

Actionable Patient Safety Solutions™ (APSS™): Transfusion Safety

How to use this guide

This APSS provides evidence-based actions and resources for executives, leaders, clinicians, and performance improvement specialists. This document is intended to be used as a guide for healthcare organizations to examine their own workflows, identify practice gaps, and implement improvements. In it, you'll find:

Best Practice Summary: A high level summary of evidence-based, clinical best practices. (page 2)

Executive Summary: Executives should understand the breadth of the problem and its clinical and financial implications. (page 2)

Leadership Checklist: This section is for senior leaders to understand common patient safety problems and their implications related to transfusion safety. Most preventable medical harm occurs due to system defects rather than individual mistakes. Leaders can use this checklist to assess whether best practices are being followed and whether action is needed in their organization around transfusion safety. (page 3)

Clinical Workflow: This section includes more specific information about transfusion safety across the continuum of care. Leaders should include the people doing the work in improving the work. This section outlines what should be happening on the frontline. Clinicians can use this section to inform leaders whether there are gaps and variations in current processes. This is presented as an infographic that can be used for display in a clinical area. (page 5)

Education for Patients and Family Members: This section outlines what frontline healthcare professionals should be teaching patients and family members about transfusion safety. Clinicians can inform leaders whether there are gaps and variations in the current educational processes. (page 7)

Performance Improvement Plan: If it has been determined that there are gaps in current practice, this section can be used by organizational teams to guide them through an improvement project. (page 8)

What We Know about Transfusion Safety: This section provides additional detailed information about blood transfusions. (page 11)

Resources: This section includes helpful links to free resources from other groups working to improve patient safety. (page 12)

Endnotes: This section includes the conflict of interest statement, workgroup member list, and references. (page 13)

Citation: Patient Safety Movement Foundation. (2022). Transfusion Safety Actionable Patient Safety Solutions. Retrieved from <https://patientsafetymovement.org/community/apss/>



Best Practice Summary

Assessment and Decision Making

- Consider alternatives to a blood transfusion, such as patient blood management strategies.
- Evaluate the risks and benefits of a blood transfusion.
- Involve the patient in the decision making process, if possible, and explain the risks, benefits, and alternatives to a blood transfusion.

Appropriate Ordering

- Use a standard order set and clearly communicate key information for the transfusion, including, but not limited to, patient identification, type of units, and special requirements.
- Ensure clear communication between the ordering provider and blood bank personnel.

Order Fulfillment

- Conduct appropriate testing, including, but not limited to, type and screen, ABO for plasma, and antibody identification.
- Appropriately label blood components with all relevant information.
- Ensure blood component is appropriately stored and transported by appropriate personnel.

Verification and Administration

- Ensure two licensed professionals double check all relevant information including, but not limited to, patient identity, patient's and donor's blood ABO group and Rh factor, and crossmatch data.
- Evaluate relevant laboratory and clinical data and document baseline vitals.
- Ensure patient has filled out the consent form.
- Monitor patient for signs of reaction and remain with the patient for at least 15 minutes after administration.
- Alert provider if there are signs of reaction and treat appropriately.
- Complete post-transfusion documentation, including any complications.

Executive Summary

The Problem

Studies show that 1 in 13,000 blood units are administered to the wrong patient and because 1 in 10 in-patients receive at least one unit of blood, highly reliable transfusion processes should be a major patient safety priority around the world ([JPAC, 2020](#); [Cost et al., 2009](#)). Blood transfusions are liquid organ transplants, which inherently have significant risks. It has been shown that there is significant overuse of blood products, inaccurate perceptions of the safety of transfusions, and significant variations in use of blood products by discipline ([Johns Hopkins, 2012](#)).

The Cost

The cost of blood product loss due to errors is estimated at \$593,337. The most common clinical errors with significant implications were sample labeling errors (37.5%), inappropriate

ordering of blood (28.8%), and sample acceptance without meeting acceptance criteria (18.3%) ([Maskens et al., 2013](#)).

The Solution

Many healthcare organizations have successfully implemented and sustained improvements and reduced death from transfusion-related adverse events. This document provides a blueprint that outlines the actionable steps organizations should take to successfully improve transfusion safety and summarizes the available evidence-based practice protocols. This document is revised annually and is always available free of charge on our website.

Leadership Checklist

Use this checklist as a guide to determine whether current evidence-based guidelines are being followed in your organization:

Strengthen the relationship between the blood bank personnel and providers.

- If possible, create a permanent position for a physician trained in transfusion medicine for your organization.
- Equip blood bank personnel with tools to help ordering providers effectively make decisions around the true indications for blood transfusions.
- Standardize the approach to transfusion decision making and incorporate into training, protocols, etc.
- Identify opportunities for collaboration between blood bank personnel and ordering providers (e.g., interdisciplinary education, performance improvement initiatives, design of patient educational material, etc).
- Identify frequent areas of miscommunication between blood bank personnel and ordering providers (e.g., 'unit' terminology and the difference between cc/kilo and unit) and incorporate standards to mitigate in ongoing education, order sets, readily-accessible protocols, EHR, etc.

Ensure transfusions are effectively used.

- Clearly define all criteria for transfusion of all blood components, including appropriate patient assessment (clinical and laboratory).
- Require timely documentation of hemoglobin levels, vital signs, and patient condition before and after each blood transfusion.
- Expect that transfusion decisions are made based on signs and symptoms, in addition to invasive or non-invasive hemoglobin measures and other measures of tissue oxygenation (e.g., NIRS values).
- Thoroughly implement and standardize a patient blood management program across the system to avoid unnecessary transfusions
- Ensure all order sets are designed to prompt all clinical considerations beyond just the 'number'. Ensure these order sets also include information about signs and symptoms.
- Incorporate hard stops for information missing in EHR upon ordering blood for non-actively bleeding patients.

Use debriefs and educational opportunities meaningfully for behavior change.

- Reinforce the importance of documentation post-transfusion and expect that

documentation includes the reason for the transfusion, the outcome of the transfusion, and whether or not the transfusion alleviated the signs and symptoms for which it was ordered

- Standardize expectations for data review (e.g., timeline, what data is reviewed, what data is missing, etc) and prioritize timely feedback to all involved in transfusion safety.
- Ensure data is not exclusively reported to only one 'transfusion safety' committee but is meaningfully shared and used to change gaps in protocols, policies, etc.
- Share information about whether a transfusion could have been prevented and other strategies could have been employed.
- Share information about wasted blood components and understand why excessive blood products were ordered.

Increase awareness of transfusion risks, benefits, and alternatives among all within the organization.

- Provide feedback to partner academic institutions about transfusion safety competencies to include in the graduate curriculum.
- Consistently reinforce the appropriate considerations for transfusion decision making.
- Integrate transfusion guidelines into order sets, EHR, protocols, ongoing education, etc and ensure these guidelines include both the data-driven indications for a transfusion (e.g., hemoglobin level) and the individual-specific criteria that should be considered for a transfusion (e.g., even if the hemoglobin level is low, consider patient signs and symptoms).

Make sure patients know their role in transfusion safety and are aware of the options available to them.

- Standardize discharge education for chronically ill patients that includes if and why they are potentially at risk for future transfusion and what they can do to avoid a transfusion in the future.
- Involve Patient and Family Advisory Councils (PFACs) in understanding what the organization is or is not telling patients and family members about alternatives. Ask whether patient needs are being met with the information given. Involve PFACs in understanding the patient experience post-hospital transfusion to understand how their conditions were maintained or improved.

Implement and sustain performance improvement initiatives.

- Ensure transfusion safety information is mutually reinforcing and consistent in policies, ongoing education, labels, patient education, blood bank personnel tools for communication, EHR order sets, etc.
- Integrate proven technology for blood work to improve patient care, such as:
 - Continuous, non-invasive hemoglobin monitoring
 - Dynamic volume assessments to determine plasma volume
 - Red cell recovery technology in the operating room.
- Listen to those on the frontline about their experience in blood transfusion processes. Involve them in continuous improvement efforts.
- Ensure there are enough staff to effectively manage care when a transfusion is indicated at the bedside. Establish a culture where other bedside clinicians will step in to care for the nurse's other patients when one of the nurse's patients is being transfused.

- Debrief consistently and make people feel safe in sharing their perspectives by offering praise for the information and by making it very easy for them to provide feedback.
- Hold staff accountable for providing the standard of care and reward success.
- Ensure that leaders have a simple process to oversee improvement work while also considering how it aligns with other initiatives across the organization. Ensure the 'transfusion safety' committee is aligned with and communicating with other relevant committees.

Clinical Workflow

1. ASSESS AND CONSIDER ALTERNATIVES

- Complete physical assessment, including fatigue, fainting, shortness of breath, etc.
- Assess the laboratory value against the physical assessment to determine the need for transfusion.
- If hemoglobin is 13 or below, determine the cause of anemia and signs/symptoms related to anemia.
- Consider whether other therapies (e.g., IV iron infusions, ESAs, oral iron therapy, etc) could eliminate the need for a transfusion.
- A transfusion would likely be indicated if:
 - A patient is still actively bleeding and showing signs/symptoms of anemia intolerance
 - A patient has hemoglobin <7 or <8 in a patient with cardiac disease and all measures to address signs and symptoms have been ineffective.
- Consider a transfusion if the patient is both symptomatic, hemoglobin <7 g/dL and/or actively bleeding/threat of continued blood loss.



2. INVOLVE THE PATIENT

- Explain the need for transfusion, why alternatives are not feasible, and the details of the informed consent form. See [Education for Patients and Family Members](#).
- Ensure the patient understands the risks including infection, transfusion circulatory overload, transfusion acute lung injury, allergic reactions, etc.
- Work with the patient to complete an informed consent form and include it in the EHR.



3. ORDER

- Use a standard order set depending on the blood components needed.

- Verify patient identification, number of units, type of units, special requirements (e.g. irradiated, Sickle Cell Negative, washed, etc).
- Conduct type and screen, ABO for plasma, antibody identification/workup for positive screens, etc.
- Communicate with the ordering provider to verify any ambiguous information.



4. FULFILL

- Ensure the label includes compatibility, unit number, unit type, dates of collection, blood type (ABO and Rhesus) date and time of expiration, and patient-specific information (e.g., name, date of birth, medical record number).
- Follow policy for transport of blood and document the time the blood leaves the blood bank.
- Ensure blood is stored properly during transit and for arrival at destination.



5. CHECK AND ADMINISTER

- Ensure two licensed professionals are present to verify:
 - Patient's identity
 - Medical record number
 - Patient's blood ABO group and Rh factor
 - Donor's blood ABO group and Rh factor
 - Crossmatch data
 - Blood bank ID number
 - Expiration date and time of the product.
- Verify the need for medication administration before and after the transfusion.
- Ensure IV pump, normal resuscitation equipment, angiocatheter, PPE, tubing with filter, additional filter if sent by blood bank for non-leukoreduced components, normal saline, and tape are in the room.
- Confirm that type and crossmatch have been completed and "in-date" per institutional guidelines.
- Evaluate relevant laboratory data, including platelet count and coagulation values.
- Confirm that the patient has filled out all necessary paperwork and consent forms.
- Record baseline vitals.

- Use only normal saline to prime tubing.
- Confirm that documentation is complete.



6. ADMINISTER AND MONITOR

- Begin transfusion within 30 minutes of product leaving the blood bank. Complete transfusion within four hours.
- Watch for signs of reaction (e.g., fever, chills, hives, respiratory distress, etc).
- Monitor vital signs at 15 minutes, then per hospital policy.
 - Nurse to stay with the patient for the first 15 minutes.
- Document:
 - Date and time that the transfusion began
 - Name of the second clinician who completed the two person verification process
 - Name and amount of the specific type of transfusion (e.g., one unit of packed red blood cells)
 - Blood product number
 - IV site
 - Size of angiocath used
 - Duration of transfusion
 - Vital signs taken and when
- If signs of reaction:
 - Stop transfusion immediately.
 - Treat reaction.
 - Report to provider.
 - Inform the blood bank that a suspected reaction has occurred and return blood and tubing to the blood bank (do not dispose).
 - Disclose reaction to family members and patients.

Education for Patients and Family Members

The outline below illustrates all of the information that should be conveyed to the patient and family members by someone on the care team in a consistent and understandable manner.

- Explain the issue the patient is facing.
- Identify all feasible treatment options for the patient.
- Discuss with the patient the risks and benefits of each option.
- If a transfusion is indicated,;

- o Explain the different blood components and which is most relevant to the patient’s circumstance
- o Explain why a transfusion may be the best plan of care over alternative therapies
 - “Alternatives, including using medications that help your body produce more red blood cells (e.g., iron, erythropoietin, etc), , administering extra fluid to help correct symptoms, and reusing your own lost blood during surgery, might not be feasible if your symptoms don’t improve.”
- o The informed consent process and purpose
- o Communicate the blood component the patient will be receiving and why.
- o Explain what can be expected post-transfusion and any signs to watch out for.
- o Ensure thorough explanation of necessary post-discharge appointments, therapies, medications, and potential complications. Provide thorough instructions to the patient and family members in the days leading up to discharge regarding post transfusion and recovery after transfusion.
- o Help the patient understand life changes that could prevent a transfusion in the future, if possible
- Make sure the patient understands where they can go at any point if they have questions.

HOW INFORMATION IS TYPICALLY CONVEYED TO PATIENTS	HOW TO IMPROVE
<p>“A transfusion is necessary to manage your iron-deficiency anemia. Please sign the consent form so we can get started.”</p>	<p>“We’ve received your test results back and it appears your iron-deficiency anemia is getting a bit worse, which means that there is not enough oxygen in the body. One treatment option we could consider is a red blood cell transfusion, but we don’t want to do this unless we really have to because of the potential complications. Let’s talk about other options available to see what will work best...”</p>

[Here](#) is a guide for information to share with patients and family members and how to explain it in a way that is easy to understand.

Performance Improvement Plan

Follow this checklist if the leadership team has determined that a performance improvement project is necessary:

- Gather the right project team.** Be sure to involve the right people on the team. You’ll want two teams: an oversight team that is broad in scope, has 10-15 members, and includes the executive sponsor to validate outcomes, remove barriers, and facilitate spread. The actual project team consists of 5-7 representatives who are most impacted by the process. Whether a discipline should be on the advisory team or the project team depends upon the needs of the organization. Patients and family members should be involved in all improvement projects, as there are many ways they can contribute to safer care.

Complete this Lean Improvement Activity:



Conduct a [SIPOC](#) analysis to understand the current state and scope of the problem. A SIPOC is a lean improvement tool that helps leaders to carefully consider everyone who may be touched by a process, and therefore, should have input on future process design.

RECOMMENDED TRANSFUSION SAFETY IMPROVEMENT TEAM

- Providers who have the ability to order transfusions (Surgeons, anesthesiologists, nurse practitioners, etc.)
- Transfusion medicine specialists/Blood bank personnel
- Senior leaders
- Nurses
- Quality management
- Clinical educators
- Academic educators
- Discharge coordinators/Case managers
- Information technology department
- General practitioners/family doctors
- Patient and family members
- Central laboratory/laboratory scientists
- Pharmacists/purchasing department
- Finance department

Table 1: Understanding the necessary disciplines for a transfusion safety improvement team.

- Understand what is currently happening and why.** Reviewing objective data and trends is a good place to start to understand the current state, and teams should spend a good amount of time analyzing data (and validating the sources), but the most important action here is to go to the point of care and observe. Even if team members work in the area daily, examining existing processes from every angle is generally an eye-opening experience. The team should ask questions of the frontline during the observations that allow them to understand each step in the process and identify the people, supplies, or other resources needed to improve patient outcomes.

Create a [process map](#) once the workflows are well understood that illustrates each step and the best practice gaps the team has identified ([IHI, 2015](#)). Brainstorm with the advisory team to understand why the gaps exist, using whichever [root cause analysis tool](#) your organization is accustomed to ([IHI, 2019](#)). Review the map with the advisory team and invite the frontline to validate accuracy.



TRANSFUSION SAFETY PROCESSES TO CONSIDER ASSESSING

- Evaluation of alternative therapies
- Anemia testing and monitoring before, during, and after surgery
- Laboratory test order process
- Documentation before and after transfusion
- Transfusion decision process
- Pre-surgical test for coagulation
- Identification of patients at risk for hemorrhage
- Proper documentation and confirmation of blood products from type and screen through transfusion
- Proper patient identification prior to transfusion
- Anemia management
- Coagulation management
- Blood conservation technique consideration and implementation
- Massive hemorrhage/bleeding protocols
- Labeling of blood products
- Communication between provider and blood bank personnel

Table 2: Consider assessing these processes to understand where the barriers contributing to poor transfusion safety may be in your organization

- **Prioritize the gaps to be addressed and develop an action plan.** Consider the cost effectiveness, time, potential outcomes, and realistic possibilities of each gap identified. Determine which are a priority for the organization to focus on. Be sure that the advisory team supports moving forward with the project plan so they can continue to remove barriers. Design an experiment to be trialed in one small area for a short period of time and create an action plan for implementation.

The action plan should include the following:



- Assess the ability of the culture to change and adopt appropriate strategies
- Revise policies and procedures
- Redesign forms and electronic record pages
- Clarify patient and family education sources and content
- Create a plan for changing documentation forms and systems
- Develop the communication plan
- Design the education plan
- Clarify how and when people will be held accountable

TYPICAL GAPS IDENTIFIED IN TRANSFUSION PROCEDURES

- | | |
|---|---|
| <ul style="list-style-type: none"> • Lack of standardized processes for patient identification and confirmation pre-transfusion • Poor blood product labeling • Lack of thorough evaluation of alternatives to transfusion • Lack of standardization of storage protocols • Unclear standards for labeling products • Poor shared decision making | <ul style="list-style-type: none"> • There is no documentation post-transfusion to determine if the transfusion solved the issue. • There's significant emphasis on the laboratory values without consideration of other factors, like physical assessment, when determining the need for a transfusion. • Blood bank personnel and providers use terms that represent different ideas (e.g., "unit"). |
|---|---|

Table 3: By identifying the gaps in transfusion processes, organizations can tailor their project improvement efforts more effectively

- **Evaluate outcomes, celebrate wins, and adjust the plan when necessary.** Measure both process and outcome metrics. Outcome metrics include the rates outlined in the leadership checklist. Process metrics will depend upon the workflow you are trying to improve and are generally expressed in terms of compliance with workflow changes. Compare your outcomes against other related metrics your organization is tracking.

Routinely review all metrics and trends with both the advisory and project teams and discuss what is going well and what is not. Identify barriers to completion of action plans, and adjust the plan if necessary. Once you have the desired outcomes in the trial area, consider spreading to other areas ([IHI, 2006](#)).

It is important to be nimble and move quickly to keep team momentum going, and so that people can see the results of their labor. At the same time, don't move so quickly that you don't consider the larger, organizational ramifications of a change in your plan. Be sure to have a good understanding

[Read this paper](#) from the Institute for Healthcare Improvement to understand how small local steps



of the other, similar improvement projects that are taking place so that your efforts are not duplicated or inefficient.

TRANSFUSION SAFETY METRICS TO CONSIDER ASSESSING

Structural Measures

- Transfusion medicine specialist availability
 - Whether there's personnel such as a transfusion medicine physician at the healthcare setting
- Blood management information system (Asthana et al., 2017)
 - Whether there's an integrated information exchange system that will allow:
 - ◊ The blood bank staff to send real-time response to the bedside clinicians if there's any issue with the transfusion orders
 - ◊ Both blood bank staff and bedside clinicians to have a real-time view of blood inventory by location
 - ◊ The blood bank staff to monitor and track the usage of blood products once they are sent out of the blood bank
- Transfusion data review

Process Measures

- Rate of use of alternatives to a transfusion
- Patient education rate
- Re-work due to lack of tests or missing information in documentation
- Bar code scanning rate
- Single unit transfusion rate
- Complete post-transfusion documentation rate
- Post-transfusion documentation rate
- Blood return and wastage rate
- Transfusion competency reassessment rate

Outcome Measures

- Transfusion-related adverse event rate

Table 4: Consider evaluating related metrics to better understand transfusion safety practices

What We Know About Transfusion Safety

Transfusions are often used to manage anemia, a problem that impacts around 1 in 3 people worldwide ([Kassebaum et al., 2014](#)). Anemia is the source for 68.3 million years lived with disability and 8.8% of all ailments globally ([McLean et al., 2008](#)). In hospitals, anemic patients have been shown to have a 30-day mortality rate of 13 times more than their non-anemic counterparts ([Musallam et al., 2011](#)). Additionally, anemic patients have a higher likelihood of death (+20%), longer hospital stays, are at an increased risk for falls, and are more likely to contract a hospital-acquired infection ([Baron et al., 2014](#)).

Nearly 120 million units of blood are donated every year, 42% are in high-income countries ([WHO, n.d.](#)). Although blood transfusions are considered life-saving critical interventions and are one of the most common procedures performed in hospitals, they may result in adverse events due to technology restrictions or unstandardized processes. For example, it is estimated that 1 in 373 of US transfusions lead to non-infectious adverse events, including febrile nonhemolytic transfusion reactions, mild-moderate transfusion reactions, and delayed serologic transfusion reactions ([Sapiano et al., 2015](#)). On the other hand, transfusion related infections are more common in low income countries, where many healthcare systems are not able to adequately screen donated blood for diseases such as HIV, hepatitis B, hepatitis C and syphilis according to quality system requirements ([WHO, n.d.](#)).

Delays in collection, wrong blood in tube collected, or incorrect or no label applied to the

specimen are the most common cause of non-infectious transfusion adverse events during the specimen collection process (61%). Wrong blood components being dispensed (15%) is the top cause of related adverse events in laboratory errors. Factors such as patient reaction to blood components (35%), intravenous line issues (17%) and incorrect blood components being administered (12%) contribute significantly to transfusion safety events in clinical areas ([PA Patient Safety Authority, 2010](#); [Murphy, Stanworth & Yazar, 2010](#)).

Apart from transfusion-related adverse events, blood product wastage is another issue that draws attention. It is estimated that 5.2% of the whole blood donations are wasted around the world, costing 1 billion dollars (\$200 per unit) ([Beckman et al., 2019](#)). One potential reason is that transfusions are often given when simpler, safer alternatives can provide equal or greater benefit. Not only is this a waste of a scarce resource but it also exposes patients to the risk of serious adverse transfusion reactions ([WHO, 2011](#)). Technology restrictions can also drive wastage of blood products, especially in less-developed countries and regions. It is estimated that only 37% of the blood collected in low-income countries is able to be separated into components due to a lack of appropriate technology or inadequate quality systems, good manufacturing practices, and regulatory controls. For the blood products that can't meet patients' transfusion requirements, they can be categorized as waste material and destroyed.

Resources

For Transfusion Safety Improvement:

- [SHOT: Why do we make mistakes? Human factors in transfusion practice](#)
- [WHO: Manual on the management, maintenance and use of blood cold chain equipment](#)
- [Posters from Serious Hazards of Transfusion Symposium](#)
- [California Simulation Alliance: Transfusion Reaction Simulation Exercise](#)
- [Blood transfusion reaction team debrief activity](#)
- [WHO: Blood Management](#)
- [World Health Organization's Clinical Transfusion Practice Guideline](#)
- [A Framework to Support Nurses and Midwives Making the Clinical Decision and Providing the Written Instruction for Blood Component Transfusion](#)
- [Transfusion Reactions](#)
- [Transfusion Errors and Management](#)
- [Approach to the Patient with a Suspected Acute Transfusion Reaction](#)
- [Acute Transfusion Reaction Clinical Workflow Infographic](#)
- [Storage, Inspection, and Administration Guidelines from New Delhi, India](#)
- [JPAC: Transfusion of Blood Components](#)
- [Blood Transfusion: The Patient's Experience](#)

For General Improvement:

- [CMS: Hospital Improvement Innovation Networks](#)
- [IHI: A Framework for the Spread of Innovation](#)
- [The Joint Commission: Leaders Facilitating Change Workshop](#)



- [IHI: Quality Improvement Essentials Toolkit](#)
- [SIPOC Example and Template for Download](#)
- [SIPOC Description and Example](#)

Endnotes

Conflicts of Interest Disclosure

The Patient Safety Movement Foundation partners with as many stakeholders as possible to focus on how to address patient safety challenges. The recommendations in the APSS are developed by workgroups that may include patient safety experts, healthcare technology professionals, hospital leaders, patient advocates, and medical technology industry volunteers. Workgroup members are required to disclose any potential conflicts of interest.

Workgroup

Co-Chairs

Aryeh Shander

Englewood Hospital and Medical Center

Kai Zacharowski

University Hospital Frankfurt

Members

This list represents all contributors to this document since inception of the Actionable Patient Safety Solutions.

Steven Barker

Patient Safety Movement Foundation; Masimo

Suma Choorapoikayil

University Hospital Frankfurt

William Floyd

iPASS, Inc.

Ann Gordon

UT Southwestern Medical Center

Shiu-Ki Rocky Hui

Texas Children's Hospital

Josiah Huse

University of California, Irvine

Ariana Longley

Patient Safety Movement Foundation

Patrick Meybohm

University Hospital Wuerzburg

Stacey Orsat

Masimo

Sherri Osawa

Society for the Advancement of Patient Blood Management

Tomas Sanabria

Patient Safety Movement Foundation

Kerry Tomlin

Medtronic

Jonathan Waters

University of Pittsburgh Medical Center

Mary Kay Wisniewski

University of Pittsburgh Medical Center

Thomas Zeltner

Bluewin

Metrics Integrity

Robin Betts

Kaiser Permanente, Northern California Region

References

- Adams, K. W., & Tolich, D. (2011). Original research: Blood transfusion: The patient's experience. *AJN, American Journal of Nursing*, 111(9), 24-30. <https://doi.org/10.1097/01.naj.0000405057.23324.a8>
- Adverse effects of transfusion. (2003). Retrieved from https://www.rch.org.au/bloodtrans/adverse_effects/Adverse_effects_of_transfusion/
- American Society of Anesthesiologists Task Force on Perioperative Blood Management. Practice Guidelines for Perioperative Blood Management: an Updated Report by the American Society of Anesthesiologists Task Force on Perioperative Blood Management*. *Anesthesiology*. 2015 Feb;122(2):241-75.
- Arzejewski, C., Levy, R., Pantanowitz, L., Cloutier, D., Provencher, J., McGirr, J., Stebbins, J., Cronin, S., Wherry, J., Fenton, J., Donelan, E., & Johari, V. (2010). Development of electronic medical record charting for hospital-based transfusion and apheresis medicine services: Early adoption perspectives. *Journal of Pathology Informatics*, 1(1), 8. <https://doi.org/10.4103/2153-3539.65345>
- Arriaga, A. F., Szyld, D., & Pian-Smith, M. C. M. (2020). Real-time debriefing after critical events. *Anesthesiology Clinics*, 38(4), 801-820. <https://doi.org/10.1016/j.anclin.2020.08.003>
- Asthana, V., Singh, S., Deshwal, A., & Singh, T. (2017). Intraoral swelling in a Neonate: Airway management a challenge. *Journal of Blood Disorders & Transfusion*, 05(01). <https://doi.org/10.4172/2155-9864.1000283>
- AuBuchon, J. P. (2011). The role of haemovigilance in transfusion safety. *Practical Transfusion Medicine*, 181-189. <https://doi.org/10.1002/9781444311761.ch18>

- Baker, L., Park, L., Gilbert, R., Ahn, H., Martel, A., Lenet, T., Davis, A., McIsaac, D. I., Timmouth, A., Fergusson, D. A., & Martel, G. (2020). Intraoperative red blood cell transfusion decision-making. *Annals of Surgery*, 274(1), 86-96. <https://doi.org/10.1097/sla.0000000000004710>
- Bala, N., Sandhu, K. S., Bansal, L., Attri, J. P., Sandhu, G. K., & Mohan, B. (2015). Conflicts in the operating room: Focus on causes and resolution. *Saudi Journal of Anaesthesia*, 9(4), 457. <https://doi.org/10.4103/1658-354x.159476>
- Baron, D. M., Hochrieser, H., Posch, M., Metnitz, B., Rhodes, A., Moreno, R. P., Pearse, R. M., & Metnitz, P. (2014). Preoperative anaemia is associated with poor clinical outcome in non-cardiac surgery patients. *British Journal of Anaesthesia*, 113(3), 416-423. <https://doi.org/10.1093/bja/aeu098>
- Barsley, L. (2006). Competency Framework for the Administration of all Blood Products. Retrieved 2021.
- Basu, D., & Kulkarni, R. (2014). Overview of blood components and their preparation. *Indian Journal of Anesthesia*, 529-537.
- Beckman, N., Ansah, J., Follea, G., & Yazer, M. H. (2019). International Society for Blood Transfusion international survey on blood product wastage in low-and middle-income countries. *ISBT Science Series*, 14(3). <https://doi.org/10.1111/voxs.12494>
- Blood Components: How can one donation help multiple people? (2020). Retrieved from [https://www.redcrossblood.org/donate-blood/how-to-donate/types-of-blood-donations/blood-components.html#:~:text=Whole%20blood%20is%20used%20to,blood%20drive%20or%20blood%20center.&text=Red%20blood%20cells%20\(RBCs\)%2C,give%20blood%20its%20distinctive%20color](https://www.redcrossblood.org/donate-blood/how-to-donate/types-of-blood-donations/blood-components.html#:~:text=Whole%20blood%20is%20used%20to,blood%20drive%20or%20blood%20center.&text=Red%20blood%20cells%20(RBCs)%2C,give%20blood%20its%20distinctive%20color)
- Blood Donation: What are the minimum requirements to become a blood donor? (2020). Retrieved from <http://www.aabb.org/tm/donation/Pages/donatefaqs.aspx>
- Blood Transfusion Services. (2020). Retrieved from www.utmb.edu/bloodbank
- Brown, M. J., Button, L. M., Badjie, K. S., Guyer, J. M., Dhanorker, S. R., Brach, E. J., Johnson, P. M., & Stubbs, J. R. (2013). Implementation of an intraoperative blood transport and storage initiative and its effect on reducing red blood cell and plasma waste. *Transfusion*, 54(3), 701-707. <https://doi.org/10.1111/trf.12315>
- Carson, J. L., Carless, P. A. and Hebert, P. C. (2012). Transfusion Thresholds and Other Strategies for Guiding Allogeneic Red Blood Cell Transfusion... *Cochrane Database Syst Rev*, CD002042.
- Carson, J. L. (2012). Red Blood Cell Transfusion: A Clinical Practice Guideline From the AABB. *Annals of Internal Medicine*, 157(1), 49. doi:10.7326/0003-4819-157-1-201206190-00429.
- Carson, J. L., Guyatt, G., & Heddle, N. M. (2016). Clinical Practice Guidelines From the AABB Red Blood Cell Transfusion Thresholds and Storage. Special Communication.
- Centers for Disease Control and Prevention. (2020). What you should know before your surgery. Centers for Disease Control and Prevention. Retrieved September 21, 2021, from https://www.cdc.gov/patientsafety/features/before-surgery.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Ffeatures%2Fsafesurgery%2Findex.html.
- Chaparro, C. M., & Suchdev, P. S. (2019). Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. *The New York Academy of Science*, 15-31.
- Chou, S.-S., Chen, Y.-J., Shen, Y.-T., Yen, H.-F., & Kuo, S.-C. (2019). Implementation and effectiveness of a bar code-based transfusion management system for transfusion safety in a tertiary hospital: Retrospective quality improvement study. *JMIR Medical Informatics*, 7(3). <https://doi.org/10.2196/14192>
- Clinical Transfusion Practice: Guidelines for Medical Interns. (2000). World Health Organization.
- Creating a foundation for safe and Reliable Care • patient safety movement. Patient Safety Movement. (2021, June 29). Retrieved September 21, 2021, from <https://patientsafetymovement.org/clinical/creating-a-foundation-for-safe-and-reliable-care/>.
- Collection of blood components and delivery to clinical areas. (2013). *Joint United Kingdom (UK) Blood Transfusion and Tissue Transplantation Services Professional Advisory Committee*, 8.
- Cost, H., (HCUP, U. P. and others. (2009). HCUP Facts and Figures: Statistics on Hospital-based Care in the United States, 2007.
- De Pietro. (2018). How many blood transfusions can a person have? What to know. *Medical News Today*. Retrieved September 21, 2021, from <https://www.medicalnewstoday.com/articles/320664#overview>.
- Derzon, J. H., Clarke, N., Alford, A., Gross, I., Shander, A., & Thurer, R. (2019). Restrictive transfusion strategy and clinical decision support practices for reducing rbc transfusion overuse. *American Journal of Clinical Pathology*, 152(5), 544-557. <https://doi.org/10.1093/ajcp/aqz070>
- Doyle, G. R., & McCutcheon, J. A. (2015). Transfusion of Blood and Blood Products. BC Campus.
- Eppich, W., & Cheng, A. (2021). PEARLS Scripted Debriefing Tool - Quickstart Guide. Retrieved 2021, from https://www.heart.org/idc/groups/heart-public/@wcm/@hcm/@gwtg/documents/downloadable/ucm_486571.pdf.
- Frank, S. M. (2012). Blood Transfusions Still Overused and May Do More Harm Than Good in Some Patients. *John Hopkins Medicine*.
- Freedman, J. (2014). *Transfusion-Whence and Why... Transfus Apher Sci*, 50, 5-9.
- Hill, K. (2016). Prospectus Elements: Standardized Blood Transfusion Documentation. Retrieved 2021, from <https://repository.usfca.edu/cgi/view-content.cgi?article=1391&context=capstone>.
- Hill, S. E., Broomer, B., Stover, J. and White, W. (2011). Accuracy of Estimated Blood Loss in Spine Surgery. In Proceedings of the American Society of Anesthesiologists (ASA) 2011 Annual Meeting.
- Iliassa, I. I., Zahiruddin Wan Mohammad, W., Tan, J. J., & Ayob, Y. (2016). A retrospective review of cryoprecipitate transfusion practice in Kuala Lumpur Hospital. *Asian Journal of Transfusion Medicine*, 145-149.
- Institute for Healthcare Improvement. (2006). *A framework for spread: From local improvements to system-wide change: Ihi. Institute for Healthcare Improvement*. Retrieved September 21, 2021, from <http://www.ihl.org/resources/Pages/IHIWhitePapers/AFrameworkforSpreadWhitePaper.aspx>.
- Institute for Healthcare Improvement. (2015). *5 steps for creating value through process mapping and observation*. Institute for Healthcare Improvement. Retrieved September 21, 2021, from <http://www.ihl.org/communities/blogs/5-steps-for-creating-value-through-process-mapping-and-observation>.
- IHS. (2016). *Documenting Blood Administration . Integrated Healthcare Information System*. Retrieved 2021, from <https://hrs.osu.edu/-/media/files/wexnermedical/healthcare-professionals/clinical-labs/transfusion-services/documenting-blood-administration-tip-sheet.pdf?la=en&hash=5B7C3C19E90CE6BF9A322C24CEAA079AFA308BCB>.

- Johns Hopkins. (2012). Retrieved September 21, 2021, from https://www.hopkinsmedicine.org/news/media/releases/blood_transfusions_still_overused_and_may_do_more_harm_than_good_in_some_patients.
- Joint United Kingdom (UK) Blood Transfusion and Tissue Transplantation Services Professional Advisory Committee. (2020).
- JPAC, T. I. S. (2020). JPAC - TRANSFUSION GUIDELINES. Safe transfusion - right blood, right patient, right time and right place. Retrieved September 21, 2021, from <https://www.transfusionsguidelines.org/transfusion-handbook/4-safe-transfusion-right-blood-right-patient-right-time-and-right-place>.
- Kassebaum, N. J., Jasrasaria, R., Naghavi, M., Wulf, S. K., Johns, N., Lozano, R., Regan, M., Weatherall, D., Chou, D. P., Eisele, T. P., Flaxman, S. R., Pullan, R. L., Brooker, S. J., & Murray, C. J. (2014). A systematic analysis of GLOBAL Anemia burden from 1990 to 2010. *Blood*, 123(5), 615-624. <https://doi.org/10.1182/blood-2013-06-508325>
- Khawar, H., Kelley, W., & Guzman, N. (2020). Fresh Frozen Plasma (FFP). *Stat Pearls*.
- Leal-Noval SR, Arellano-Orden V, Munoz-Gomez M, et al. (2017). Red Blood Cell Transfusion Guided by Near Infrared Spectroscopy in Neurocritically Ill Patients with Moderate or Severe Anemia: A Randomized, Controlled Trial. *J Neurotrauma*, 34(17), 2553-2559.
- Levi, M. (2014). Twenty-five Million Liters of Blood into the Sewer. *Journal of Thrombosis and Haemostasis*, 12(10), 1592-1592. doi:10.1111/jth.12656.
- London Health Science: Iron. (2020). Retrieved from <https://www.lhsc.on.ca/perioperative-patient-blood-management-program/iron>
- Manitoba Transfusion Best Practice Resource Manual. *Section 4 Competency Requirements*. (2017). Retrieved 2021, from <https://bestbloodmanitoba.ca/wp-content/uploads/2016/12/Section-4-Continuous-Competency-Assessment-for-Nurses.pdf>
- Mariani, E., & Pulsatelli, L. (2020). Platelet Concentrates in Musculoskeletal Medicine. *International Journal of Molecular Science*.
- Marik, P. E., Pastores, S. M., Annane, D., Meduri, G. U., Sprung, C. L., Arlt, W., ... Vogeser, M. (2008). Recommendations for the Diagnosis and Management of Corticosteroid Insufficiency in Critically Ill Adult Patients: Consensus Statements from an International Task Force by the American College of Critical Care Medicine... *Crit Care Med*, 36, 1937-49.
- Masimo Corp. (2012). Masimo Corporation Estimate.
- Maskens, C., Downie, H., Wendt, A., Lima, A., Merkley, L., Lin, Y., & Callum, J. (2013). Hospital-based transfusion error tracking from 2005 to 2010: Identifying the key errors threatening patient transfusion safety. *Transfusion*, 54(1), 66-73. <https://doi.org/10.1111/trf.12240>
- McCullough, J., Refaai, M. A., & Cohn, C. S. (2015). Blood Procurement and Red Cell Transfusion. *William's Hematology*.
- McLean, E., Cogswell, M., Egli, I., Wojdyla, D., & de Benoist, B. (2008). Worldwide prevalence Of ANAEMIA, WHO vitamin and mineral nutrition information System, 1993-2005. *Public Health Nutrition*, 12(04), 444. <https://doi.org/10.1017/s1368980008002401>
- Müller, M. M., Geisen, C., Zacharowski, K., Tonn, T., & Seifried, E. (2015). Transfusion of Packed Red Cells Indications, Triggers and Adverse Events. *Deutsches Arzteblatt*, 507-518.
- Murphy, G. J., Reeves, B. C., Rogers, C. A., Rizvi, S. I. A., Culliford, L. and Angelini, G. D. (2007). Increased Mortality Postoperative Morbidity, and Cost After Red Blood Cell Transfusion in Patients Having Cardiac Surgery. *Circulation*, 116(22), 2544-2552. doi:10.1161/circulationaha.107.698977
- Murphy, M. F., Harris, A., & Neuberger, J. (2021). Consent for blood transfusion: Summary of recommendations from the Advisory Committee for the safety of BLOOD, tissues and Organs (SaBTO). *Clinical Medicine*, 21(3), 201-203. <https://doi.org/10.7861/clinmed.2020-1035>
- Murphy, M., Stanworth, S. & Yazar, M. (2010). Transfusion practice and safety: current status and possibilities for improvement. <https://doi.org/10.1111/j.1423-0410.2010.01366.x>
- Musallam, K. M., Tamim, H. M., Richards, T., Spahn, D. R., Rosendaal, F. R., Habbal, A., Khreiss, M., Dahdaleh, F. S., Khavandi, K., Sfeir, P. M., Soweid, A., Hoballah, J. J., Taher, A. T., & Jamali, F. R. (2011). Preoperative anaemia and postoperative outcomes in non-cardiac surgery: A retrospective cohort study. *The Lancet*, 378(9800), 1396-1407. [https://doi.org/10.1016/s0140-6736\(11\)61381-0](https://doi.org/10.1016/s0140-6736(11)61381-0)
- NHS. (2012). Blood transfusion policy and procedures. Retrieved September 21, 2021, from https://www.transfusionsguidelines.org/document-library/documents/blood-transfusion-policy-and-procedures/download-file/rtc-scent_2015_06_P_tx_ox_univ_hosps.pdf.
- Paganini, M., Abowali, H., Bosco, G., Balouch, M., Enten, G., Deng, J., Shander, A., Ciesla, D., Wilson, J., & Camporesi, E. (2021). Quality improvement project of a Massive TRANSFUSION Protocol (MTP) to reduce wastage of blood components. *International Journal of Environmental Research and Public Health*, 18(1), 274. <https://doi.org/10.3390/ijerph18010274>
- PA Patient Safety Authority. (2010). Improving the Safety of the Blood Transfusion Process. Retrieved from http://patientsafety.pa.gov/ADVISORIES/Pages/201006_33.aspx
- Patient Safety Essentials Toolkit: Ihi*. Institute for Healthcare Improvement. (2019). Retrieved September 21, 2021, from <http://www.ihl.org/resources/Pages/Tools/Patient-Safety-Essentials-Toolkit.aspx>.
- Patient Safety Essentials Toolkit*. Institute for Healthcare Improvement. (2021). Retrieved September 21, 2021, from <http://www.ihl.org/resources/Pages/Tools/Patient-Safety-Essentials-Toolkit.aspx>.
- Patient Safety Movement. (2021). *January Webinar: Improving patient safety Using CANDOR*. YouTube. Retrieved September 21, 2021, from <https://www.youtube.com/watch?v=L7PD1sRvEno&list=PL1t1eQbvK0QdiM3GAzRJ2zj3KzvD9Pg0H&index=15>.
- Platelet Concentrates. (2009). *Transfus Med Hemother*, 372-382.
- Practice guidelines for perioperative blood Management. (2015). *Anesthesiology*, 122(2), 241-275. <https://doi.org/10.1097/aln.0000000000000463>
- Saint Luke's: When You Need a Blood Transfusion (Adult). (2020). Retrieved from <https://www.saintlukeskc.org/health-library/when-you-need-blood-transfusion-adult>
- Salisbury, A. C., Reid, K. J., Alexander, K. P., Masoudi, F. A., Lai, S. M., Chan, P. S., ... Kosiborod, M. (2011). Diagnostic Blood Loss from Phlebotomy and Hospital-acquired Anemia During Acute Myocardial Infarction... *Arch Intern Med*, 171, 1646-53.
- Sapiano, M. et al. (2015). Supplemental findings from the National Blood Collection and Utilization Surveys, 2013 and 2015. *Transfusion*. Retrieved from <https://onlinelibrary.wiley.com/doi/10.1111/trf.14168>
- Sarode, R. (2020). Precautions and Adverse Reactions During Blood Transfusion. *MSD Manual*.
- Schiffer, C. A., Anderson, K. C., Bennett, C. L., Bernstein, S., Elting, L., Goldsmith, M., . . . Wagnon, A. H. (2001). Platelet transfusion for patients with cancer: Clinical practice guidelines of the American Society of Clinical Oncology. *Laboratory Medicine and Pathology*, 19(5), 1519-1538.

- Sipoc+cm diagram. ASQ. (2021.). Retrieved September 21, 2021, from <https://asq.org/quality-resources/sipoc>.
- SSDI. (2021, June 5). How to complete the sipoc diagram. Sixsigma DSI. Retrieved September 21, 2021, from <https://sixsigmadsi.com/how-to-complete-the-sipoc-diagram/>.
- Suddock, J. T., & Crookston, K. P. (2020). Transfusion Reactions. Statpearls.
- Target Information Systems. (2014). JPAC - TRANSFUSION GUIDELINES. Welcome to JPAC. Retrieved September 21, 2021, from <https://www.transfusionguidelines.org/transfusion-handbook/4-safe-transfusion-right-blood-right-patient-right-time-and-right-place/4-10-administration-to-the-patient>.
- Target Information Systems. (2014). JPAC - TRANSFUSION GUIDELINES. Welcome to JPAC. Retrieved September 21, 2021, from <https://www.transfusionguidelines.org/transfusion-handbook/4-safe-transfusion-right-blood-right-patient-right-time-and-right-place/4-10-administration-to-the-patient>.
- Target Information Systems. (2021). JPAC - TRANSFUSION GUIDELINES. Welcome to JPAC. Retrieved September 21, 2021, from <https://www.transfusionguidelines.org/transfusion-handbook/4-safe-transfusion-right-blood-right-patient-right-time-and-right-place/4-7-pre-transfusion-blood-sampling>.
- The Royal Children's Hospital Melbourne. (2021). Retrieved September 21, 2021, from https://www.rch.org.au/bloodtrans/adverse_effects/Adverse_effects_of_transfusion/.
- Tynngård, N. (2009). Preparation, storage and quality control of platelet concentrates. *Science Direct*, 41(2), 97-104.
- Veen, J., Vora, A., & Welch, J. (2003). Guidelines for the use of platelet transfusions. *British Committee for Standards in Hematology, Blood Transfusion Task Force*, 122(1), 10-23.
- Vretzakis G, Georgopoulou S, Stamoulis K, Tassoudis V, Mikroulis D, Giannoukas A, Tsilimingas N, Karanikolas M. (2013). Monitoring of Brain Oxygen Saturation (INVOS) in a Protocol to Direct Blood Transfusions During Cardiac Surgery: a Prospective Randomized Clinical Trial. *J Cardiothorac Surg*, 8(145).
- Weiser, T. G., Regenbogen, S. E., Thompson, K. D., Haynes, A. B., Lipsitz, S. R., Berry, W. R. and Gawande, A. A. (2008). *An Estimation of the Global Volume of Surgery: a Modelling Strategy Based on Available Data...* *Lancet*, 372, 139-44.
- What Happens to Donated Blood: Your blood journeys through many steps and tests that ensure our blood supply is as safe as possible and helps as many people as possible. (2020). Retrieved from <https://www.redcrossblood.org/donate-blood/blood-donation-process/what-happens-to-donated-blood.html#:~:text=Red%20cells%20are%20stored%20in,for%20up%20to%20one%20year>.
- Whitlock, E. L., Kim, H. and Auerbach, A. D. (2015). Harms Associated with Single Unit Perioperative Transfusion: Retrospective Population Based Analysis. *BMJ*, 350(jun12 21), h3037-h3037. doi:10.1136/bmj.h3037.
- Whitney, G. M., Woods, M. C., France, D. J., Austin, T. M., Deegan, R. J., Paroskie, A., Booth, G. S., Young, P. P., Dmochowski, R. R., Sandberg, W. S., & Pilla, M. A. (2015). Reducing intraoperative red blood cell unit wastage in a large academic medical center. *Transfusion*, 55(11), 2752-2758. <https://doi.org/10.1111/trf.13214>
- World Health Organization. (2010). *Availability, Safety and Quality of Blood Products. Sixty-Third World Health Assembly*, 21.
- WHO. (n.d.). Blood transfusion safety. Retrieved from https://www.who.int/health-topics/blood-transfusion-safety#tab=tab_1
- WHO. (2011). Global Database on Blood Safety. Retrieved from https://www.who.int/bloodsafety/global_database/GDBS_Summary_Report_2011.pdf?ua=1 que
- World Health Organization. (2011). Haemoglobin Concentrations for the Diagnosis of Anaemia and Assessment of Severity.
- World Health Organization. (2021). *Clinical Transfusion Practice - Guidelines for Medical Interns*. World Health Organization.