

Pediatric Trauma Patient Intensive Care Resource Utilization in U.S. Military Operations in Iraq and Afghanistan

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Objectives: Children represent a unique patient population treated by military personnel during wartime, as seen in the recent conflicts in Iraq and Afghanistan. We sought to describe ICU resource utilization by U.S. military personnel treating pediatric trauma patients in Iraq and Afghanistan.

Design: This is a retrospective review of prospectively collected data within Department of Defense Trauma Registry.

Setting: We studied pediatric casualties treated in U.S. and coalition military hospitals in Iraq and Afghanistan between January 2007 and January 2016.

Patients: We queried the Department of Defense Trauma Registry for patients less than 18 years with one documented day within an ICU.

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The United States Army Institute of Surgical Research regulatory office reviewed protocol H-16-014 and determined it was exempt from Institutional Review Board oversight. We obtained only de-identified data.

The authors have disclosed that they do not have any potential conflicts of interest.

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Interventions: We used descriptive statistics to analyze injuries patterns and interventions. We defined prolonged length of stay as ICU stay four days or greater. Regression methodology was utilized to identify factors associated with prolonged length of stay.

Measurements and Main Results: There were 1955 (56.8%) pediatric patients that met our inclusion criteria. The most common mechanism of injury was explosive (45.2%) followed by gunshot wounds (20.8%). The median composite ISS was 14. The median length of stay was 3 days with 90.2% surviving to hospital discharge. Mechanical ventilation was the most frequent intervention (67.6%) followed by arterial access (21.8%). Prolonged length of stay was associated with all serious injuries, ventilator management, blood product administration, wound dressing, bronchoscopy, imaging, and central venous access.

Conclusions: Pediatric casualties accounted for nearly one in 10 admissions with the majority requiring intensive care. The most commonly performed interventions were mechanical ventilation, vascular access, and imaging, each of which requires a specialized skill set to provide optimal patient management. All serious injuries by body region except facial were associated with a prolonged length of ICU stay, as well as blood product administration, ventilator management, intracranial pressure monitoring, wound care, bronchoscopy, imaging, and central venous access. The epidemiology of this unique population may be useful in planning future pre-deployment training and resource management in ICUs in deployed environments.

Key Words: armed conflicts; critical care; health resources; military medicine; pediatrics; wounds and injuries

Children represent a unique patient population during wartime, as seen in the recent conflicts in Iraq and Afghanistan (1–3). Children in conflict-ridden areas often become casualties as a matter of collateral damage, unintentional exposure to weapons and explosives, the result of terrorist attacks, or even as young combatants (4). Based on the U.S. military's medical rules of eligibility for humanitarian care in Iraq and Afghanistan, the deployed U.S. military trauma system provides care for pediatric casualties. Based on previously published data, the majority of patients treated in U.S. military facilities in Iraq and Afghanistan

are adults, pediatric patients made up 5.8% of all admissions and 10% of bed days between 2001 and 2011 in military hospitals (3). These children were treated throughout the spectrum of care: pre-hospital field resuscitation, emergency departments (EDs), medical and surgical wards, and ICUs (1–3, 5).

Care of the pediatric patient poses challenges to deployed military physicians, particularly in the ICU. Assigned physicians rarely have a background in pediatric intensive care, requiring many to function outside of their scope of practice. Furthermore, preadolescent children require size-appropriate equipment which may not always be available. In the ED, the majority of pediatric patients presented with explosive injuries, most often requiring vascular access and IV fluid resuscitation (1). Specific to intensive care, drug administration including continuous infusions require weight-based dosing and blood draw volumes must be adjusted when performing laboratory testing (6, 7). Mechanical ventilation of the critically ill pediatric casualty requires knowledge of their unique airway anatomy, pulmonary system, and physiologic reserve (8). Further, vital signs ranges and targets are different than adults (9). These nuances may challenge nonpediatric intensivists, nursing, and support staff.

Recent studies have analyzed the care of pediatric patients treated by the U.S. military in deployed environments, particularly in the prehospital and ED settings (1, 10, 11). This study uniquely focuses on ICU resource utilization and procedures necessary to care for pediatric casualties.

GOAL OF THIS INVESTIGATION

We sought to describe ICU resource utilization necessary to treat pediatric trauma patients admitted to U.S. Military Hospitals in Iraq and Afghanistan.

METHODS

Data Acquisition

We identified subjects as part of a study seeking to evaluate prehospital and ED interventions for pediatric trauma patients (1, 12). The U.S. Army Institute of Surgical Research regulatory office reviewed protocol H-16-014 and determined it was exempt from institutional review board oversight. We obtained only de-identified data.

Subjects and Setting

We queried the Department of Defense (DOD) Trauma Registry (DODTR) for all pediatric (age < 18 yr) encounters from January 2007 to January 2016. This is a retrospective review of prospectively collected data within the registry. We included subjects with missing data provided there was a documented age or estimated age within the records. We requested all available documentation of prehospital care and fixed-facility based care. Subjects were placed into categories based on Centers for Disease Control and Prevention age groupings: less than 1 year, 1–4 years, 5–9 years, 10–14 years, and 15–17 years (13). If a subject received an intervention more than once, it was only counted one time. We excluded subjects that were documented as dead on arrival. This is a secondary analysis of previously published data on pediatric casualties with at least 1 day in a deployed ICU (1, 12). Procedures were included if they had a documented location to include ICU,

medical/surgical unit, and burn unit. Multiple in-hospital locations were included because these units are rarely geographically separated within the deployed military treatment facilities. We used an abbreviated injury score (AIS) of 3 or greater to define a serious injury (14, 15). All blood administrations were included as the registry does not capture specific locations of the transfusions.

To further investigate ICU resource and skills utilization, admission data and length of stay (LOS) were used as markers for resource utilization, and procedural coding registry data were used to indicate necessary psychomotor skills required by a provider to perform these tasks.

Department of Defense Trauma Registry Description

The DODTR, formerly known as the Joint Theater Trauma Registry, is the data repository for DOD trauma-related injuries (1, 12, 16–19). The DODTR includes documentation regarding demographics, injury-producing incidents, diagnoses, treatments, and outcomes of injuries sustained by U.S./non-U.S. military and U.S./non-U.S. civilian personnel in wartime and peacetime from the point of injury to final disposition. The DODTR comprises all patients admitted to a role 3 (fixed-facility) or forward surgical team (FST) with an injury diagnosis using the *International Classification of Diseases*, 9th Edition (ICD-9) between 800 and 959.9, near-drowning/drowning with associated injury (ICD-9 994.1) or inhalational injury (ICD-9 987.9) and trauma occurring within 72 hours from presentation. We defined the prehospital setting as any location prior to reaching a FST or a combat support hospital to include the role 1 (point of injury, casualty collection point, battalion aid station) and role 2 (temporary limited-capability forward-positioned hospital inside combat zone without surgical support).

Data Analysis

We performed all statistical analysis using Microsoft Excel (Version 10; Microsoft Corporation, Redmond, WA) and JMP Statistical Discovery from SAS (Version 13; SAS Institute Inc, Cary, NC). We used descriptive statistics. For continuous variables with normal distribution, we reported means and 95% CIs; for ordinal variables and continuous variables without normal distribution, we reported medians and interquartile ranges. For reporting of odds ratios (ORs), we used logistic regression models.

To better understand which interventions were associated with prolonged ICU LOS, we developed a multivariable model controlling for mechanism of injury, age group, gender, injury location [country of origin], and injury severity score. Location of injury, namely Afghanistan versus Iraq, was controlled for to avoid bias due to cultural differences, possible differences in tactical approaches during conflict, and differences in evacuation to a role 3 facility. We defined prolonged ICU stay as stay greater than 3 days, which has been shown to be associated with adverse outcomes in both pediatric and adult populations (20–22). Furthermore, as our list of procedures is not all-inclusive and the registry has limitations in what procedures it captures, we created a multivariable model based on serious injuries by anatomical region to better understand which injured anatomic areas were associated with prolonged ICU LOS. We reported ORs of serious injuries by anatomic location,

as well as in-hospital interventions which were associated with ICU stay greater than 3 days.

RESULTS

From January 2007 to January 2016, there were 42,790 encounters in the DODTR. Of those, 3,439 (8.0%) were pediatric by documented or estimated age. Within that group, 1,955 (56.8%) had at least 1 day documented in the ICU, with a median LOS of 2–3 ICU days across all pediatric age groups (Table 1). Most patients (90.2%; Table 1) survived to hospital discharge. Children in the 5–9 age group accounted for the largest portion of ICU encounters (33.8%). Overall, the majority of encounters were in Afghanistan (68.7%), and most were injured by explosive (45.2%) followed by gunshot wounds (20.8%).

The median composite Injury Severity Score (ISS) was 14 with the head/neck being the most frequent body region with a serious injury (34.3%). The median ISS was most severe in the 10–14 year age group, which comprised 31.2% of all patients (median ISS of 14), and lowest in infants less than 1 year (1.7% of patients, median ISS of 10) (Table 1). Patients in both age groups had similar rates of survival to hospital discharge (91.4% vs 91.8% survival to discharge; Table 1).

Radiography was the most frequent imaging modality (non-chest radiograph [non-CXR] 15.9%, chest [CXR] 15.2%) followed by CT scanning (CT, 10.1%) (Table 2). Mechanical ventilation was

the most frequent critical intervention (67.6%; Table 2), and its use increased across each patient age group. Patients required a median of 2 ventilator days. Arterial access (21.8%) and central venous access (5.9%) were also frequently performed procedures. Cardiopulmonary resuscitation was infrequently performed (0.8%) with only five children placed on a hypothermia protocol (0.7%) and all in the 5–9 age group. Packed RBCs (PRBCs) were the most frequently administered blood product during their ICU course (54.5%) and were most frequently administered to the 15–17 age group (66.9%). Whole blood was the most infrequently administered product (1.1%; Table 2). Many of these procedures were associated with a ICU stay greater than 3 days (Table 3), including blood product administration (OR, 2.71), ventilator management (OR, 2.53), intracranial pressure (ICP) monitoring (OR, 11.31), wound dressing (OR, 1.79), bronchoscopy (OR, 5.39), imaging (OR, 1.53), and central venous access (OR, 1.70). We found that serious injuries to all body regions except the face were associated with prolonged ICU LOS, with skin/superficial injuries (OR, 2.60) most strongly associated (Table 4).

DISCUSSION

Our study is the first to focus on pediatric patients treated in U.S. military ICUs in Iraq and Afghanistan. Understanding the types and frequency of procedures performed on patients in this population, as well as which patients require more resources due to longer

TABLE 1. Demographics of Subjects, Reported As Percent (*n*) or Median (Interquartile Range)

Demographic Categories	Demographics	Total (<i>n</i> = 1,955)	< 1 (<i>n</i> = 35)	1–4 (<i>n</i> = 416)	5–9 (<i>n</i> = 661)	10–14 (<i>n</i> = 610)	15–17 (<i>n</i> = 233)
Gender	Male, % (<i>n</i>)	76.2 (1,491)	60.0 (21)	62.3 (259)	74.4 (492)	84.8 (517)	86.7 (202)
Location	Afghanistan, % (<i>n</i>)	68.7 (1,343)	51.4 (18)	54.3 (226)	71.8 (475)	78.6 (480)	61.8 (144)
	Iraq, % (<i>n</i>)	31.3 (89)	48.5 (17)	45.6 (190)	28.1 (186)	21.3 (130)	38.2 (89)
Mechanism of injury	Explosive, % (<i>n</i>)	45.2 (884)	25.7 (9)	35.5 (148)	46.6 (308)	51.5 (314)	45.1 (105)
	Gunshot wound, % (<i>n</i>)	20.8 (408)	20.0 (7)	10.5 (44)	18.7 (124)	23.6 (144)	38.2 (89)
	Motor vehicle collision, % (<i>n</i>)	11.1 (217)	11.4 (4)	9.8 (41)	14.5 (96)	9.6 (59)	7.3 (17)
	Other, % (<i>n</i>)	22.8 (446)	42.8 (15)	43.9 (183)	20.1 (133)	15.3 (93)	9.4 (22)
Injury Severity Scores	Composite, median (95% CI)	14 (9–22)	10 (4–17)	13 (9–22)	14 (9–21)	16 (9–24)	14 (9–22)
Serious injuries by body region	Head/neck, % (<i>n</i>)	34.3 (671)	31.4 (11)	32.6 (136)	37.8 (250)	36.0 (220)	23.1 (54)
	Face, % (<i>n</i>)	0.3 (7)	0 (0)	0.2 (1)	0.4 (3)	0.4 (3)	0 (0)
	Thorax, % (<i>n</i>)	16.8 (329)	14.2 (5)	11.5 (48)	17.5 (116)	18.5 (113)	20.1 (47)
	Abdomen, % (<i>n</i>)	15.5 (303)	8.5 (3)	8.4 (35)	16.3 (108)	18.3 (112)	19.3 (45)
	Extremities, % (<i>n</i>)	20.4 (400)	2.8 (1)	9.8 (41)	18.6 (123)	25.5 (156)	33.9 (79)
	Skin/superficial, % (<i>n</i>)	11.4 (223)	20.0 (7)	25.4 (106)	7.8 (52)	7.5 (46)	5.1 (12)
Outcome	ICU LOS, mean (95% CI)	3 (2–5)	2 (2–6)	3 (2–7)	3 (2–5)	3 (2–5)	2 (2–5)
	Ventilatory LOS, mean (95% CI)	2 (0–3)	0 (0–2)	1 (0–3)	2 (0–3)	2 (0–3)	2 (0–3)
	Hospital LOS, mean (95% CI)	5 (2–11)	2 (1–8)	4.5 (2–10)	5 (2–10)	6 (3–12)	5 (2–10)
	Survival to discharge, % (<i>n</i>)	90.2 (1,723)	91.4 (32)	87.9 (366)	90.7 (600)	90.4 (552)	91.8 (214)

LOS = length of stay.

TABLE 2. Interventions and Blood Product Utilization by Age Group, Reported As Percent (n)

Interventions	Total, n = 1,955, % (n)	< 1, n = 35, % (n)	1-4, n = 416, % (n)	5-9, n = 661, % (n)	10-14, n = 610, % (n)	15-17, n = 233, % (n)
Chest radiograph	15.2 (299)	22.8 (8)	16.3 (68)	14.3 (95)	15.9 (97)	13.3 (31)
Non-chest radiograph (other)	15.9 (311)	5.7 (2)	12.2 (51)	15.1 (100)	21.3 (130)	12.0 (28)
CT scan	10.1 (198)	8.5 (3)	8.6 (36)	10.4 (69)	11.8 (72)	7.7 (18)
Ultrasound	2.7 (53)	0 (0)	1.6 (7)	2.7 (18)	3.7 (23)	2.1 (5)
Nebulizer	1.0 (20)	0 (0)	1.4 (6)	1.4 (9)	0.6 (4)	0.4 (1)
Vasopressor	0.6 (13)	2.8 (1)	0.4 (2)	0.6 (4)	0.8 (5)	0.4 (1)
Arterial access	21.8 (428)	14.2 (5)	16.5 (69)	21.0 (139)	26.8 (164)	21.8 (51)
Central venous access	5.9 (116)	5.7 (2)	6.4 (27)	4.6 (31)	6.3 (39)	7.3 (17)
Bronchoscopy	2.8 (56)	0 (0)	2.6 (11)	2.1 (14)	4.1 (25)	2.5 (6)
Tracheostomy	0.1 (3)	0 (0)	0.2 (1)	0.1 (1)	0 (0)	0.4 (1)
Mechanical ventilation	67.6 (1,322)	45.7 (16)	61.0 (254)	67.0 (443)	72.1 (440)	72.5 (169)
Thoracostomy	1.4 (29)	2.8 (1)	2.1 (9)	1.2 (8)	1.8 (11)	0 (0)
Nasogastric tube	16.5 (323)	11.4 (4)	16.5 (69)	14.2 (94)	20.4 (125)	13.3 (31)
Endotracheal tube	2.7 (5)	5.7 (2)	3.8 (16)	2.7 (18)	2.1 (13)	2.1 (5)
Intracranial monitor	1.8 (37)	0 (0)	1.9 (8)	1.9 (13)	2.4 (15)	0.4 (1)
Wound dressing	18.1 (72)	5.7 (2)	12.2 (51)	15.1 (100)	21.3 (130)	30.9 (72)
Electrocardiogram	3.4 (9)	5.7 (2)	2.4 (10)	3.3 (22)	4.1 (25)	3.8 (9)
Wound debridement	1.4 (4)	5.7 (2)	1.6 (7)	1.5 (10)	0.9 (6)	1.7 (4)
Cardiopulmonary resuscitation	0.8 (17)	2.8 (1)	1.9 (8)	0.6 (4)	0.4 (3)	0.4 (1)
Whole blood	1.1 (22)	2.8 (1)	0.4 (2)	0.4 (3)	1.6 (10)	2.5 (6)
Packed RBC	54.5 (1,067)	37.1 (13)	47.1 (196)	49.9 (330)	60.9 (372)	66.9 (156)
Fresh frozen plasma	38.6 (756)	17.1 (6)	27.1 (113)	34.8 (230)	45.7 (279)	54.9 (128)
Platelets	11.8 (231)	2.8 (1)	6.0 (25)	9.2 (61)	15.2 (93)	21.8 (51)
Cryoprecipitate	6.1 (120)	0 (0)	2.1 (9)	3.7 (25)	9.0 (55)	13.3 (31)

ICU stays, may have implications for pre-deployment readiness, supply allocation, and procedural training. Overall, we found that 8.0% of all admissions were pediatric casualties, with more than half requiring intensive care. Although the majority of casualties were 5-9 years old, all ages were represented in our study, highlighting the need for age-appropriate training and equipment. Notably, the overwhelming majority of patients survived to hospital discharge. Similar to the adult population in the deployed environment, explosives followed by gunshot wounds accounted for the majority of mechanisms of injury (3, 23, 24). The median ISS was most severe in the 10-14 year age group and lowest in infants, which is likely related to the ability of older children to ambulate and leave their home, putting them in harm's way. It is also plausible that some in this older age group were young combatants.

As expected, most serious injuries (all except injuries to the face), were associated with ICU stay greater than 3 days. This suggests that, unless patients have an isolated facial injury, having an AIS of 3 or greater for the remaining body regions predicts a prolonged ICU

course. Although these scores are used at the bedside, the gestalt assessment of these body regions would likely suffice. Skin and superficial injuries, found in only 11.4% of patients, were associated with the highest significant odds of prolonged ICU stay, demonstrating that a small subset of patients required a significant amount of ICU resources. Based on unpublished data in the DODTR, skin and superficial injuries (which are inclusive of burns, avulsions, scalds, lacerations, etc.) are most commonly represented as burns. This suggests that skin and soft tissue injuries, most commonly burn injuries, are likely the most resource-consuming in our patient setting.

A broad range of interventions were performed in the ICU. Many of these procedures and treatment modalities were associated with a prolonged stay in the ICU, including administration of blood products, ventilator management, ICP monitoring, bronchoscopy, imaging, and vascular access. As expected, children requiring a longer ICU stay would have an increased number and range of procedures/treatments performed, therefore, these procedures are associated with higher pediatric resource utilization.

TABLE 3. Multivariable Regression Model Developed to Determine Association With Limited Interventions With Prolonged ICU Length of Stay Controlling for Mechanism of Injury, Age Group, Gender, Country of Origin, and Injury Severity Score

Intervention	OR (95% CI)
Blood products (any)	2.71 (2.15–3.42)
Ventilator management	2.53 (1.95–3.26)
Intracranial pressure monitor	11.31 (2.63–48.48)
Wound dressing	1.79 (1.36–2.36)
Bronchoscopy	5.39 (2.28–12.73)
Imaging (any)	1.53 (1.21–1.93)
Central venous access	1.70 (1.08–2.68)
Intubation	1.93 (0.97–3.83)
Arterial access	1.13 (0.86–1.48)
Wound debridement	1.64 (0.66–4.11)
Cardiopulmonary resuscitation	0.42 (0.13–1.39)
Splinting	0.61 (0.23–1.56)
Thoracostomy	1.05 (0.42–2.58)

OR = odds ratio.

TABLE 4. Multivariable Regression Model Developed to Determine Association of Seriously Injured Body Regions With Prolonged ICU Length of Stay (> 3 d) Controlling for Mechanism of Injury, Age Group, Country of Origin, and Gender

Serious Injury Location	OR (95% CI)
Head/neck	1.46 (1.17–1.82)
Face	4.01 (0.75–21.37)
Thorax	1.93 (1.50–2.48)
Abdomen	1.93 (1.47–2.52)
Extremities	1.60 (1.25–2.05)
Skin/superficial	2.60 (1.82–3.71)

OR = odds ratio.

Of the procedures which were both common and associated with a prolonged ICU stay, several require specialized skill sets in pediatric patients, notably vascular access and airway management. In particular, arterial and central venous access were performed in a large proportion of patients, and both were associated with a long ICU stay. Compared to adult data from the same database, pediatric patients had a much higher rate of arterial access (18). Access in children, particularly young children with small vessels, may pose challenges to providers, and requires different sized needles

and catheters than adults. Similarly, the most frequently performed procedure was mechanical ventilation across all age groups, a skill which requires a knowledge of pediatric pulmonary mechanics in order to adequately ventilate the patient. In our study, mechanical ventilation—a mainstay of intensive care—was required in approximately two-thirds of patients, and was associated with a prolonged ICU stay. Compared to adult data, children admitted to the ICU had lower rates of intubation than adults treated in the emergency department in the same database (18). Intubation and ventilation of small children requires a unique skill set. Compared with adults, children have small airways with a comparatively large head-to-body ratio, a prominent occiput, a short, anterior airway, and a relatively larger tongue (8). The cricoid cartilage is the narrowest portion of the pediatric airway, while the narrowest point in adults is the vocal cords. Therefore, intubating small children requires an age-appropriate endotracheal tube and often the use of a straight blade in infants to visualize the cords in the setting of a floppy epiglottis (8). Mechanical ventilation may also pose challenges to the deployed provider both in terms of ventilator management knowledge and limitations in the ventilators typically carried in the deployed setting. Pediatric patients may range from neonates to adult-sized adolescents, with each patient population lending its own individualized limitations (25). For instance, some adult ventilators do not deliver tidal volumes small enough to support an infant. Additionally, small children may require shorter respiratory circuits, precise tidal volume delivery, and minimal gas leak (26); the mechanical ventilators provided in a deployed environment may not support these requirements. Reassuring, however, is that survival to hospital discharge and ICU LOS are not significant different across age groups, suggesting no major pitfalls in care for patients ranging from infants through adolescents.

Many of our findings are consistent with those of previous studies of prehospital and ED pediatric patients in Iraq and Afghanistan (1, 12, 27). The majority of our patients were male, likely due to sociocultural norms of these areas. Vascular access and airway management were frequently performed skills in our patient population, as seen in ED settings but less frequently in the prehospital setting. However, there were also several differences seen in ICU patients. First, patients treated in the ICU had an expectedly higher average ISS score (14 in the ICU compared with nine in the ED) (1), associated with a higher proportion of central venous and arterial access, mechanical ventilation, and wound dressings. Second, there was a higher proportion of blood products administered to patients requiring ICU bed days. More than half of all patients in the ICU required PRBCs, compared to one-third in the ED (1). Similarly, one-third of ICU patients required fresh frozen plasma (FFP), while one-fourth of patients treated in the ED required this. This difference is likely related to the higher proportion of severe injuries in patients requiring ICU care compared with the general population treated in the ED, but highlights the importance of a sound understanding of pediatric-specific blood product administration and massive transfusion protocols (28). It should be noted that our data shows a lower proportion of platelets transfused compared with PRBCs and FFP. This is most likely due to our patient setting and the studied time period. Platelets have a very short shelf-life and are difficult to store in theater; access to platelets is

therefore limited (29). Platelet transfusion is more commonly given via whole blood transfusion in deployed resource-limited settings (30). What is notable in our data set is that platelet, cryoprecipitate, and whole blood use increases as patient age increases. Although causation and medical decision-making cannot be directly commented on, this rate does mirror increasing rates of extremity, thorax, and abdominal injury across age groups, which can be sources of large amounts of blood loss.

Compared to civilian data, our patients had a longer average length of ICU stay (1.7 d in civilian PICU vs 3 d in our population), however, this is not adjusted for severity of injury (31). Additionally, the mechanism of injury in civilian pediatric trauma patients is most often falls and motor vehicle collision (32), compared with explosives and gunshot wounds in our patient population. Given these differences in trauma rates and mechanism of injury in trauma patients, treatments are likely to differ, and modeling ICU resources and procedure requirements based on civilian data may lead to an imbalance of supplies in theater.

Overall, our data highlights common procedures and challenges that physicians may face when treating critically ill pediatric casualties during combat operations, and which populations and procedures are associated with high pediatric resource utilization. Pediatric patients with severe injuries require a significant amount of ICU resource utilization and bed days and require specialized knowledge and equipment. The unique training and equipment needs of pediatric casualties must be met to deliver care within the medical rules of eligibility, but modeling this information after civilian ICU data with a different patient population and different injury patterns may not address the needs of pediatric wartime casualties. Lessons learned from these combat operations must be carried forward into future operations that involve humanitarian care. We do not have data on procedural success rates for the procedures we have described, nor do we have adult comparative data for this cohort. Rather, further studies looking specifically at outcomes associated with certain procedures in this population and success of different skills among deployed providers would be useful in qualifying adequacy of preparedness for treatment of these patients. Additionally, further studies comparing the mortality and LOS of pediatric patients to adult patients within the same dataset may shed light on gaps in pediatric-specific care.

There are several limitations of this study. First, this is a retrospective, observational study. Thus, conclusions drawn from this study can only show correlation, not causation. Although the DODTR data are prospectively collected, gaps in data exist, and we are unable to draw conclusions related to outcome of specific procedures or treatment modalities performed in our population (33, 34). Subjects are included in the registry even if data omissions occur which places limitations on data quality. Also, the database does not track patients after they are discharged from the military system; therefore, survival and intervention data of patients upon transfer to local facilities is unknown. Specifically, we do not have data on functional outcomes. Finally, due to local limitations in birth data, patient ages in this study may be inaccurate. However, it is unlikely to affect the overall substance of our dataset.

CONCLUSIONS

Pediatric casualties accounted for nearly one in 10 admissions with the majority requiring intensive care. The most commonly performed interventions were mechanical ventilation, vascular access, and imaging, each of which requires a specialized skill set to provide optimal patient management. Serious injuries to all body regions except the face were associated with a prolonged length of ICU stay, as well as blood product administration, ventilator management, ICP monitoring, wound care, bronchoscopy, imaging, and central venous access. The epidemiology of this unique population may be useful in planning future pre-deployment training and resource management in ICUs in deployed environments.

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