The Effect of Prehospital Blood Transfusion on Patient Body Temperature from the Time of Emergency Medical Services Transfusion to Arrival at the Emergency Department

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ABSTRACT

Background: Transfusion of blood products is life-saving and time-sensitive in the setting of acute blood-loss anemia, and is increasingly common in the emergency medical services (EMS) setting. Prehospital blood products are generally "cold-stored" at 4°C, then warmed with a portable fluid-warming system for the purpose of preventing the "lethal triad" of hypothermia, acidosis, and coagulopathy. This study aims to evaluate body temperature changes of EMS patients receiving packed red blood cells (PRBC) and/or fresh frozen plasma (FFP) when using the LifeWarmer Quantum Blood & Fluid Warming System (LifeWarmer, https://www.lifewarmer.com/). **Methods:** From 1 January 2020 to 31 August 2021, patients who qualified for and received PRBC and/or FFP were retrospectively reviewed. Body-temperature homeostasis pre- and post-transfusion were evaluated with attention given to those who arrived to the emergency department (ED) hypothermic (<36°C). **Results:** For all 69 patients analyzed, the mean initial prehospital temperature (°C) was 36.5 ± 1.0, and the mean initial ED temperature was 36.7 ± 0.6, demonstrating no statically significant change in value pre- or post-transfusion (0.2 ± 0.8, p = .09). Shock index showed a statistically significant decrease following transfusion: 1.5 ± 0.5 to 0.9 ± 0.4 (p < .001). **Conclusion:** Use of the Quantum prevents the previously identified risk of hypothermia with respect to unwarmed prehospital transfusions. The data is favorable in that body temperature did not decrease in critically ill patients receiving cold-stored blood warmed during administration with the Quantum.

KEYWORDS: *prehospital blood transfusion; lethal triad; damage-control resuscitation; tactical combat casualty care*

Introduction

Prehospital hypothermia, generally defined as a core temperature <36°C, is frequently observed in victims of trauma.[1,2] Although primary hypothermia is defined by core temperatures <35°C, secondary hypothermia associated with trauma is considered at temperatures <36°C and is reflected in the current Tactical Combat Casualty Care guidelines.[3] As early as the American Revolutionary War, hypothermia had been identified as a detriment to the clinical recovery of soldiers suffering traumatic injuries. More recent literature has described prehospital hypothermia alone as an independent risk factor for early death in critically ill patients.[4,5]

Perhaps most commonly, hypothermia is considered within the context of the "lethal triad," a clinical condition additionally characterized by coagulopathy and acidosis. It is associated with increased risk of mortality.[1,2,6] Acute blood loss in the setting of trauma or non-traumatic hemorrhagic conditions leads to a vicious cycle of hypoperfusion and acidosis. This, in conjunction with rapid development of coagulopathy and thermoregulatory instability, leads to further bleeding, portending to catastrophic outcomes.[1,2] Proper resuscitative management in the prehospital setting involves volume expansion with an oxygen carrying fluid to sustain tissue perfusion, as well as the delivery of clotting factors to replace those lost due to hemorrhage.[2]

Based on successful outcomes in the combat setting, civilian ground EMS systems are increasingly establishing blood-transfusion programs. Wheeler et al. noted within a retrospective review that patients transfused with non-warmed blood before arrival to the hospital were more likely to be hypothermic (<35°C).[7] Prehospital blood products are generally "cold-stored" at 4°C, then warmed with a portable fluid warming system.[8] Alone, cold-stored blood can lower core body temperature by 0.5–1°C per 500mL administered.[8] Previous studies implicate non-warmed prehospital IV fluids and blood products as a risk factor for developing hypothermia.[7,9] Thermodynamic modelling shows the major beneficial effect of active fluid warming is the prevention of further net heat loss.[10] Inline blood warmers, such as the Quantum used in this study, aim to warm the transfusing blood to a normothermic range ≥36°C. The goal is to decrease the temperature differential between the transfusing blood and patient temperature to ultimately prevent unintended hypothermia. As EMS blood protocols become more common, an evidence-based evaluation of temperature management during prehospital blood transfusion is imperative to guide appropriate patient care.

Published data on body-temperature maintenance following prehospital blood transfusions is lacking. In this retrospective case series analysis, the authors primarily seek to identify how body temperature is affected when using the Quantum to transfuse PRBC and/or FFP in the prehospital setting.

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Methods

This is a retrospective case series of prehospital and inpatient electronic health records (EHR) for patients age >18 years of age who were transported to the ED by the Prisma Health Ambulance Service (PHAS) and received prehospital blood products, from 1 January 2020 to 31 August 2021. All cases occurred within the South Carolina Upstate region (western SC) and the majority of patients were transported to hospitals within the Prisma Health Network (encompassing greater Greenville County and Oconee County, SC). Other facilities to which a smaller number of patients were transported include Bon Secours Health System – St. Francis Downtown (Greenville, SC) and AnMed Health Medical Center (Anderson, SC). This study was approved by the Prisma Health-Upstate Institutional Review Board under the expedited category.

The SC Department of Health & Environmental Control – Bureau of EMS (SCDHEC EMS) approved PHAS to provide prehospital blood transfusion as a pilot project according to strict criteria as dictated by protocol. Prior to this initiative, blood products were not transfused by ground ambulance systems in the state of SC.

Setting

PHAS is a hospital-based EMS system in the upstate region of SC providing basic life support (BLS), advanced life support (ALS), and critical-care transport. PHAS is the sole 911 EMS responder for Oconee County, SC, which is geographically 674 mi^2, and has an estimated population of 72,633 people. From within Oconee County, average transport time to a Level-1 trauma center (Greenville Memorial Hospital) is 46 minutes and 54 seconds. Through mutual-aid agreements, PHAS also provides 911 services for Anderson, Greenville, Laurens, and Pickens, SC counties. PHAS is also the sole interfacility and critical-care provider for eight acute-care hospitals. From 1 January 2020 to 31 August 2021, PHAS answered 70,902 requests for service and transported 58,500 patients.

Blood Alert Process

PHAS operates a tiered response plan with 25 transport ambulances and four ALS quick-response vehicles equipped with blood products. Requests for service are answered by an Emergency Medical Dispatch (EMD) certified communications center. PHAS blood products are dispatched automatically by EMD protocol, or upon the request of the 911 system provider of either Greenville, Laurens, or Pickens counties. All blood dispatches are initially alerted to the medical and operational directors and EMS supervisors through a text-page "Blood Alert." This occurs in real time (at the time of EMS request for transfusion) and is sent via the regional communications center. This is a communication requirement of all transfusions as set forth in the PHAS Blood Transfusion protocol and allows for the directors to track the patient's chart electronically once it has been signed by the EMS crew. All patient care is documented in an electronic patient care report system with a searchable database.

Training

All PHAS paramedics received eight hours of in-person training, including four hours of psychomotor and medical simulations. This training included indications for emergent prehospital transfusion and the blood-transfusion protocol (Figure 1). Additionally, all PHAS clinicians were educated on possible adverse reactions to transfusion, as well as how to manage these complications. Paramedics authorized to administer blood received and additional hour of Just In Time Training before implementation of the pilot.

Patient Care Protocol

The prehospital blood protocol was developed with collaboration from the medical and executive directors of EMS, Trauma Services, and Laboratory Services at Prisma Health-Upstate. The protocol and alert criteria were reflective of the standards for similar inpatient treatment (Figure 1).

Patients warranting transfusion were identified by their mechanism of injury or nature of illness and were required to meet at least two physiological parameters indicative of significant blood loss. If able, patients were consented using a hospital-established standardized blood consent form. Implied consent was utilized in emergent scenarios in which patients were unable to provide consent and blood transfusion was considered an emergent standard of care. When at all possible, patients were screened for a history of transfusion reaction, and any patient with a reported history of such did not receive blood products.

A full set of vital signs were obtained and documented as is standard for the prehospital patient evaluation. Temperatures were obtained by an oral thermometer prior to blood administration. In this review, this initial value served as the "pre-transfusion temperature."

Following establishment of bilateral IV access and a bolus of fluid if appropriate, adult patients were administered a goal volume of two units of O-positive PRBC and two units of FFP. Blood products were warmed using the Quantum following manufacturer instructions.[11] All patients were continuously monitored for any adverse events during transport. EMS care was considered complete following a thorough patient handoff to the accepting ED team with, at minimum, an explanation of why blood was transfused, and verbal report with written documentation of all products transfused. If blood product was still infusing, the paramedic would report how much total product was given.

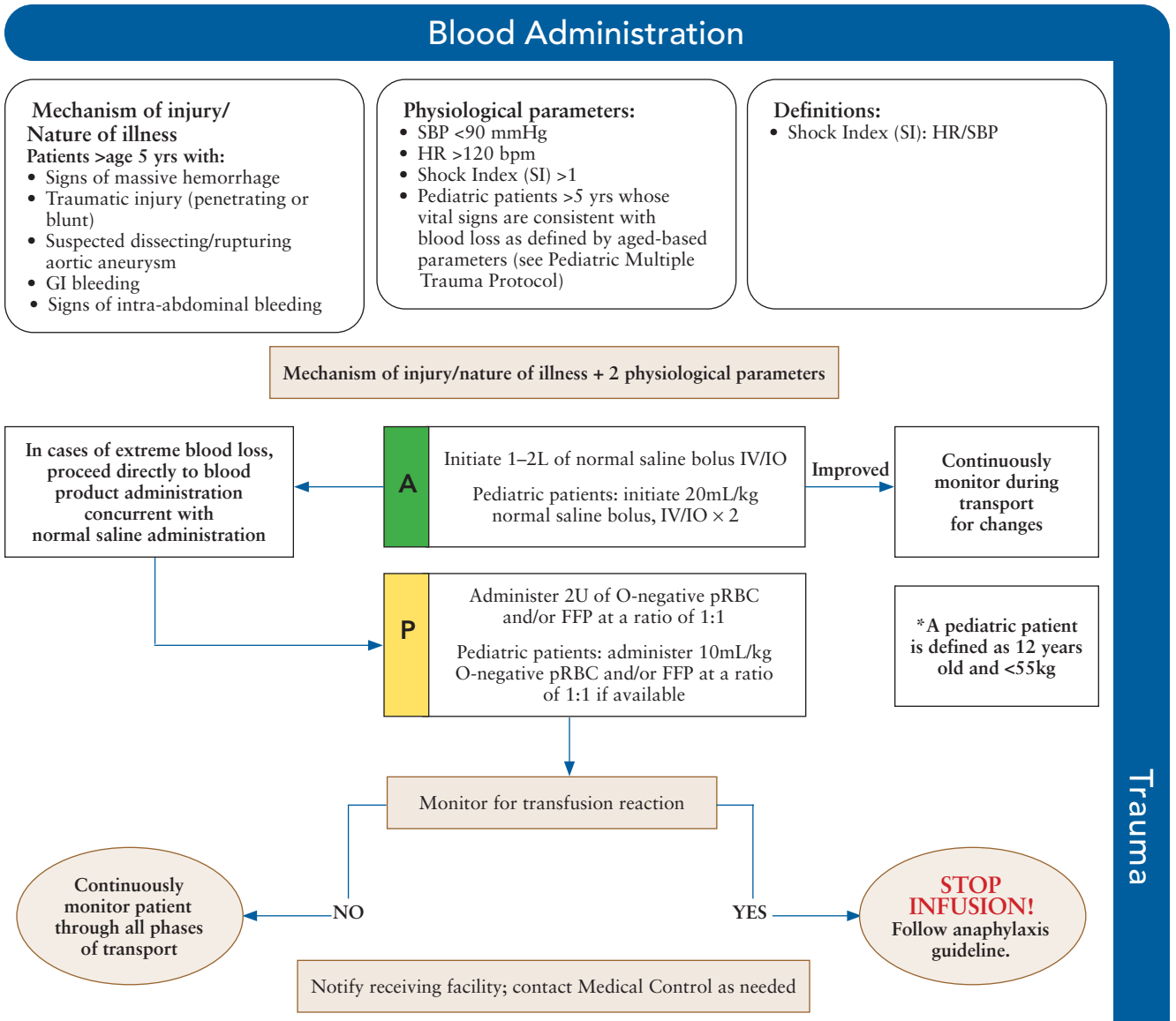
Prehospital blood products were maintained in the Credo ProMed (Peli BioThermal, https://pelibiothermal.com/products/credo-promed) transport bag. Temperatures were monitored by ThermoWorks alarming thermometers (https://www.thermoworks.com/) and LogTag (https://logtagrecorders.com/us/) thermal recording technology. All unused prehospital blood units were exchanged on a strict 24-hour schedule at the hospital blood bank. Data were downloaded weekly into reports that were electronically sent to the hospital blood bank for review and quality monitoring.

Emergency Department Care

ED care was based on physician assessment and standard of care within that health system. All patients were carefully monitored for any post-transfusion events. For critically ill trauma or obstetrical patients that were taken to the operating room (OR), care in the ED may have been relatively brief.

Temperatures in the ED were generally taken at the time of arrival (initial nursing triage and assessment) by the oral route, although some were taken cutaneously (axillary), rectally, or via temperature-sensing bladder catheter. These temperatures

FIGURE 1 *Blood administration algorithm.*



PEARLS:

- Prime blood tubing and warmer. Tubing should be changed after 2 units if possible, or as manufacturer recommends. Care should be taken to prevent hypothermia.
- Monitor patients for signs and symptoms of transfusion reaction and adverse effects, including temperature at time of infusion and 15 minutes after start.
- **For any reason, STOP the infusion, remove all tubing and product from the patient and save all equipment. Flush IV line.**
- Consider any fluid overload issues such as CHF or patient weight (pediatrics, and monitor for signs and symptoms appropriately.
- **Allergic reaction (onset <15 min):** Mild skin itching or hives <25% body, Temp 38°C (100.4°F) or change of >1°C (>2°F) from pre-transfusion value, chills, and hives/rash >25% body
- **Febrile transfusion reaction:** Temp 38°C (100.4°F) or change of >1°C (<1.8°F) from pre-transfusion value, chills, headache, facial flushing, palpitations, cough, chest tightness, increased pulse rate and/or flank pain
- **Hemolytic transfusion mentions:** Immediate lysis of transfused blood can result in fever and/or tachycardia. Other symptoms can include chills, back/flank pain, nausea/vomiting, dyspnea, flushing, bleeding, and/or hypotension. Begin aggressive NS 0.9% treatment.
- **Dilutional thrombocytopenia:** This is generally not seen with infusion of 1–2 units unless patient has pre-existing thrombocytopenia or disseminated intravascular coagulation.
- **Potassium intoxication (hyperkalemia):** Symptoms can include flaccidity, muscle twitching, bradycardia, EKG changes (tall peaked T waves, prolonged P-R interval, absent P waves, prolonged QRS) and/or cardiac arrest.
- **Hypoglycemia (from citrate toxicity that binds Ca):** Symptoms can include arrhythmias, hypotension, muscle cramping, nausea, vomiting, seizure activity, and/or tingling sensation in the fingers. Patient with acute or chronic hepatic insufficiency are at a relatively higher risk of citrate toxicity. To avoid, administer PRBC at a minimum rate of >5 minute. Treatment with Calcium Gluconate 1gm infused slowly in a different IV/IO line.
- Contact Medical Control for additional boluses as necessary.

SBP = systolic blood pressure, HR = heart rate, IV = intravenous, IO = intraosseous, pRBC = packed red blood cells, FFP = fresh frozen plasms, U = unit

were documented in the EHR by nursing staff, and served as the "post-transfusion temperature." If patients were taken directly to the OR upon arrival, the first documented OR temperature served as the post-transfusion temperature. For any interfacility transports, the post-transfusion temperature was taken from the first set of vitals upon arrival to the receiving facility.

Outcome Measures

The primary outcome of interest was the number of patients who arrived to the ED with temperatures <36°C. An additional analysis assessed the patient's post-transfusion temperature as compared to pre-transfusion temperature. Secondary outcome measures included pre- and post-transfusion shock index (SI), first-recorded hemoglobin (Hgb), and any additional blood products given over four hours following ED arrival.

Data Collection

Over the course of 19 months, two EHRs were used for data acquisition: ESO (https://www.eso.com/) for all prehospital data, and Epic (https://www.epic.com/) for all ED or inpatient data. Data from 94 adult patients receiving EMS blood products were reviewed. Inclusion criteria were (1) patients age >18 years who received blood products and were transported to an ED by PHAS, with (2) a full set of vital signs recorded both before and after ED arrival (temperature, heart rate (HR), respiratory rate, oxygen saturation, and blood pressure). Exclusion criteria included (1) patients age <18 years of age and (2) patients who did not survive to ED arrival or (3) did not have complete vital signs recorded at ED arrival. Patient demographic data were gathered for descriptive statistical analysis.

Statistical Analysis

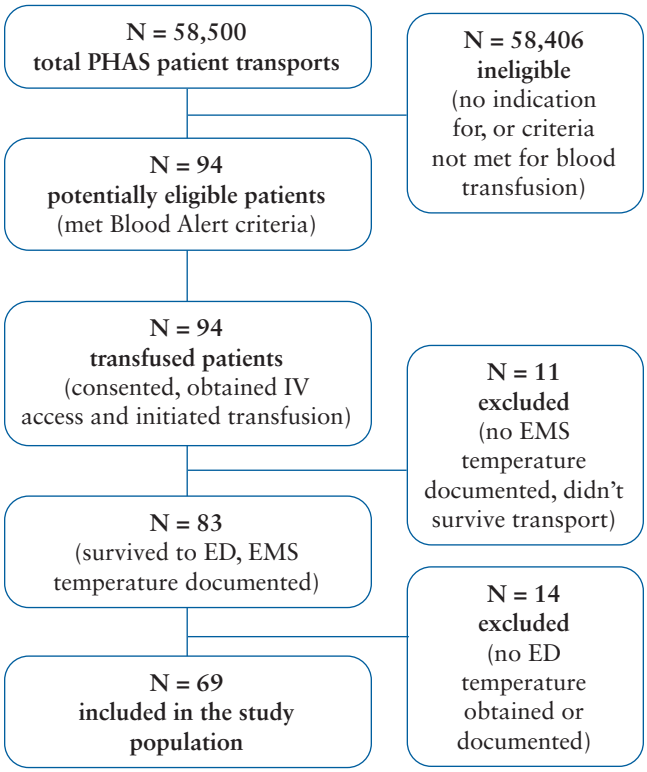
Sixty-nine patients met inclusion criteria and were thus analyzed for their demographics (age, gender, body mass index (BMI)), initial EMS vital signs (including shock index (SI)), and initial vital signs upon arrival to the ED. Total number of units and type of blood product (PRBC and/or FFP) transfused were recorded. Additional factors identified were type of transport (911 versus interfacility), ambient temperature, heat index, scene time, and transport time. Ambient temperatures and heat indices were obtained from the National Weather Service online archives, from a central location thought to best represent these factors across the general transport area.[12] Other elements abstracted included first-recorded Hgb at the hospital, whether or not the patient received blood in the ED, and whether or not they received a massive transfusion protocol (MTP). Further documented were any routine home medications for exogenous heart rate or blood pressure control (calcium-channel blockers or beta blockers), toxicological factors (urine drug screen), survival to admission, and survival to discharge.

Results

Study Characteristics

Between 1 January 2020 and 31 August 2021, of the 94 patients who received prehospital blood products, 69 (73%) met inclusion criteria for analysis (Figure 2). Table 1 describes a summary of patient demographics. No patients experienced adverse transfusion reactions. Disposition status was unable to be obtained for three patients due to anonymous names given upon arrival, and the subsequent inability to locate a complete hospital chart. Table 2 describes causes of blood loss, and Table 3 describes the blood products received by type.

FIGURE 2 *Study population.*



ED = emergency department, EMS = emergency medical services, PHAS = Prisma Health Ambulance Service, IV = intravenous.

Main Measurements

Sixty-four of 69 patients arrived to the ED normothermic, and 67 of 69 patients did not experience hypothermia due to temperature loss. For all 69 patients analyzed, the mean initial prehospital temperature (°C) was 36.5 ± 1.0, and the mean initial ED temperature was 36.7 ± 0.6, demonstrating no statistically significant change in temperature (0.2 ± 0.8, $p = .09$) pre- or post-transfusion (Table 4). SI showed a statistically significant decrease following transfusion: 1.5 ± 0.5 to 0.9 ± 0.4 ($p < .001$) (Table 4).

Pre-transfusion, 11 patients (16%) were hypothermic by their EMS temperature. Of those, only three patients (4%) arrived hypothermic to the ED; these patients are designated as Patients 3, 4, and 5 (Table 5). Patients 3 and 4 each had improvements in their body temperature upon ED arrival.

Two patients (Patients 1 and 2) who were normothermic upon initial EMS evaluation arrived hypothermic to the ED (Table 5). Two additional patients (Patients 3 and 4), who were hypothermic prior to ED arrival, had improvements in their temperatures upon arrival to the ED.

Only one patient (Patient 5) arrived to the ED with a temperature of <35°C (Table 5). Patient 5 was hypothermic on EMS evaluation (35.9°C orally) and remained hypothermic by post-transfusion temperature (35.5°C axillary).

Patients 6 and 7 (Table 6) were unique in that they each received a total of four units of PRBC and four units of FFP

TABLE 1 *Summary Demographics and EMS Data (Blood Alert)*

	Number N = 69	Percent
Gender		
M	41	59
F	28	41
Age (yrs)	54.3 ± 18.7	
BMI	28.5 ± 7.0	
Calcium Channel or Beta Blocker		
Yes	22	32
No	44	64
Unknown	3	4
Toxicological Factors		
None	49	71
EtOH	7	10
Opioids	4	6
Benzodiazepines	4	6
Amphetamines	5	7
Marijuana	1	1
Unknown	9	13
Hgb* (g/dL)	10.4 ± 3.2	
Survival to Discharge		
Yes	57	83
No	7	10
AMA	2	3
Unknown	3	4
Ambient temp (°C)	18.0 ± 8.4	
Heat Index	19 ± 13	
Scene Time (min)	19.4 ± 18.6	
911 Response	59	86
Interfacility	10	14

AMA = against medical advice, BMI = Body Mass Index, EtOH = Ethyl alcohol, Hgb = Hemoglobin.
*First-recorded hemoglobin.

TABLE 2 *Cause of Blood Loss*

Cause of Blood Loss	Number	Percent
GIB	32	46
Trauma	22	32
Gynecological/Obstetric	4	6
A-V Fistula Bleed	2	3
Post-operative Bleed	2	3
Other (medical)*	7	10

GIB = gastrointestinal bleed.
*Specific medical diagnoses known prior to interfacility transfer, to include sepsis, disseminated intravascular coagulopathy (DIC), and complications of pancreatitis.

(Table 6). Of note, these units were given as an exception to protocol, approved by online medical control).

Discussion

With transfusion, there is the risk of impacting body-temperature homeostasis. The temperature differential between cold blood (~ 4°C) and the patient can lower core body temperature by 0.5–1°C per 500mL administered.[8] As part of the established protocol, the Quantum was used to prevent unintentional hypothermia. This retrospective descriptive study demonstrates that in the aforementioned patient population,

TABLE 3 *EMS Blood Products Received*

	Number	Percent
PRBC		
0	1	1
1	12	17
2	54	78
4	2	3
FFP		
0	25	36
1	10	14
2	32	46
4	2	3

PRBC = packed red blood cells, FFP = fresh frozen plasma.

TABLE 4 *Vital Sign Changes.*

	EMS	ED	Δ	P
Temp (°C)	36.5 ± 1.0	36.7 ± 0.6	0.2 ± 0.8	0.091
SI	1.5 ± 0.5	0.9 ± 0.4	–0.6 ± 0.7	2.00×10^{-16}

SI = shock index, EMS = emergency medical services, ED = emergency department.

only 2 of 69 patients (3%) had a decrease in temperature that led to hypothermia upon ED arrival, with likely no clinically significant difference. Other measures of secondary benefits of early blood transfusion were realized including a statistically significant decrease in SI ($p < .001$). An improved SI is likely indicative of improved perfusion and therefore thermoregulation, which supports overall body-temperature homeostasis. SI was considered to be the most applicable indicator of disease severity based on our patient population, although other measures of disease severity were considered (e.g., Trauma Injury Severity Score (TRISS and Revised Trauma Score)).

Patient 1 was unique in that she had undergone rapid sequence intubation (RSI) prior to transfer and was critically ill from multisystem illness (Table 5). This patient had a primary diagnosis of skull fracture and acute-on-chronic subdural hematoma as well as pancytopenia. The authors suspect there were multiple factors that impacted her post-transfusion temperature. Patient 2 had a prolonged prehospital scene and transport time (a total of 77 minutes) due to scene-safety delays as well as a geographically rural location (Table 5). This may have also had an impact on body-temperature maintenance.

Mode of temperature acquisition is further discussed in the limitations section. Patient 5 had a prehospital temperature taken orally and an ED temperature taken cutaneously (axillary). It is considered that her change in temperature (–0.6°C) may have been related to the anatomical site.

Particular attention is drawn to two patients, Patients 6 and 7 who each received a total of four units of PRBC and four units of FFP after EMS sought medical direction from the on-call physician (exception to protocol, Table 6). A total of eight units of blood products administered in the field is equivalent to many in-hospital MTP protocols. The authors feel it is notable that neither of these patients experienced a decrease in temperature despite high volumes of product transfused. Furthermore, it is worth noting that two of the patients within the hypothermic cohort. Patients 3 and 4, experienced a relative warming effect (Table 5).

TABLE 5 *Hypothermic ED Arrivals*

Patient	Age (yrs)	M/F	BMI	T_{EMS}* (°C)	T_{ED}* (°C)	ΔT (°C)	$T_{Ambient}$ (°C)	HI	EMS SI	Scene Time (min)	Transport Time (min)	ED SI	Hgb† (g/dL)	MTP‡	Tox§	Diagnosis	pRBC transfused (units)	FFP transfused (units)	Survival to Admission	Survival to Discharge
1	44	F	24	36.8 O	35.9 B	−0.9	32.8	32	1.3	28	19	0.9	8.0	Y	None	Trauma, SDH	1	1	Y	N
2	36	F	19	36.9 O	35.9 R	−1.0	22.2	23	2.2	34	43	2.2	13.5	Y	Amph, Benzo	Trauma, GSW	2	0	Y	Y
3	54	M	27	32.9 O	34.3 O	+1.4	7.2	5	2.0	6	32	0.9	8.1	Y	None	GIB	2	2	Y	Y
4	65	M	30	34.7 O	35.3 R	+0.6	19.4	18	0.8	14	22	0.7	4.5	Y	None	GIB	1	1	Y	Y
5	58	F	21	35.9 O	35.3 A	−0.6	31.1	34	2.0	6	10	1.0	7.6	Y	EtOH	Trauma, laceration	2	0	Y	Y

*Temp source: A = axillary, B = bladder (temp-sensing catheter), O = oral, R = rectal
†Hemoglobin, first-recorded in hospital
‡Massive Transfusion Protocol initiated in ED
§Toxicological factors: EtOH (ethyl alcohol), amph (amphetamine), benzo (benzodiazepine)
HI = Heat index
SI = Shock index
SDH = Subdural hematoma
GSW = Gunshot wound
GIB = Gastrointestinal bleeding

TABLE 6 *Patients Receiving Additional EMS Blood Products*

Patient	Age (yrs)	M/F	BMI	T_{EMS}* (°C)	T_{ED}* (°C)	ΔT (°C)	$T_{Ambient}$ (°C)	HI	EMS SI	Scene Time (min)	Transport Time (min)	ED SI	Hgb† (g/dL)	MTP‡	Tox§	Diagnosis
6	41	M	24	36.2 O	36.7 R	+0.5	11.1	10	1.8	21	9	1.1	8.3	Y	None	Trauma, leg amputation
7	54	M	32	36.7 O	36.6 A	−0.1	12.8	11	1.9	8	93	0.8	12.1	Y	None	GIB

*Temp source: A = axillary, B = bladder (temp-sensing catheter), O = oral, R = rectal
†Hemoglobin, first-recorded in hospital
‡Massive Transfusion Protocol initiated in ED
§Toxicological factors: EtOH (ethyl alcohol), amph (amphetamine), benzo (benzodiazepine)
HI = Heat index
SI = Shock index
SDH = Subdural hematoma
GSW = Gun-shot wound
GIB = Gastrointestinal bleeding

The authors acknowledge that warming patients is a "bundle" of various efforts. Additional interventions such as removing wet clothing, applying blankets, and controlling indoor ambient temperature are important to maintaining normothermia. The authors feel that these data support transfusing warmed prehospital blood to minimize body temperature change in critically ill patients. Future research might take into account the warming treatment "bundle" as a whole.

Limitations

The authors recognize several limitations to this study. First, the modality for post-transfusion temperature measurement was not standardized, and included the following routes: oral, cutaneous, rectal, and temperature-sensing bladder catheter. Sund-Levander et al. investigated normal body temperature in adults by oral, rectal, tympanic, and axillary routes. Their results suggested that, when looking at studies with "strong or fairly strong evidence" of normal body temperature, the rectal route was only slightly higher (36.9°C) when compared to oral (36.4°C), tympanic (36.5°C) and axillary (36.3°C) means.[13] Additionally, there were possibly pertinent differences in the timing of temperature acquisition upon patient arrival to the hospital. Critical trauma patients, for example, may not have had their temperature obtained until other aspects of the primary assessment were performed.

Per protocol, patients may have received intravenous (IV) fluids prior to blood administration. Volume of crystalloid transfused was not accounted for in this analysis. Prehospital fluids are stored in the temperature-controlled patient-care compartment of the ambulances and are not warmed. The addition of an unknown amount of non-warmed crystalloid IV fluid would be expected to exacerbate a decrease in body temperature, although the temperature difference between room-temperature IV fluid and body temperature is small compared to that of refrigerated blood. It is possible the addition of warmed blood products mitigated the potential crystalloid fluid temperature drop but this is unknown. Regardless, it appears that in this study patient population, the crystalloid fluid volume does not appear to influence the results. Future work may consider comparing the effects of warmed IV fluid versus ambient-temperature fluid on body temperature.

It must be considered that there may have been inconsistencies in documentation, particularly related to home medications that may have affected physiological parameters from the time of EMS intervention to ED assessment. Patients may not have had updated medication lists in their chart or may have had inconsistent adherence to their regimens.

For those patients who were excluded from data analysis due to incomplete vital sign documentation and no documented temperature, it should be acknowledged that a febrile transfusion reaction could have been overlooked. However, no transfusion reactions were identified in receiving hospital records over the course of this time period.

Environmental effects were also of consideration. Patients were treated at varying environmental temperatures and conditions. For example, it is possible that wet clothing, which would have likely had an effect on lowering body temperature, was not accounted for and unable to be identified in a retrospective chart review. Furthermore, although interventions such as forced-air warming systems were often documented, other routine interventions such as warmed blankets or "bundling" may not have been documented.

When assessing pre- and post-transfusion blood pressure (i.e., SI), both manual and automated blood pressures were included, and the measurement modality was not always documented in charting. Finally, children were not included in this study, and the results may not be generalizable to a pediatric population.

Conclusion

These data are favorable in support of warmed prehospital blood transfusion in preventing body- temperature decrease in critically ill patients. This retrospective descriptive study demonstrates that in this patient population, only two of 69 patients (3%) had a decrease in temperature that led to hypothermia upon ED arrival. Overall, there was no statistically significant difference in pre- and post-transfusion body temperature, including two patients receiving large-volume transfusions with eight units of blood products each.

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Author Contributions
All authors conceived the study. EM prepared the initial protocol; EM, RP, and AD drafted the manuscript. EM, AD, and LE collected and organized data. Data analytics were performed by the Prisma Health-Upstate Biostatistics team. All authors read and approved the final manuscript.

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