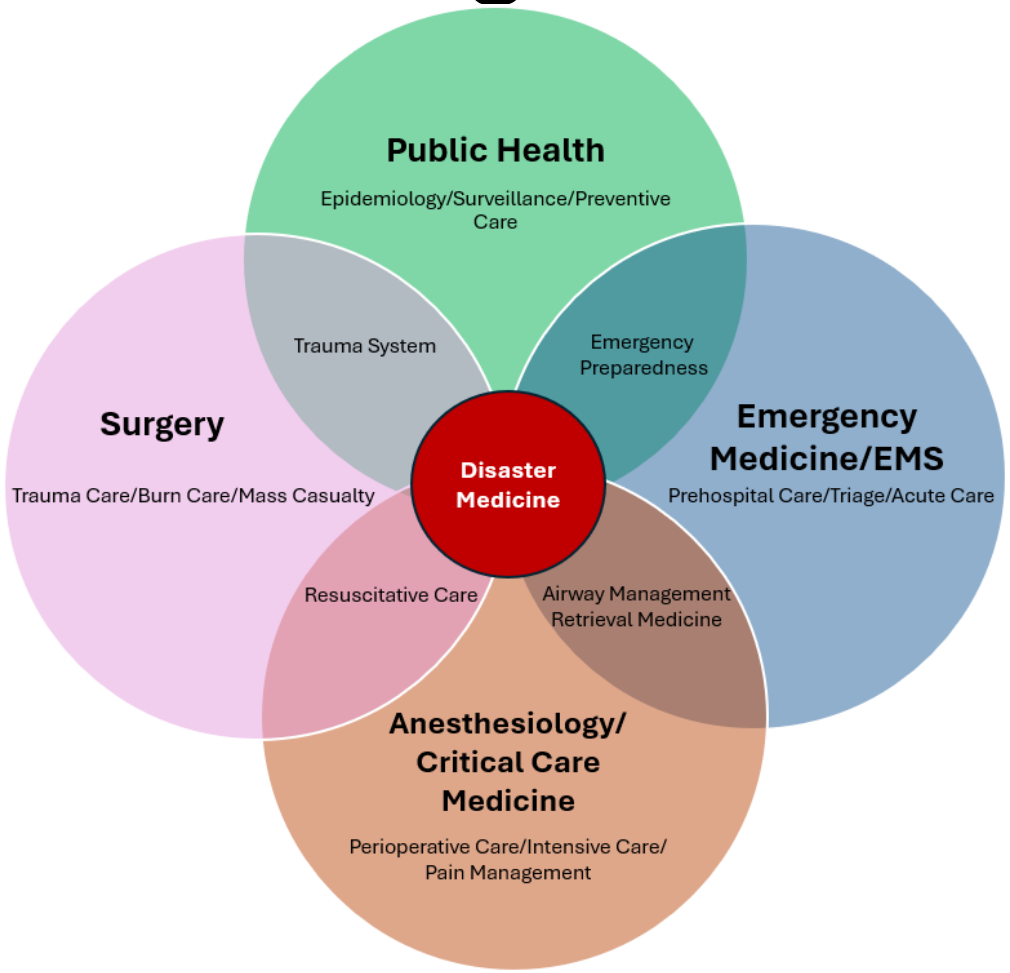
From Blood Supply to Blood Resilience

THE VIEW FROM THE TIP OF THE SPEAR

Brent Lee, MD, MPH, FASA
Patient Safety Officer
North American Partners in Anesthesia

- American Society of Anesthesiologists, Committee on Trauma and Emergency Preparedness
- National Center for Health Security and Resilience, Georgetown University/MedStar
- WFSA Disaster Planning Working Group
- Blood Desert Coalition

Anesthesiologists Role in Disasters and Large-Scale Emergencies



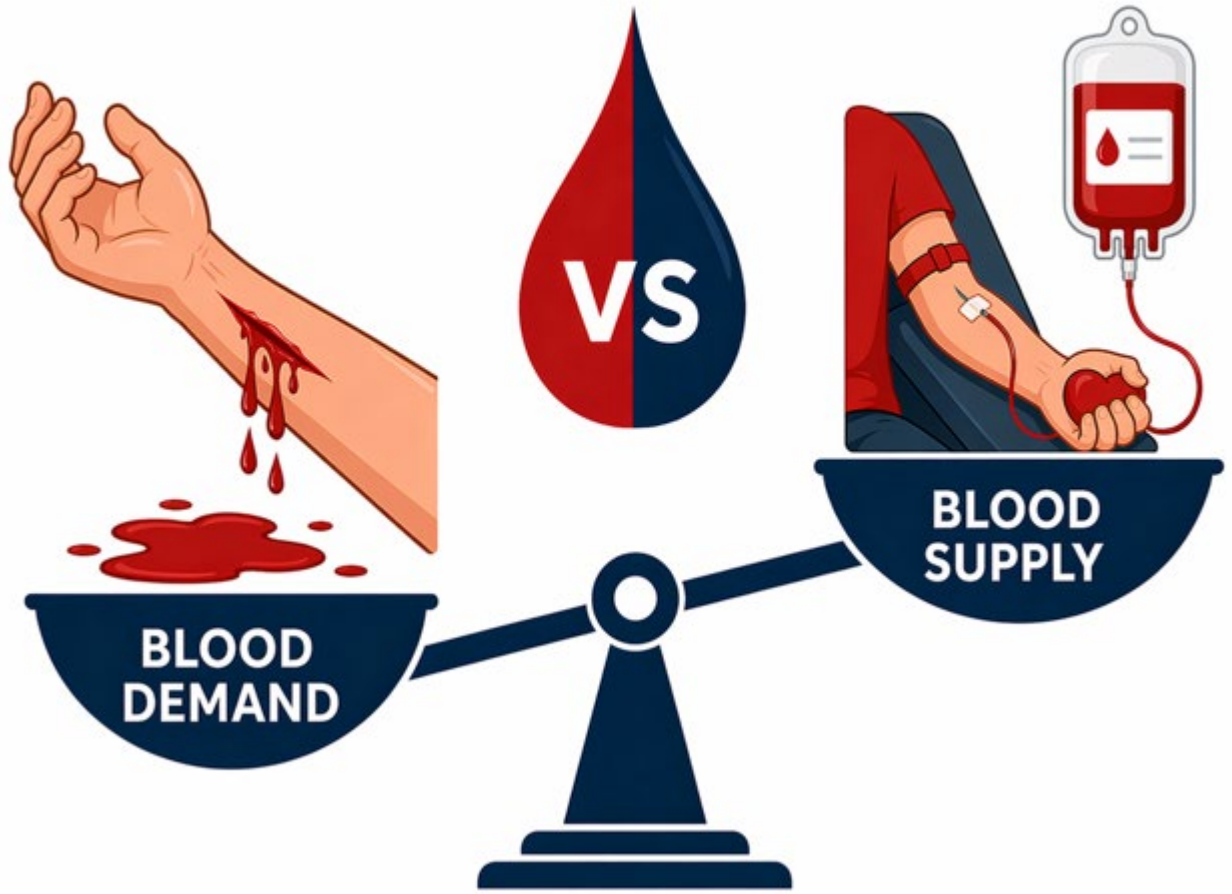
40-60% of all blood administered in hospitals are given by anesthesia clinicians¥

¥Growe, G. H., Jenkins, L. C., & Naiman, S. C. (1991). Anesthesia training in transfusion medicine. Transfusion Medicine Reviews, 5(2), 152-156.

* Adapted from: Pretto, E. A., & Barach, P. (2008). Principles and practice of disaster medicine: what every anesthesiologist should know about responding to medical disasters. Advances in Anesthesia, 26, 175-199.

Key Strategies for Building National Blood Resilience

- Blood Conservation
- Blood Stewardship
- Innovative mitigation strategies



Patient Blood Management (PBM) Strategies

PILLAR 1
Preoperative Optimization of Red Cell Mass

1. Anemia detection and treatment —
Preoperative anemia is an independent risk factor for morbidity, mortality, and transfusion. The 2018 Frankfurt Consensus Conference strongly recommends detecting and managing anemia sufficiently early before major elective surgery. Functional iron deficiency is the most common cause and should be treated with oral or intravenous iron; erythropoietin-stimulating agents (ESAs) can be used in selected cases. [1][4-6]

2. Medication management —
Individualized assessment of thrombotic risk vs. bleeding risk guides decisions on discontinuing anticoagulants and antiplatelet agents preoperatively. Directly acting anticoagulants can generally be stopped 48 hours before surgery with normal renal function; aspirin can often be continued. [1][7]

PILLAR 2
Minimization of Intraoperative Blood Loss

1. **Tranexamic acid (TXA)** — Reduces blood loss and transfusion requirements by approximately 30% in orthopedic and cardiac surgery. It is safe, inexpensive, and recommended when anticipated blood loss is high. [5][7][9]
2. **Intraoperative cell salvage** — Collects and reinfuses shed blood during surgery. Recommended when anticipated blood loss exceeds 500 mL. Preferred over preoperative autologous donation because it avoids rendering the patient anemic preoperatively. [3][5][7]
3. **Acute normovolemic hemodilution (ANH)** — Blood is removed during anesthesia induction and replaced with crystalloid/colloid; the whole blood is reinfused at the end of surgery. Evidence on efficacy is mixed, and use is limited in some surgical settings. [3]
4. **Anesthetic techniques** — Maintaining normothermia (hypothermia impairs coagulation), controlled hypotension to reduce surgical bleeding, proper patient positioning, and use of neuraxial/regional anesthesia where appropriate. [1][5][7]
5. **Surgical techniques** — Advanced electrocautery, topical hemostatic agents, fibrin sealants, tourniquets, and minimally invasive surgical approaches. [1][5][7]
6. **Viscoelastic point-of-care testing (TEG/ROTEM)** — Provides real-time coagulation analysis to guide targeted component therapy (FFP, platelets, cryoprecipitate, antifibrinolytics), reducing empiric transfusion. [9-11]
7. **Reduced CPB circuit priming** — In cardiac surgery, reduced priming volume and retrograde autologous priming of the cardiopulmonary bypass circuit reduce hemodilution and transfusion. [9]

PILLAR 3
Optimizing Tolerance to Anemia (Restrictive Transfusion Practice)

1. Restrictive transfusion thresholds —
The Frankfurt Consensus Conference established evidence-based hemoglobin triggers: <7 g/dL for critically ill, clinically stable ICU patients (with or without septic shock); <7.5 g/dL for cardiac surgery patients; and <8 g/dL for patients with hip fractures and cardiovascular disease. [4]

2. Single-unit transfusion policy —
"Why give 2 when 1 will do" — transfusing one unit at a time with reassessment before additional units, consistent with the Choosing Wisely campaign. [5][12]

3. Minimizing diagnostic phlebotomy —
Using smaller phlebotomy tubes (microtainers) and reducing unnecessary laboratory testing, particularly in ICU settings where phlebotomy-related blood loss can be substantial. [2][5]

4. Point-of-care hemoglobin testing —
Rapid turnaround reduces uncertainty and empiric transfusion decisions. [5][12]

Effectiveness of Patient Blood Management (PBM) Strategies

Impact on Blood Utilization and Clinical Outcomes

Study / Program	Population	RBC Reduction	Clinical Outcomes	References
Althoff et al. meta-analysis	235,779 surgical patients	↓ 39% lower transfusion rate	↓ Complications (20%) | ↓ Mortality (11%)	[1]
Frankfurt Consensus (20 cohort studies)	Multiple populations	↓ 22% fewer RBC/1000 pts	↓ Length of Stay by 0.50 days	[2]
Western Australia (Leahy et al.)	605,046 patients	↓ 41% reduction	↓ Mortality (OR 0.72) | ↓ Infections (OR 0.79)	[3]
German PBM Network	1.2 million patients	↓ 13.9% reduction	Non-inferiority for safety confirmed	[4]
Mayo Clinic (Warner et al.)	400,998 admissions	607 → 405 RBC units per 1,000 admissions	↓ Length of Stay | ↓ Adverse events	[5]
ONTraC Ontario (Ontario PBM Program)	25 hospitals, 20 years	Total Knee Arthroplasty: 25% → 0.4% transfusion rate | CABG: 60% → 27% transfusion rate	↓ Infections | ↓ Length of Stay	[6]
Zurich (Kaserer et al.)	213,882 patients	↓ 35% overall reduction | ~40% reduction in RBC	No change in mortality | $12.4M saved	[7]

Abbreviations: RBC = red blood cell; LOS = length of stay; OR = odds ratio; CABG = coronary artery bypass graft

INNOVATION IN PRACTICE

ANESTHESIOLOGY® OPEN

National Shortage of Type O Blood: What Anesthesiologists Can Do

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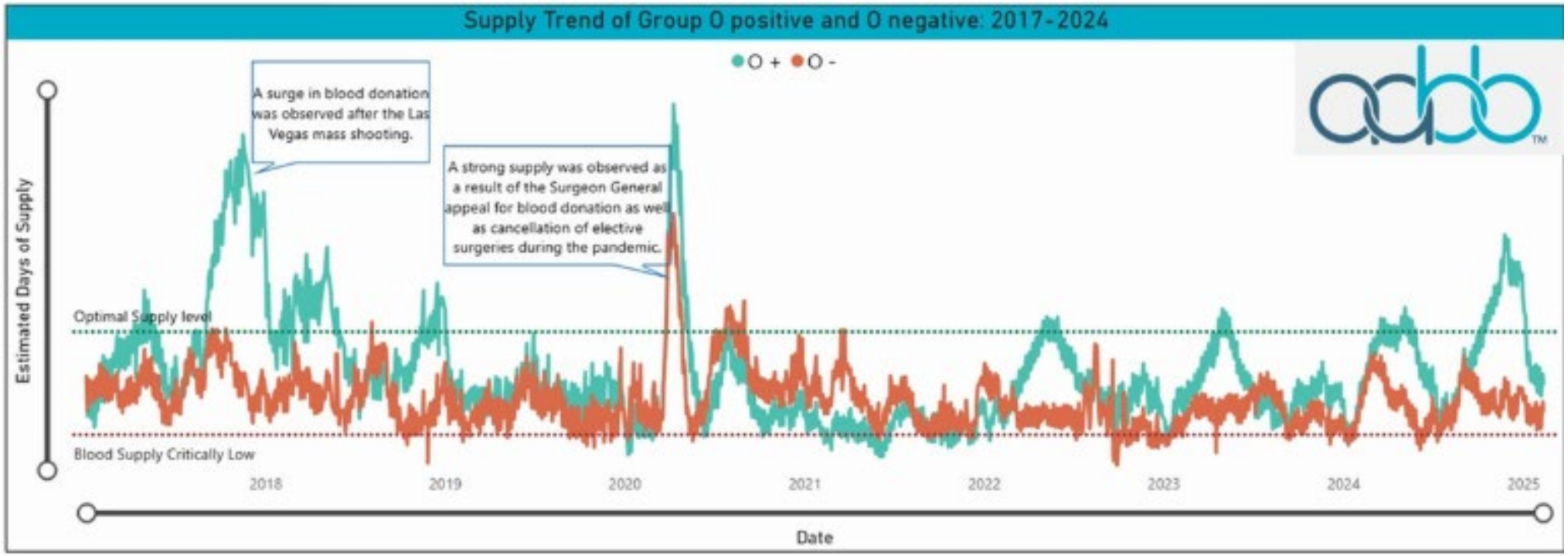
Anesthesiology Open 2026; 1:e0010

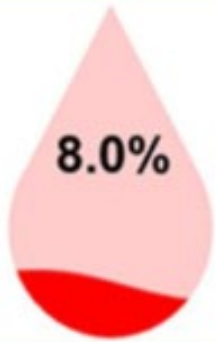
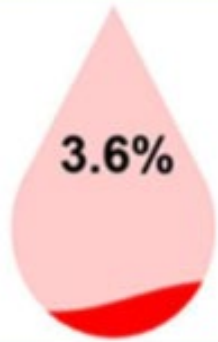
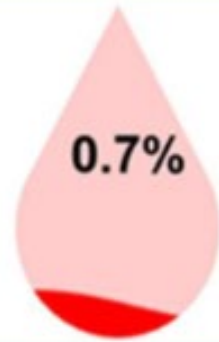
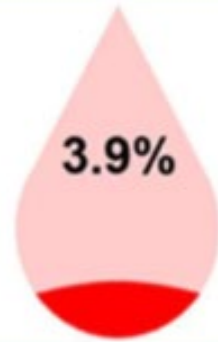
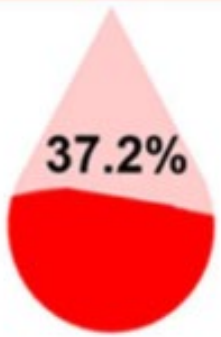
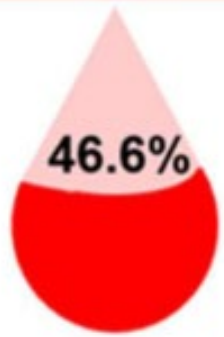
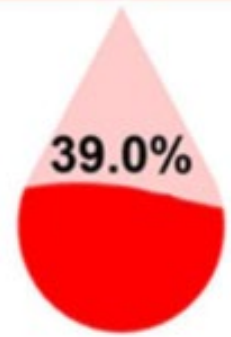
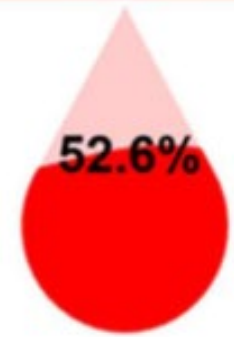
ABSTRACT

Chronic shortages of type O red blood cells, particularly O-negative units, represent a growing national concern that threatens transfusion readiness and patient safety. Despite O-negative blood type comprising only 6.9% of the U.S. population, demand for O-negative red blood cells now exceeds 12% of all transfused units. Overutilization—especially transfusion to non–O-negative recipients, routine emergency use, and expiration-driven practices—has intensified the imbalance. Demographic shifts toward a more ethnically diverse donor base may further exacerbate this mismatch. In response, the American Red Cross launched the Empower Group O Care Initiative, promoting the principles to "Start Smart" and "Switch Sooner": initiating emergency transfusions with O-positive red blood cells in males and females beyond childbearing potential and converting to type-specific products as early as feasible. Anesthesiologists, who administer up to 60% of U.S. transfusions, play a pivotal role in stewardship efforts to optimize utilization, preserve scarce O-negative blood, and strengthen the national blood supply.

Anesthesiology Open 2026; 1:e0010



U.S. supply trend of O-positive and O-negative RBC units from 2017 to 2024.[5] RBC, red blood cell. Adapted with permission from AABB.[5]

	White/Caucasian	Black/African-American	Asian	Latino
O-				
O+				

U.S. demographics of O-negative and O-positive blood by race/ethnicity. Adapted with permission from American Red Cross.[10]

INAPPROPRIATE / AVOIDABLE USE OF O-NEGATIVE BLOOD

Multiple studies show that a large proportion of O-negative red blood cell (RBC) transfusions are unnecessary and could have been avoided.

HOW OFTEN IS O-NEGATIVE BLOOD GIVEN INAPPROPRIATELY?

Selected Studies with Reported Data

STUDY	SETTING	INAPPROPRIATE / POTENTIALLY AVOIDABLE O-NEGATIVE USE	APPROPRIATE USE
GROUP Study (Zeller et al.) 38 hospitals / 11 countries	International hospitals	43.2%	56.8%
OPTIMUS Study (31 institutions) U.S. hospitals	U.S. hospitals	44.5%	55.5%
Virk et al. Stanford / academic center	Before policy (higher inventory)	67%	33%
	After policy (lower inventory)	57%	43%

0% 50% 100%

% of O-negative RBC transfusions to patients who could have received another blood type

% of O-negative RBC use deemed inappropriate

% of O-negative use deemed inappropriate (reduced after inventory reduction policy)

Inappropriate / Potentially Avoidable Use | Appropriate Use

WHY IS O-NEGATIVE BLOOD USED INAPPROPRIATELY?

Top Reasons Identified

EMERGENCY RELEASE / UNCROSSMATCHED USE

- Emergency release of O-negative RBCs (no time for testing)
- Habit / protocol inertia in emergencies

FAILURE TO SWITCH TO TYPE-SPECIFIC BLOOD

- Delayed or missed opportunity to switch to type-specific RBCs
- Policies or workflows that do not prioritize early sampling and review

INVENTORY / NEAR-EXPIRATION MANAGEMENT

- Nearing expiration / short shelf-life management
- Inventory management / shortage mitigation practices

KEY TAKEAWAY: Nearly 40–50% of O-negative RBC transfusions may be avoidable.

Better stewardship—Start Smart, Switch Sooner, and Minimize Blood Loss—can conserve this scarce resource for patients who need it most.

Sources: Zeller et al. (GROUP Study); OPTIMUS Study Investigators; Virk et al., Stanford University.

Anesthesiologists administer up to **60%** of blood transfusions, and play a critical role in reducing overutilization of O-negative RBCs

START SMART

- When blood type is known, use type-specific RBCs whenever possible
- In emergencies when patient blood type is unknown, start with O-positive for males and females beyond childbearing potential
- Reserve O-negative RBCs for O-negative patients and females of childbearing potential when blood type is unknown

SWITCH SOONER

- Collect a patient sample for blood type testing as early as possible to expedite the switch to type-specific RBCs
- Develop policies that define when to transition O-negative patients to O-positive RBCs when O-negative inventory is being depleted

MINIMIZE BLOOD LOSS

Use established blood conservation techniques to reduce the need for transfusion, including:

- Point-of-care testing to rapidly identify hemostatic defects
- Reinfusion of shed blood/cell salvage
- Topical hemostatic agents

EVERY UNIT MATTERS

Thoughtful transfusion practices conserve O-negative RBCs for patients that need them most

BLOOD DESERT COALITION

Nobody Should Die from a Lack of Blood

But Millions Worldwide Still Do

VIEWPOINT | VOLUME 12, ISSUE 3, E522-E529, MARCH 2024

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Innovative blood transfusion strategies to address global blood deserts: a consensus statement from the Blood Delivery via Emerging Strategies for Emergency Remote Transfusion (Blood DESERT) Coalition

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Open Access • Published: March, 2024 • DOI: https://doi.org/10.1016/S2214-109X(23)00564-8 •

Check for updates

A “blood desert” is...

“A geographic region where essential clinical demand for blood components cannot be met at the point-of-care in a timely and affordable maner, in at least 75% of cases where transfusion is needed.”

Raykar N, Raguveer V et al. Innovative Blood Transfusion Strategies To Address Global Blood Deserts, The Lancet Global Health, 2024

BLOOD D.E.S.E.R.T COALITION

BLOOD DESERTS IN HIGH-INDEX COUNTRIES

Blood deserts are not just a low-resource problem—
they also exist in high-income countries due to time, distance, and disrupted supply.

BLOOD DESERT =
Area or time when blood is unavailable when needed

1. TEMPORAL BLOOD DESERTS

When blood cannot get to the patient in time

Temporary disruptions prevent blood from reaching hospitals, even though blood centers and supply exist elsewhere.

KEY SCENARIOS

NATURAL DISASTERS
Natural disasters damage infrastructure and cut off supply routes.

Examples: hurricanes, earthquakes, floods, wildfires

SUPPLY ROUTE DISRUPTIONS
Transportation barriers delay or prevent blood delivery.

Examples: bridge down, too windy to fly, snowstorms, road closures

ULTRA MASS CASUALTY EVENTS
Demand rapidly exceeds available supply.

Examples: terrorist attacks, mass shootings, LSCOs, large-scale accidents

TEMPORAL BLOOD DESERT IMPACT:
Hospitals have blood refrigerators but no blood.
Minutes to hours of delay can cost lives.

BLOOD DESERT
When and where patients cannot get the blood they need

2. ULTRA REMOTE BLOOD DESERTS

When distance creates persistent barriers to blood access

Geographic remoteness creates persistent barriers to blood access, even in well-resourced health systems.

KEY SETTINGS

REMOTE INDUSTRY SITES
Work sites far from population centers or blood centers.

Examples: oil rigs, mining sites, wind farms

EXTREME REMOTE COMMUNITIES
Small populations far from regional blood centers.

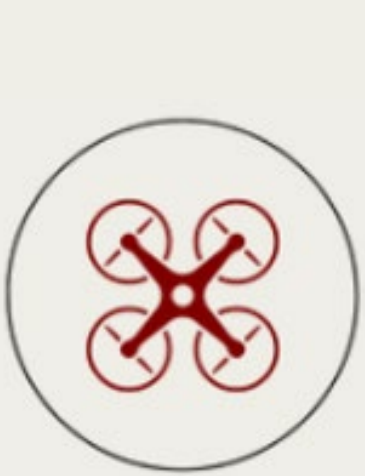
Examples: Arctic villages, islands, desert towns, frontier communities

SPECIAL OPERATIONS / DEPLOYED ENVIRONMENTS
Military or expeditionary teams far from resupply.

Examples: Arctic operations, maritime missions, space analog missions

ULTRA REMOTE BLOOD DESERT IMPACT:
Limited or no on-demand access to blood.
Reliance on long or intermittent transport times.

Innovative Stopgap Transfusion Strategies for Global Blood Deserts



Drones/Delivery

Autotransfusion

Walking Blood Bank

BLOOD D.E.S.E.R.T COALITION

Drone-based blood delivery (DBD)

Extending the blood delivery range of blood collection centers

Implementation

Nisingizwe (2022, Rwanda)
Retrospective cohort study
DBD was 80-100 min faster than ground based delivery services
Reduced wastage by 67%

Sylverken (2022, Ghana)
Descriptive study
COVID samples sent via drone for centralized testing came from 10 districts, farthest was 270 km away
Flight times took 78min less than ground transport

Ling (2019)
Highlights efforts by the US military, Zipline, and QuiQui in delivering medical products including blood to remote areas

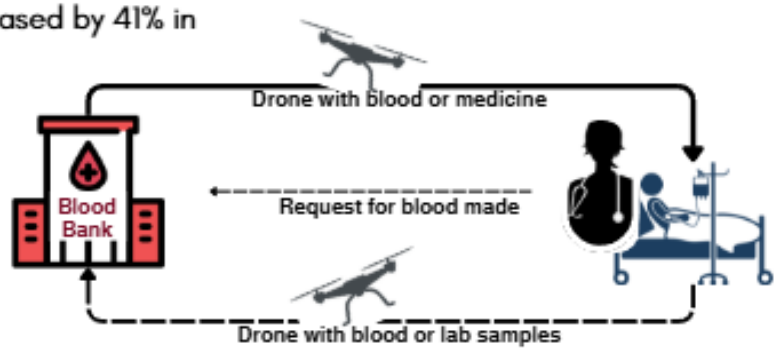
Demuyakor (2020, Ghana)
Online survey
Providers reported positive impact of drone delivery on emergency health delivery

Safety

Homier (2021, Canada)
Prospective drone flight testing
Drone delivery was significantly faster than ground transport and maintained appropriate temperatures during flight

Amukele (2017)
Prospective flight testing
Lab and hematologic samples showed no or minimal changes but require environmental regulation

Kremer (2023, Ghana)
Cross sectional study
Vaccination coverage improved by 13-38% with drone delivery
Infectious diarrhea decreased by 41% in children 5-9 years old



Cost

Ochieng (2020, Liberia)
Cost-effectiveness analysis
DBD was more expensive than motorcycle delivery of lab samples

Zailani (2021, Borneo)
Cost-effectiveness analysis
DBD was more expensive than ambulance based transport, but significantly shorter delivery times offset costs

Haidari (2016, Mozambique)
Model simulation sensitivity analysis
DBD likely increases vaccine availability and reduces cost if used regularly and frequently

BLOOD D.E.S.E.R.T COALITION

Intraoperative Autotransfusion (IAT)

A real-time, safe way to give lost blood back to patients during surgery

HIC CONTEXT

Use of Cell Saver Devices is safe and cost-effective across fields

TRAUMA

Lilienstein (2022)
Retrospective cohort study
IAT use in contaminated trauma laparotomy fields was not associated with a higher rate of complications.

Li (2015)
Systematic review
IAT did not affect mortality or adverse events in patients undergoing surgery for abdominal or thoracic trauma

ONCOLOGY

Murtha-Lemekhova (2022)
Systematic Review & Meta-Analysis
Autotransfusion is safe in patients with hepatocellular carcinoma undergoing resection or transplantation

CARDIAC

Wang (2018)
Retrospective cohort
Autotransfusion can significantly reduce demand of allogeneic blood in CABG when blood loss is 600-1000mL

ORTHOPEDICS

Chi (2023)
Retrospective cohort
For adolescents undergoing scoliosis surgery, IAT was cost effective in cases with >1500mL blood loss

Rao (2012)
Retrospective cohort
Post-operatively washed salvaged cells may be cost-saving in patients receiving total hip arthroplasty

OBSTETRICS

Xia (2024)
Autotranfusion is more effective than allogenic blood transfusion at attenuating inflammatory response in women undergoing C-sections

Phillips (2023)
Retrospective cohort
Autotransfusion is safe and effective in vaginal obstetric hemorrhage

Oborre (2022)
IAT in women undergoing C-sections with high risk of hemorrhage is associated with lower incidence of transfusion related events and decreased length of stay

BLOOD D.E.S.E.R.T COALITION

Intraoperative Autotransfusion (IAT)

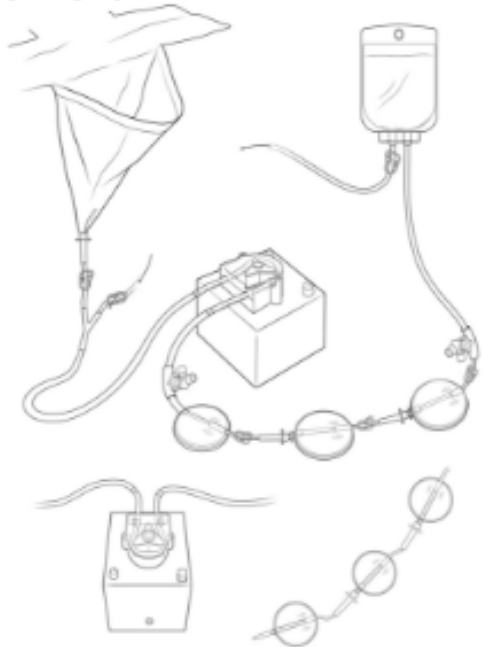
A real-time, safe way to give lost blood back to patients during surgery

LMIC CONTEXT

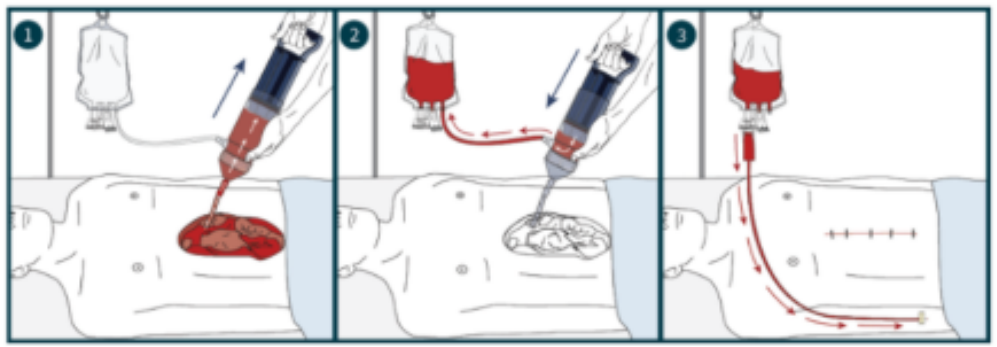
Palmqvist (2022)
Systematic Review
Most common indications were hemoperitoneum and hemothorax. Techniques include the soup & ladle, Tanguieta funnel, and Hemafuse devices.

Bihariesingh (2021)
Case Report
Use of Hemoclear filter to salvage postoperatively shed blood cells

Munoz-Valencia (2022)
Training program in Kenya and Ghana teaching providers how to salvage up to 900mL of whole blood per case



Device design.... Image per graphic design by Christina Wheeler.



POST PARTUM HEMORRHAGE IN LMIC

Yost (2019)
design of a novel device with leukocyte depletion filters to address PPH in low resource settings.

Selo-Ojeme (2003)
Scoping Review
16 LMICs using manual techniques for IAT to treat ruptured ectopic pregnancies

Priuli (2009)
Three hospitals salvaging intraperitoneal blood in ruptured ectopic pregnancies using a perforated metallic conical funnel

Dobiesz (2017)
Prototype medical device with leukocyte filter for accessible IAT use in postpartum hemorrhage

BLOOD D.E.S.E.R.T COALITION

Walking Blood Banks (WBBs)

A "just-in-time" transfusion strategy using donors from a pre-screened community pool and rapid diagnostic tests (RDTs) for point of care transfusion

MILITARY SETTINGS

Spinella (2012)

Retrospective review: 50 US military facilities in Iraq, Afghanistan
Results: 258,000+ blood units transfused to >26,000 casualties in 10 years
1:1:1 plasma-RBC-platelet ratio improved survival in massive transfusions
Fresh whole blood (WB) is a feasible alternative when other blood components unavailable

Gurney & Holcomb (2017)

Retrospective review: military and civilian trauma care in WWI, WWII, Korean War, Vietnam War, Iraq, and Afghanistan
Results: WB transfusion improved survival rates in combat environments compared to component therapy
US military is working to adopt WB transfusion operations at the point of injury and in pre-hospital settings

AUSTERE TRAUMA SETTINGS

Katsura et al (2020)

Retrospective cohort study over 20 years: Okinawa Islands, Japan
WFWB use <24 hours of admission in 3 austere civilian trauma settings
Results: 28 patients, median transfusion 1800 mL, no adverse events
Early WFWB use within 4 hours of admission associated with a significant reduction in platelet transfusion requirement
WFWB transfusion is safe & feasible for austere civilian trauma settings

Miller et al (2018)

Case series: Maritime helicopter crash victims and the use of WFWB
Results: 54 units of WFWB collected for 6 patients, 39 units transfused; WFWB available within 60 minutes from time of arrival; all patients survived
WBBs are critical for maritime mass casualty management, ensuring timely WFWB transfusion and optimal outcomes in austere naval settings

CIVILIAN SETTINGS

Apelseth et al (2022) - Norway

Prospective intervention pilot study detailing implementation strategy
3 rural hospitals, 2 air ambulance bases, 4 municipal health care services
Results: Successfully implemented decentralized CWBBs, including emergency donor pools, training programs, activation protocols, post-transfusion follow-up, and quality assessment systems
CWBB is feasible and recommended for locations with prolonged transport times

Martinaud et al (2021) - Mali, Norway

International survey of WBB programs across 10 countries
2 civilian programs (Mali [LIC] and Norway [HIC])
Results: Variable implementation strategies globally with all protocols including methods for pre-screening and activating donors
Use of collected blood and monitoring systems differ
Common challenges include transfusion safety, lack of post TTI guidelines, infrequent protocol activation

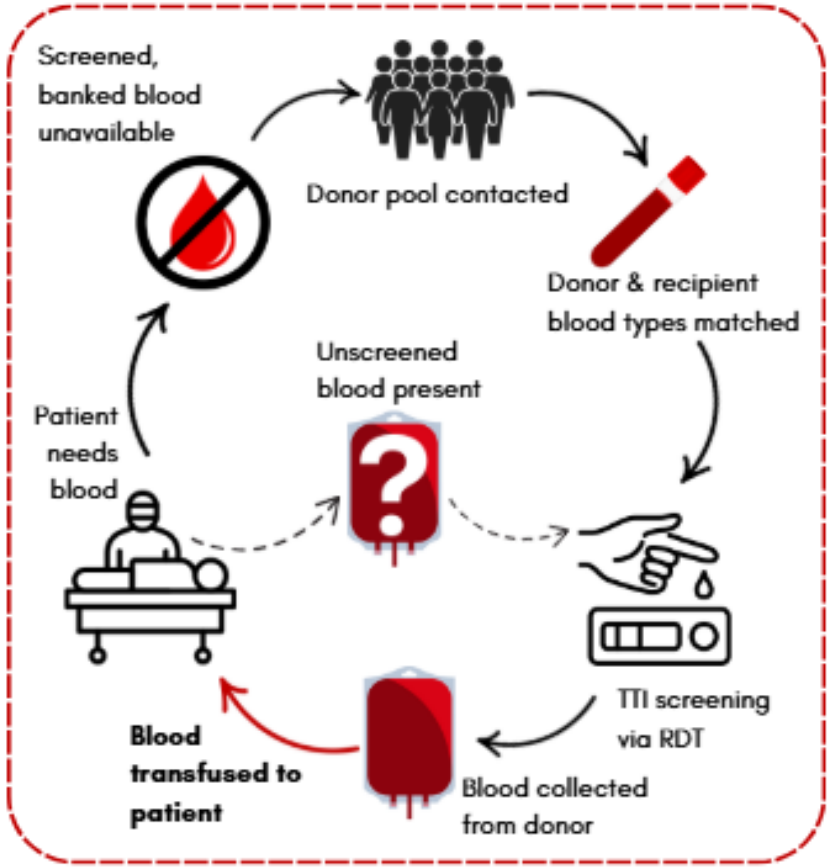
How is a walking blood bank different?

	Traditional Blood Bank	Walking Blood Bank
Patients	All indications for transfusion	Emergency or urgent indications
Donors	Voluntary donors	Soldiers, family, healthcare workers, volunteers
Processing	Components or Whole Blood	Fresh whole blood
Testing	Centralized laboratory-based testing	Rapid diagnostic testing (RDTs)
Timing	Days to weeks	Minutes to hours

IMPLEMENTATION PROGRESS

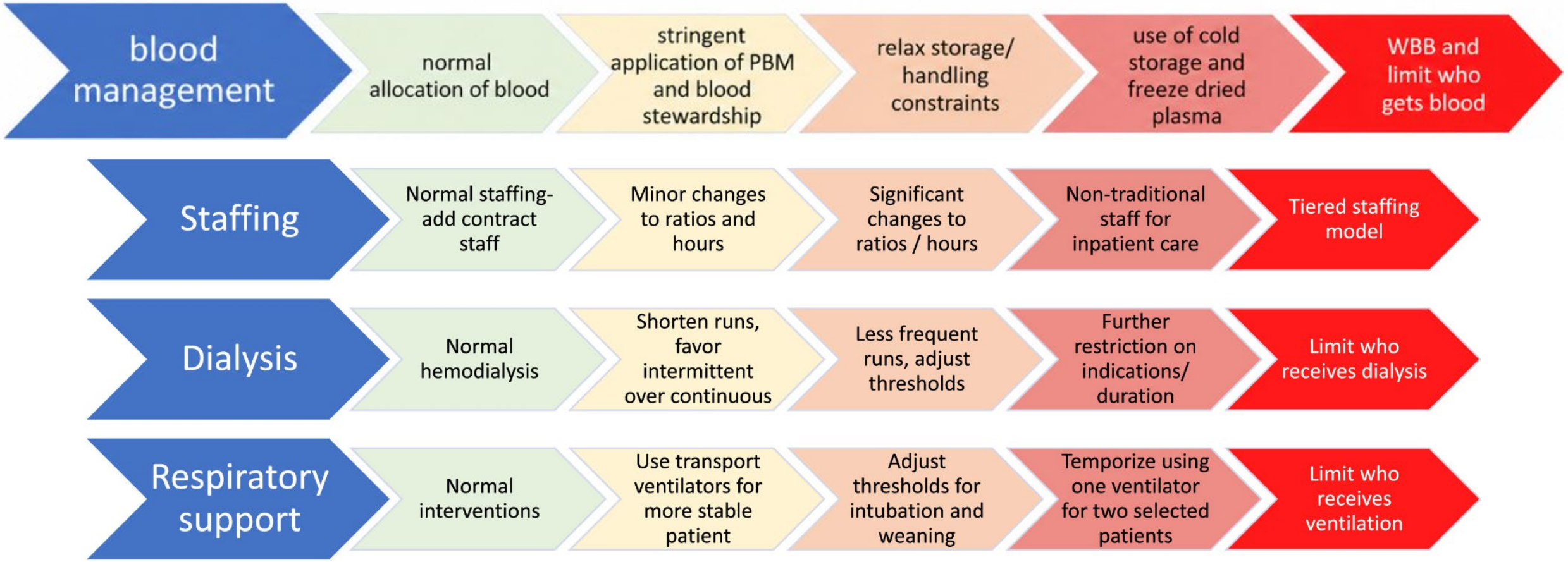
WHO Recognition & Guidelines

- **2013**: Blood and blood components added to core list of 18th WHO *Model List of Essential Medicines*
- **2018**: RDTs added to WHO *Model List of Essential In Vitro Diagnostics* since its first publication for TTIs
- **2023**: *'Guidance on Ensuring a Sufficient Supply of Safe Blood and Blood Components During Emergencies'* supports principles relevant to WBBs through community donor engagement, establishment of donor database, emergency preparedness, risk assessment, alternative donation sites, and mass casualty blood demand management



BLOOD D.E.S.E.R.T COALITION

Crisis Standards of Care



Conventional Care → **Contingency Care** → **Crisis Care**

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Thank you

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