for the community. Along the theme of helping others, different hospitals and organizations should collaborate and share supplies in need. The Harvard Business Review claims pooled resources can help all hospitals and patients survive blood shortages. (Howard et al., 2022). Cooperation between entities is necessary to deal with blood shortages and ensure proper healthcare. For instance, if a patient in Manhattan needs an emergency transfusion, but the supplies are unavailable, a nearby hospital or clinic should lend the blood or tools. When the medical field is treated as a competition, lives can be lost, so teamwork presents another possible

solution to dealing with shortages. In brief, there are multiple responses to frequent blood unavailability that are in use and being developed, indicating that further effort and advancement is necessary to improve the system of blood transfusions across America.

Methods and responses are also being developed to prevent transfusion-transmitted infections. Fairly recently, pathogen inactivation technology has been helping reduce the risk of transferred infections, explains the AABB Pathogen Inactivation Technology Review Work Group. In 2017, the Food and Drug Administration (FDA) approved pathogen inactivation, which is still used today. It consists of "treating" the blood to rid it of any infectious agents upon collection—this method represses the virus's ability to replicate. When amotosalen, a chemical agent, is activated by ultraviolet light to bind nucleic acids, the DNA cannot replicate ("Questions, 2017"). The success of this method is apparent through its common use today. It helps ensure "clean" blood for patients, prevents them from exposure to infections, and saves their immune systems from further strain. Moreover, in January of 2023, the FDA proposed guidelines and questions that should be added to blood donor registration questionnaires. These proposals include blood establishments performing required blood testing for infections, asking donors about their past sexual partners, and recording their history with HIV and HIV medication ("FDA Proposes," 2023). These measures will help reduce the likelihood of transmitted diseases. By promoting blood testing, health professionals will be certain if the blood is eligible for transfusions and helping patients. The sexual and HIV questions will help crack down on the transfer of HIV to possible patients and ensure optimal quality blood donations. Along with updated donor questionnaires, the Association for the Advancement of Blood and Biotherapies ("AABB22," 2022) reports that new questions include asking donors about any existing blood deficiencies/disorders, and tool kits will be administered to blood collectors and

centers to ensure proper transfusions. AABB is currently awaiting approval from the FDA ("AABB22," 2022). Donor applications are necessary to approve or reject blood volunteers to ensure the safety of future transfusions and patients' health. Asking about a donor's blood disorders helps determine if the patient can handle donating blood and ensure their safety. It also avoids transferring infections/deficiencies to recipients. Moreover, these tool kits will provide blood collectors with new equipment and make receiving blood easier. In short, approaches to reducing the risk of transfusion-transmitted infections are underway and still being developed.

Blood transfusions are an important medical process in dealing with a patient's health conditions, both long-term and life-threatening. Along with the benefits come disadvantages and external factors that affect their success and positive effects. These include blood shortages and transmitted infections, which hinder the provision of proper healthcare. Fortunately, solutions are being developed to help improve the dependability and distribution of transfusions. However, these advancements are only possible through the collaborative efforts of experts, scientists, healthcare professionals, and community members.

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