

Standardizing EMS Metrics for Survival in Transfusion and Advanced Resuscitation: The SEMSTAR Project



A Consensus-Based Framework for Prehospital Blood Transfusion Program Metrics

Matthew J. Levy, DO, MSc, FAEMS, FACEP, NRP
Professor of Emergency Medicine & Surgery, Johns Hopkins University
Chief Medical Officer, Howard County Fire & Rescue

Disclosures

MJL is a consultant for Abbott, Stryker Emergency Care, GMR, BoundTree, and Cresilon. The opinions expressed by Dr. Matthew J. Levy are those of Dr. Matthew J. Levy and not necessarily those of any organization, public or private, or the US Government.

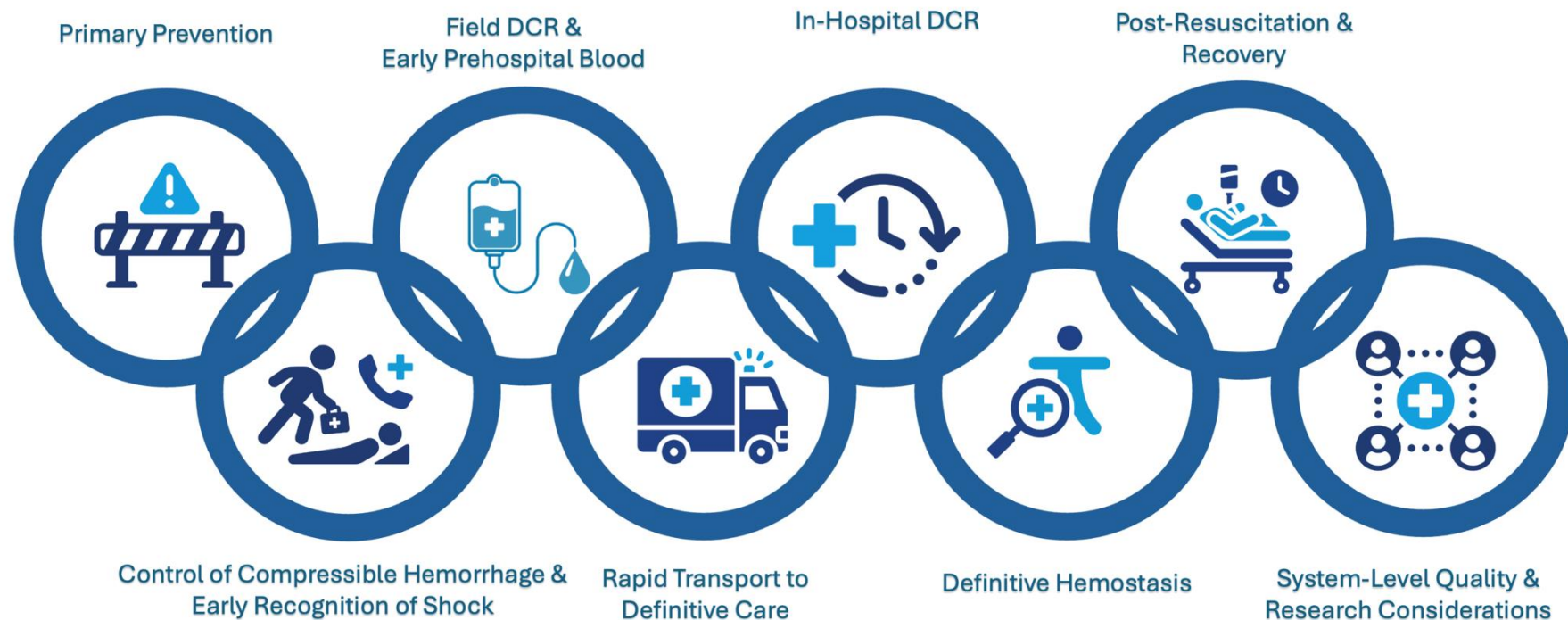
Establishing the Standardized EMS Metrics for Survival in Transfusion and Advanced Resuscitation: the SEMSTAR project



Matthew J Levy ,^{1,2} Holly O'Byrne ,³ Kaytlin Hack,¹ Amanda Staudt ,⁴ Remle Crowe,^{5,6} Eric A Bank,⁷ Joshua B Brown ,⁸ Timothy Brown,⁹ Armand Cayer,¹⁰ David Edwards,⁹ Gabriel H Gan,³ Eric Garfinkel,¹ Craig Goolsby,^{11,12} Frances Guyette ,¹³ Ryan B Fransman ,¹⁴ John B Holcomb ,^{15,16} Dionne Huggins,¹⁷ Donald H Jenkins,¹⁸ Michelle Kobayashi,¹⁷ N Clay Mann,¹⁹ Asa M Margolis,¹ Kevin Nicholes ,¹⁹ Shaun Patterson,¹⁷ Art Samaras,²⁰ Randall Schaefer,²¹ Philip Spinella,²² David Vitberg,²³ Christopher M Wend ,²⁴ Kelsey Wilhelm ,^{11,25} Christopher Winckler,⁶ Tung-Lin Jesse Yuan ,^{10,26} Jon Krohmer^{27,28}

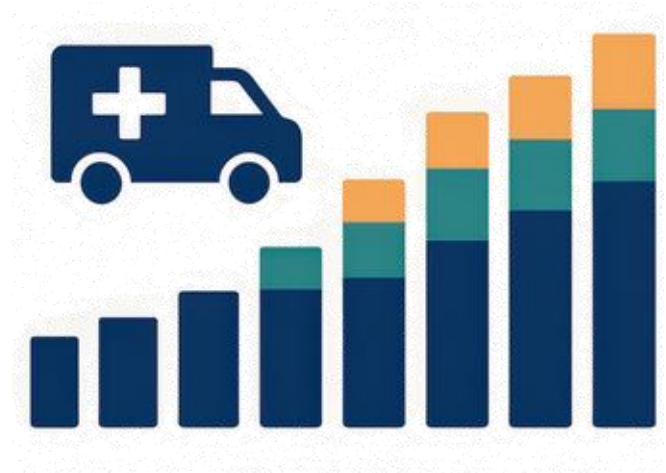
Background: Prehospital Transfusion

- Improves survival in hemorrhagic shock through earlier hemostatic resuscitation and shortened time to first transfusion.
- Integral to the chain of survival for hemorrhagic shock.



The Problem

- Broad diversity in data collection and outcomes definitions across EMS transfusion programs.
- Limits comparability, benchmarking, QI, and multicenter research.
- Threatens ability to demonstrate efficacy, secure funding, & optimize protocols.



The Need

- Standardization of common elements and definitions amongst broad and diverse EMS systems.
- Universal definitions for outcomes, survival and metrics
- A basis for comparison & form the basis to establish a robust evidence base.



**Fire Department-
Based Systems**



**Diverse Service
Models**



**Volunteer EMS
Programs**



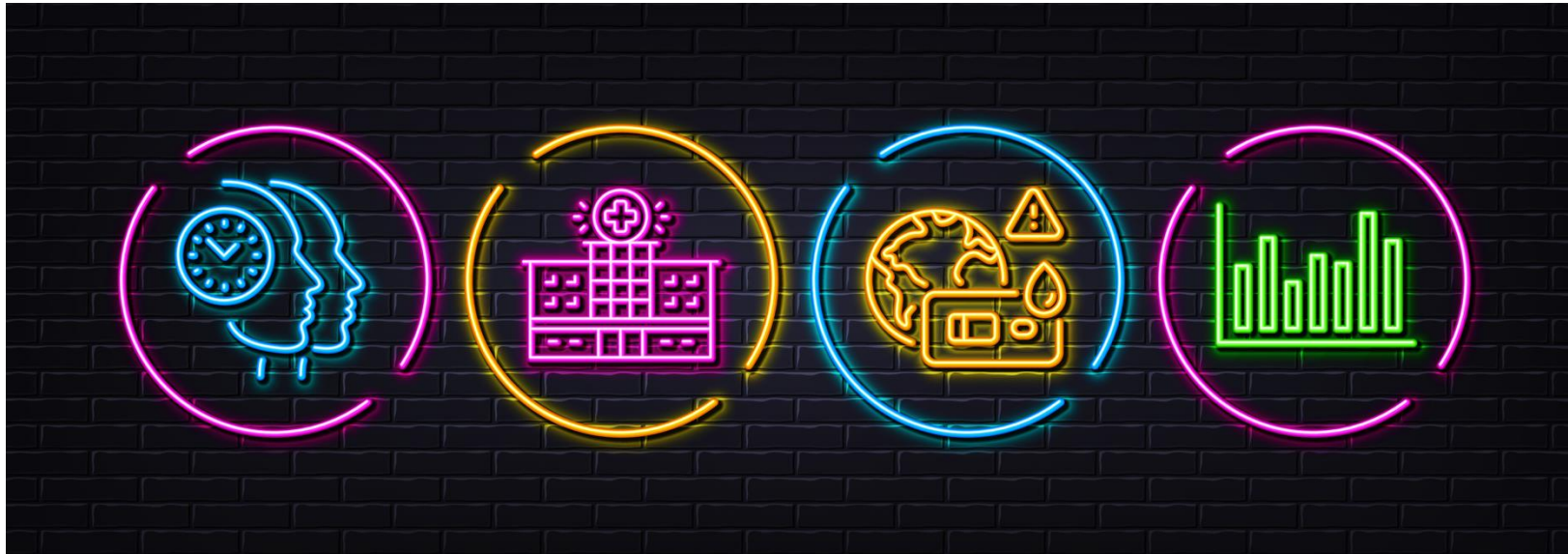
**Aeromedical
Services**



**Health
Systems**

Study Objective

- Develop consensus-driven data elements for consistent and standardized reporting across EMS transfusion programs.



SEMSTAR

- The first national, consensus-driven framework for standardized data collection and outcome reporting in prehospital transfusion programs.
- Emphasize impact on benchmarking, QI, and research
- SEMSTAR addresses both “what to measure” and “how to measure it” uniformly.



SEMSTAR

Prehospital Metrics for Survival in Transfusion and
Advanced Resuscitation

Methods Overview

- Modified Delphi methodology with three rounds and predefined thresholds.
- Surveys via Qualtrics; SAS used for analysis; IRB exempt approval.
- 5-point Likert scale ranging from “extremely important” to “not important at all.”
- Round 1: Open EMS system survey (one response per system)
- Rounds 2–3: SME voting and classification.
 - 28 subject-matter experts (EMS, trauma, transfusion medicine, resuscitation).



28 Member Expert Panel

- Broad representation to ensure generalizability EMS systems
- Panel eligibility (one or more of the following):
 - Direct experience with the implementation of a prehospital transfusion program;
 - Direct clinical experience with prehospital transfusion;
 - Multiple publications on prehospital transfusion; or
 - Expertise in prehospital damage-control resuscitation.

Primary EMS System Role	n
EMS Medical Director/Chief Medical Officer	7
Trauma Surgeon & Critical Care Physician	4
Researcher	3
EMS Program Analyst	3
EMS Agency Blood Program Manager	2
EMS Associate/Assistant Medical Director	2
EMS Department Chief	2
Emergency Physician (Non-EMS)	2
EMS Operations Chief	1
Operational EMS Physician	1
EMS Quality Improvement Specialist	1

SEMSTAR Subject Matter Expert Pannel

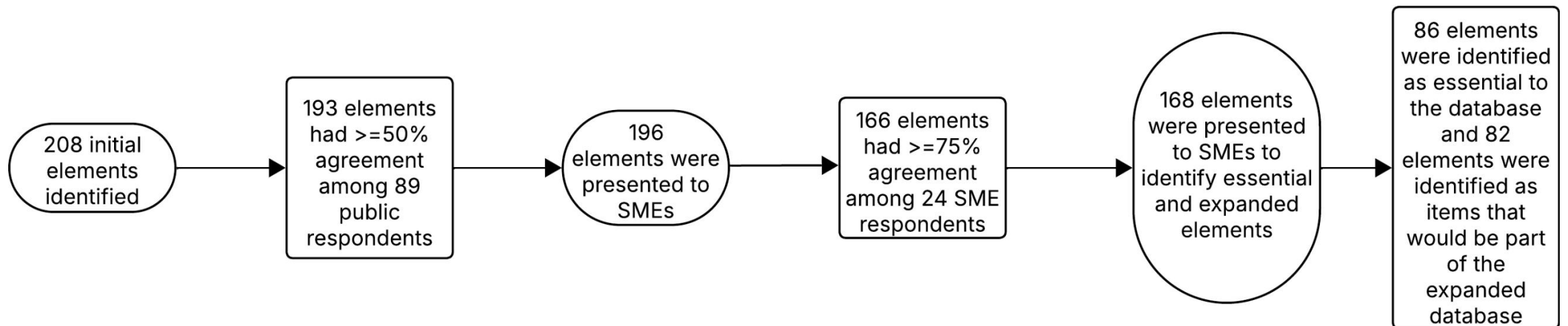
Eric Bank <i>Harris County Emergency Services District No. 48,</i>	Eric Garfinkel <i>Johns Hopkins University Emergency Medicine Howard County Department of Fire Rescue</i>	Jon Krohmer <i>Michigan State University, Emergency Medicine EMS MD PLLC</i>	Randall Schaefer <i>Schaefer Consulting, LLC</i>
Joshua B. Brown <i>University of Pittsburgh, Surgery</i>	Craig Goolsby <i>Harbor-UCLA Medical Center David Geffen School of Medicine</i>	Matthew Levy <i>Johns Hopkins University Emergency Medicine Howard County Department of Fire Rescue</i>	Philip Spinella <i>University of Pittsburgh School of Medicine</i>
Timothy Brown <i>Thompson Valley Emergency Medical Services</i>	Frances Guyette <i>University of Pittsburgh, Emergency Medicine</i>	N. Clay Mann <i>University of Utah School of Medicine, Pediatrics</i>	David Vitberg <i>Sibley Memorial Hospital, Emergency Medicine</i>
Armand Cayer <i>University Hospital, Emergency Medical Services</i>	John Holcomb <i>University of Alabama at Birmingham, Surgery; Uniformed Services University, Surgery</i>	Asa Margolis <i>Johns Hopkins University Emergency Medicine Howard County Department of Fire Rescue</i>	Christopher Wend <i>Johns Hopkins University Emergency Medicine</i>
Remle Crowe <i>ESO Solutions University of Texas HSC San Antonio</i>	Dionne Huggins <i>Hackensack University Medical Center Emergency Medical Services</i>	Kevin Nicholes <i>University of Utah School of Medicine National EMS Information System Tac Center</i>	Kelsey Wilhelm <i>Harbor-UCLA Medical Center Los Angeles County Dept of Health Services</i>
David Edwards <i>Thompson Valley Emergency Medical Services</i>	Donald Jenkins <i>University of Texas HSC San Antonio</i>	Holly O'Byrne <i>Washington DC Department of Fire and Rescue</i>	Gamunu Wijetunge <i>National Highway Traffic Safety Administration Office of Emergency Medical Services</i>
Ryan Fransman <i>Emory University Trauma Surgery</i>	Jeremy Kinsman <i>National Highway Traffic Safety Administration Office of Emergency Medical Services</i>	Shaun Patterson <i>Hackensack University Medical Center Emergency Medical Services</i>	Christopher Winckler <i>University of Texas Health Science Center at San Antonio, Emergency Health Sciences</i>
Gabriel Gan <i>Government of the District of Columbia, Department of Fire and Rescue Services</i>	Michelle Kobayashi <i>Hackensack University Medical Center Emergency Medical Services</i>	Art Samaras <i>Atlantic Health System Critical Care Transport</i>	Tung-Lin Yuan <i>Rutgers New Jersey Medical School University Hospital, EMS Services</i>

Delphi Rounds & Thresholds

- Round 1: Advance if $\geq 50\%$ rate “moderately important” or higher.
- Round 2: Advance if $\geq 75\%$ SMEs rate “moderately important” or higher.
- Round 3: Core vs expanded classification at $\geq 75\%$; standardized definitions accepted at $\geq 85\%$
 - Panelists could propose revisions to definitions in Round 3 if they disagreed

Results Summary

- Initial survey: 208 elements; responses from 89 EMS systems.
- 193 elements advanced; 168 achieved consensus.
- Final classification: **86 core** and **82 expanded** elements.
- Consensus on standardized survival and circulatory collapse definitions.



Framework Structure

- 86 core metrics: Universal reporting for all prehospital transfusion programs.
- 82 expanded metrics: Deeper analysis and research; a secondary priority after core metrics are obtained.
 - i.e. implement the core metrics, then expand as resources permit.
- Leveraging Existing Data Systems
 - 100 elements sourced from NEMSIS v3.5.
 - 30 elements from trauma registries.
 - 38 elements (11 core, 17 expanded) require manual entry

SEMSTAR Core Metrics & Source Data

Metric Name	Source	Data Element
Patient weight (kg)	NEMSIS/NTDS	eExam.01, Initial ED/Hospital Weight
Incident date	NEMSIS/ITDX	eTimes.03/ Injury Incident Date
Incident time (NEMSIS categories)	NEMSIS	eTimes.*
Duration of on-scene time	NEMSIS	eTimes.09 - eTimes.06
Time blood product transfusion started	NEMSIS	eMedications.01 oreProcedures.01
Time blood product transfusion completed	Manual Entry	
Incident location (NEMSIS categories)	NEMSIS	eScene.09
Patient comorbidities - Acute alcohol use	NEMSIS/NTDS	eHistory.17/Alcohol Screen Results
Cause of bleeding - GI bleed	NEMSIS	eInjury.01
Cause of bleeding - Vaginal bleed NOS	NEMSIS	eSituation.11, eSituation.12
Cause of bleeding - Peripartum hemorrhage	NEMSIS	eSituation.11, eSituation.12
Cause of bleeding - Vascular access device (e.g. fistula)	NEMSIS	eInjury.01
Cause of bleeding - Other medical cause	NEMSIS	eSituation.11, eSituation.12
Cause of bleeding - Shooting victim	NEMSIS	eInjury.01
Cause of bleeding - Stabbing or slashing victim	NEMSIS	eInjury.01
Cause of bleeding - Blast or shrapnel	NEMSIS	eInjury.01
Cause of bleeding - MVC victim	NEMSIS	eInjury.01
Cause of bleeding - Fall	NEMSIS	eInjury.01
Cause of bleeding - Asault	NEMSIS	eInjury.01
Cause of bleeding - Pedestrian struck by auto	NEMSIS	eInjury.01
Cardiac arrest - Witnessed or unwitnessed	NEMSIS	eArrest.04
Cardiac arrest - Witnessed by EMS personnel	NEMSIS	eArrest.04
Prehospital interventions - Extremity TQ	NEMSIS	eProcedures.03
Prehospital interventions - Junctional TQ	NEMSIS	eProcedures.03
Prehospital interventions - Pressure dressing	NEMSIS	eProcedures.03
Prehospital interventions - Hemostatic dressing	NEMSIS	eProcedures.03
Prehospital interventions - Pelvic binder	NEMSIS	eProcedures.03
Prehospital interventions - Supplemental oxygen	NEMSIS	eProcedures.03/eMedications.03
Prehospital interventions - Open or finger thoracostomy	NEMSIS	eProcedures.08
Airway management - Patient protecting own airway	Manual Entry	
Airway management - Endotracheal intubation	NEMSIS	eProcedures.03

Pre-treatment vital signs - Initial heart rate	NEMSIS	eVitals.10
Pre-treatment vital signs - Proximate heart rate (immediately before blood given)	NEMSIS	eVitals.10
Pre-treatment vital signs - Initial blood pressure	NEMSIS	eVitals.06, eVitals.07
Pre-treatment vital signs - Proximate blood pressure (immediately before blood pr given)	NEMSIS	eVitals.06, eVitals.07
Pre-treatment vital signs - Unable to obtain blood pressure	NEMSIS	eVitals.06, eVitals.07
Pre-treatment vital signs - BP obtained manually	NEMSIS	eVitals.08
Pre-treatment vital signs - Initial Shock Index	NEMSIS	eVitals.10/eVitals.06
Pre-treatment vital signs - Proximate Shock Index (immediately before blood pr given)	NEMSIS	eVitals.10/eVitals.06
Pre-treatment vital signs - Respiratory rate	NEMSIS	eVitals.14
Pre-treatment vital signs - Pulse oximetry	NEMSIS	eVitals.12
Pre-treatment vital signs - End tidal CO2	NEMSIS	eVitals.16
Post-treatment vital signs - Proximate heart rate (first set of VS obtained after blood given)	NEMSIS	eVitals.10
Post-treatment vital signs - Final heart rate at hospital hand-off	NEMSIS	eVitals.10
Post-treatment vital signs - Proximate blood pressure (first VS obtained after blood given)	NEMSIS	eVitals.06, eVitals.07
Post-treatment vital signs - Unable to obtain blood pressure	NEMSIS	eVitals.06, eVitals.07
Post-treatment vital signs - BP obtained manually	NEMSIS	eVitals.08
Post-treatment vital signs - BP obtained using automated cuff	NEMSIS	eVitals.08
Post-treatment vital signs - Final blood pressure at hospital hand-off	NEMSIS	eVitals.06, eVitals.07
Post-treatment vital signs - Shock Index at hospital hand-off	NEMSIS	eVitals.10/eVitals.06
Post-treatment vital signs - Pulse oximetry	NEMSIS	eVitals.12
Blood product given - LTOWB	NEMSIS	eMedications.03
Blood product given - O neg whole blood	NEMSIS	eMedications.03
Blood product given - pRBC	NEMSIS	eMedications.03
Blood product given - Liquid plasma	NEMSIS	eMedications.03
Blood product given - Dried plasma	NEMSIS	eMedications.03
Blood product given - Cryoprecipitate	NEMSIS	eMedications.03
Blood product given - Platelets	NEMSIS	eMedications.03
Route of administration, quantity administered - IV <18 g	NEMSIS	eMedications.04, eMedications.05, eMedications.06, eProcedures.03, eProcedures.04
Route of administration, quantity administered - IV ≥18 g	NEMSIS	eMedications.04, eMedications.05, eMedications.06, eProcedures.03, eProcedures.04

Additional medications given - TXA	NEMSIS	eMedications.03
Additional medications given - Calcium gluconate	NEMSIS	eMedications.03
Additional medications given - Calcium chloride	NEMSIS	eMedications.03
Hospital clinical metrics - hCG quantitative	Manual Entry	
Hospital clinical metrics - Additional blood products received in first 4 hours	NTDS	Packed Red Blood Cells (4 Hours), Whole Blood (4 Hours), Transfusion Plasma (4 Hours), Transfusion Platelets (4 Hours), Cryoprecipitate (4 Hours)
Hospital interventions - Operative intervention for hemorrhage control	NTDS	Surgery for Hemorrhage Control Type
Outcome - Alive at hospital arrival	NEMSIS/NTDS	eOutcome.01, eOutcome.02/ ED Discharge Disposition, Hospital Discharge Disposition
Outcome - Alive at 6 hours after hospital arrival	Manual Entry	
Outcome - Alive at 12 hours after hospital arrival	Manual Entry	
Outcome - Alive at 72 hours after hospital arrival	Manual Entry	
Outcome - Alive at 30 days after hospital arrival	Manual Entry	
Outcome - Patient neurological outcome	Manual Entry	
ED disposition - OR	NTDS	ED Discharge Disposition
ED disposition - ICU	NTDS	ED Discharge Disposition
ED disposition - Stepdown unit	NTDS	ED Discharge Disposition
ED disposition - Floor	NTDS	ED Discharge Disposition
ED disposition - Transferred	NTDS	ED Discharge Disposition
Hospital disposition - Home	NTDS	ED Discharge Disposition, Hospital Discharge Disposition
Hospital disposition - Morgue	NTDS	ED Discharge Disposition, Hospital Discharge Disposition
Cause of death - Date/time of death	Manual Entry	
Cause of death attributed to hemorrhage	Manual Entry	
Injury Severity Score (ISS) highest value - Head	ITDX	ISS Body Region, Locally Calculated ISS
Injury Severity Score (ISS) highest value - Neck	ITDX	ISS Body Region, Locally Calculated ISS
Injury Severity Score (ISS) highest value - Chest	ITDX	ISS Body Region, Locally Calculated ISS
Injury Severity Score (ISS) highest value - Abdomen	ITDX	ISS Body Region, Locally Calculated ISS
Evidence of transfusion reaction in first 24 hours - (Yes or no)	Manual Entry	

SEMSTAR Expanded Metrics & Source Data

Metric Name	Source	Data Element
Patient age	NEMESIS/NTDS	ePatient.15, ePatient.16/Age, Age Units
Patient biologic sex at birth	NEMESIS/NTDS	ePatient.25/Sex
EMS agency	NEMESIS	eResponse.02
Patient comorbidities - Alcohol dependence, severe	NEMESIS/NTDS	eHistory08/Pre-existing conditions
Patient comorbidities - Acute substance use	NEMESIS/NTDS	eHistory08/Pre-existing conditions
Patient comorbidities - Anticoagulation	NEMESIS/NTDS	eHistory.12/Pre-existing conditions
Patient comorbidities - Antiplatelet use	NEMESIS/NTDS	eHistory.12/Pre-existing conditions
Cause of bleeding - Medical/chronic wound	Manual Entry	
Cardiac arrest - Bystander CPR initiated	NEMESIS	eArrest.20
Initial cardiac rhythm - Asystole	NEMESIS	eVitals.03, eArrest.11
Initial cardiac rhythm - Wide complex PEA or PEA <40 bpm	NEMESIS	eVitals.03, eArrest.12
Initial cardiac rhythm - Narrow complex PEA or PEA >40 bpm	NEMESIS	eVitals.03, eArrest.13
Initial cardiac rhythm - Ventricular fibrillation	NEMESIS	eVitals.03, eArrest.14
Initial cardiac rhythm - Ventricular tachycardia	NEMESIS	eVitals.03, eArrest.15
Initial cardiac rhythm - Normal sinus rhythm	NEMESIS	eVitals.03, eArrest.16
Initial cardiac rhythm - Sinus tachycardia	NEMESIS	eVitals.03, eArrest.17
Initial cardiac rhythm - Sinus bradycardia	NEMESIS	eVitals.03, eArrest.18
Prehospital interventions - Chest seal	NEMESIS	eProcedures.03
Prehospital interventions - Needle thoracostomy	NEMESIS	eProcedures.03
Airway management - NIPPV	NEMESIS	eProcedures.04
Airway management - Nonrebreather mask	NEMESIS	eProcedures.05
Airway management - Nasal cannula	NEMESIS	eProcedures.06
Airway management - Bag-mask ventilations	NEMESIS	eProcedures.07
Airway management - Extraglottic airway	NEMESIS	eProcedures.08
Pre-treatment vital signs - Highest heart rate	NEMESIS	eVitals.10
Pre-treatment vital signs - Nadir blood pressure	NEMESIS	eVitals.06, eVitals.07
Pre-treatment vital signs - BP obtained using automated cuff	NEMESIS	eVitals.08
Post-treatment vital signs - Highest heart rate	NEMESIS	eVitals.10
Post-treatment vital signs - Nadir blood pressure	NEMESIS	eVitals.06, eVitals.07
Post-treatment vital signs - Respiratory rate	NEMESIS	eVitals.14

Route of administration, quantity administered - IO	NEMESIS	eMedications.04, eMedications.05, eMedications.06, eProcedures.03, eProcedures.05
Route of administration, quantity administered - Existing vascular access (e.g., central access or dialysis catheter)	NEMESIS	eMedications.04, eMedications.05, eMedications.06, eProcedures.03, eProcedures.05
Additional medications given - 4F-PCC	NEMESIS	eMedications.03
Additional medications given - Vitamin K	NEMESIS	eMedications.03
Additional medications given - Recombinant factor for hemophilia	NEMESIS	eMedications.03
Hospital clinical metrics - Initial hemoglobin	Manual Entry	
Hospital clinical metrics - Initial ionized calcium	Manual Entry	
Hospital clinical metrics - Initial platelets	Manual Entry	
Hospital clinical metrics - Initial INR	Manual Entry	
Hospital clinical metrics - TEG	Manual Entry	
Hospital clinical metrics - Initial lactate or base deficit	Manual Entry	
Hospital clinical metrics - Blood type	Manual Entry	
Hospital clinical metrics - Rh status	Manual Entry	
Hospital clinical metrics - Antibodies	Manual Entry	
Hospital clinical metrics - hCG qualitative	Manual Entry	
Hospital interventions - Thoracotomy and/or sternotomy	NTDS	ICD-10 Hospital Procedures
Hospital interventions - Tube or finger thoracostomy	NTDS	ICD-10 Hospital Procedures
Hospital interventions - Exploratory laparotomy	NTDS	ICD-10 Hospital Procedures
Hospital interventions - Angiography	NTDS	ICD-10 Hospital Procedures
Hospital interventions - REBOA	NTDS	ICD-10 Hospital Procedures
Hospital interventions - Intubation	NTDS	ICD-10 Hospital Procedures
Hospital interventions - EDTXA	Manual Entry	
Hospital interventions - AC reversal	NTDS	ICD-10 Hospital Procedures
Outcome - Alive at 24 hours after hospital arrival	Manual Entry	
Outcome - Discharged alive from hospital	NEMESIS/NTDS	eOutcome.01, eOutcome.02/ED Discharge Disposition, Hospital Discharge Disposition
Outcome - ICU length of stay	NTDS	Total ICU Length of Stay
Hospital disposition - Subacute rehab	NEMESIS/NTDS	eOutcome.01, eOutcome.02/ED Discharge Disposition, Hospital Discharge Disposition
Hospital disposition - Skilled nursing facility or long term care facility	NEMESIS/NTDS	eOutcome.01, eOutcome.02/ED Discharge Disposition, Hospital Discharge Disposition

Hospital disposition - Length of stay (days)	ITDX	eTimes.11, eOutcome.16/ED - Hospital Arrival Date, ED - Hospital Arrival Time, ED Discharge Orders Written Date, ED Discharge Orders Written Time
Cause of death - Days til death after arrival to hospital	Manual Entry	
Abbreviated injury scale (AIS) highest value - Head	ITDX	AIS Body Region, AIS Severity
Abbreviated injury scale (AIS) highest value - Face	ITDX	AIS Body Region, AIS Severity
Abbreviated injury scale (AIS) highest value - Neck	ITDX	AIS Body Region, AIS Severity
Abbreviated injury scale (AIS) highest value - Chest	ITDX	AIS Body Region, AIS Severity
Abbreviated injury scale (AIS) highest value - Abdomen	ITDX	AIS Body Region, AIS Severity
Abbreviated injury scale (AIS) highest value - Spine	ITDX	AIS Body Region, AIS Severity
Abbreviated injury scale (AIS) highest value - Upper extremity	ITDX	AIS Body Region, AIS Severity
Abbreviated injury scale (AIS) highest value - Lower extremity	ITDX	AIS Body Region, AIS Severity
Injury Severity Score (ISS) highest value - Face	ITDX	AIS Body Region, AIS Severity
Evidence of transfusion reaction in first 24 hours - Allergic reaction	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Anaphylaxis	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Febrile non-hemolytic reaction	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Transfusion-related acute lung injury (TRALI)	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Transfusion-associated circulatory overload (TACO)	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Infection	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Fluid overload	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Citrate toxicity	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Delay to definitive care based on arrival time	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Isoimmunization	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Hemolysis	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Harms related to the method of administration	Manual Entry	
Evidence of transfusion reaction in first 24 hours - Risk of clotting when Ringer's lactate solution combined with blood	Manual Entry	

Standardized Consensus Definitions

- **Hemorrhagic Circulatory Collapse:** Profound hypoperfusion due to life-threatening hemorrhage, with altered mental status, apnea/agonal respirations, and no palpable central pulse.
- **Survival Following Prehospital Transfusion:** survival to hospital arrival, 6h, 12h, 24h, 72h, and either 30 days or discharge.
- **SEMSTAR Survival** (excludes pretransfusion collapse): same endpoints, however, excluding those who had circulatory collapse before transfusion.

Vision & Impact

- Foundational framework for a dedicated prehospital transfusion registry (akin to CARES).
- Enables nationwide benchmarking, collaborative QI, and evidence-based program development.
- Creating a registry that includes both medical and trauma etiologies.

