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SCIENTIFIC REVIEW

Epidemiology of Injuries Sustained by Civilians and Local Combatants in Contemporary Armed Conflict: An Appeal for a Shared Trauma Registry Among Humanitarian Actors

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Abstract

Background Conflict-related injuries sustained by civilians and local combatants are poorly described, unlike injuries sustained by US, North Atlantic Treaty Organization, and coalition military personnel. An understanding of injury epidemiology in twenty-first century armed conflict is required to plan humanitarian trauma systems capable of responding to population needs.

Methods We conducted a systematic search of databases (e.g., PubMed, Embase, Web of Science, World Health Organization Catalog, Google Scholar) and grey literature repositories to identify records that described conflict-related injuries sustained by civilians and local combatants since 2001.

Results The search returned 3501 records. 49 reports representing conflicts in 18 countries were included in the analysis and described injuries of 58,578 patients. 79.3% of patients were male, and 34.7% were under age 18 years. Blast injury was the predominant mechanism (50.2%), and extremities were the most common anatomic region of injury (33.5%). The heterogeneity and lack of reporting of data elements prevented pooled analysis and limited the generalizability of the results. For example, data elements including measures of injury severity, resource utilization (ventilator support, transfusion, surgery), and outcomes other than mortality (disability, quality of life measures) were presented by fewer than 25% of reports.

Conclusions Data describing the needs of civilians and local combatants injured during conflict are currently inadequate to inform the development of humanitarian trauma systems. To guide system-wide capacity building and quality improvement, we advocate for a humanitarian trauma registry with a minimum set of data elements.

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Introduction

Civilians are increasingly vulnerable to injury on the modern battlefield [1–3]. Contemporary conflicts such as those in Syria, Yemen, and Libya are characterized by protracted fighting in civilian centers and have been refractory to typical de-escalation strategies [4]. Substantial loss of civilian lives has resulted, both directly by violence and indirectly by incapacitation of fragile civil, safety, and health infrastructure [5–8]. During active conflict, organized health systems often break down or become impaired, leaving wounded civilians to rely on care provided by an uncoordinated, ad hoc patchwork of actors including local hospitals and international humanitarian non-governmental organizations (NGOs) that are rarely able to meet the needs of affected populations [9].

Organized trauma systems reduce preventable death and disability [10, 11]. However, planning and maintaining trauma systems requires an understanding of target population needs as well as resource constraints. Advances in military and civilian trauma care have been possible largely because of quality improvement programs that rely on systematic data collection [12, 13]. However, in contrast to data regarding wartime injuries among US, North Atlantic Treaty Organization (NATO) and coalition military personnel detailed by the Department of Defense Trauma Registry (DODTR), the epidemiology of injuries sustained by civilians and local combatants is incompletely understood. Injury patterns among these individuals have not been systematically characterized, and currently available data are inadequate to inform the planning and organization of trauma systems capable of addressing the unmet needs of this population [14–16].

The injuries of US and NATO military personnel are likely different from those sustained by civilians and local combatants. Whereas coalition military forces are almost exclusively young and healthy, civilians wounded in conflict include young and elderly patients, pregnant females, and individuals with preexisting comorbidities. Like civilians, local combatants from poorly resourced militaries are often unprotected by body armor and may seek care from a similar assortment of health-care facilities. As there is no centralized trauma registry to provide insight into the needs of these patients, few data exist to guide resource allocation and quality improvement programming.

To address this gap, we systematically reviewed the literature to identify records that described injuries sustained by civilians and local combatants in twenty-first century armed conflict. We also examined data elements presented by reports to assess the state of data collection and reporting, and contrasted injury patterns in our sample to that described in a US military population. The findings might inform efforts to improve humanitarian trauma systems.

Methods

Search strategy

We conducted a systematic search of the literature to identify records that described traumatic injuries sustained by civilians and local combatants in conflict. A local combatant was defined as any member of a party to conflict not belonging to one of the 29 NATO member states or coalition forces providing support to US and NATO-led International Security Assistance Force (ISAF) troops in Afghanistan [17, 18]. The term "humanitarian" has been defined as "action [undertaken] to save lives, alleviate suffering and maintain human dignity during and in the aftermath of man-made crises and natural disasters," encompassing care provided to "civilians and those no longer taking part in hostilities," and rendered in accordance with International Humanitarian Law and the humanitarian principles of humanity, neutrality, and independence [19]. We adhere to this definition in our review, which includes care provided by medical teams of any designation (local, humanitarian NGO, military, or other contracted actors) to address the needs of the target population.

Searches were conducted in PubMed (includes MEDLINE), Embase, the Cumulative Index to Nursing and Allied Health Literature, Web of Science, World Health Organization Catalog, and Google Scholar, and grey literature repositories; e.g., National Technical Reports Library, Policy File Index, and humanitarian agency reports (see Supplementary Material). Records that described isolated psychological trauma were excluded. To represent modern armed conflict, the search was restricted to records published since 2001 (i.e., the start of Operation Enduring Freedom [OEF], the US-led war in Afghanistan). The review protocol was registered in advance with PROSPERO (#104478) [20].

Eligibility

Records must have described conflict-related injuries sustained by civilians or local combatants, injury-related healthcare resource utilization, care processes, and/or outcomes. Reports that only described the type of care provided or procedures performed were excluded given previous reports on this topic [21, 22]. Reports were not excluded on the basis of language, study design, or quality given limited primary data. Reports that did not present primary data, did not have full-text availability, or that solely detailed isolated terrorist attacks were excluded.

Record management

Records identified through database searches were screened for relevance by two reviewers using Covidence systematic review software (Veritas Health Innovation, Australia.) A senior reviewer arbitrated discrepancies. Two reviewers assessed full-text reports of relevant records and screened reference lists of included reports. Reports that presented potentially duplicative data were identified and reviewed. Of those reports, only the largest and/or most recent report was selected for analysis. PRISMA reporting guidelines were followed at all stages.

Data extraction and analysis

Primary data of interest described the epidemiology of injuries sustained by civilians or local combatants in armed conflict since the start of OEF. Secondary data of interest included process metrics/resource utilization (e.g., pre-hospital data, transfusion needs, intensive care requirements, surgical interventions) and outcomes (e.g., complications, mortality, disability, quality of life measures).

Data elements of interest were frequently unavailable or presented using non-standardized measures. As the lack of uniformity in data capture and reporting prevented pooled analysis, available data were synthesized in narrative format in accordance with Cochrane Collaboration Handbook for Systematic Reviews [23]. Data were only presented if described by greater than 25% of reports, or if particularly novel or useful for quality improvement programming.

Subgroup analyses were performed by conflict setting (urban, semi-urban, rural) classified by utilizing European Commission country-specific definitions for degree of urbanization [24]. We designated four categories: (1) urban (“urban centers” in the source document); (2) semi-urban (“urban clusters”); (3) rural; and (4) multiple/unknown (studies presenting data from multiple or undisclosed facilities). We defined children as age less than 18 years in accordance with the Paris Principles [25]. Lastly, we compared injury epidemiology among patients in our sample to a DODTR report of nearly 30,000 combat-related injuries sustained by US military personnel in Iraq and Afghanistan [15].

Results

Our search identified 4450 records, 949 of which were duplicates (Fig. 1). The titles and abstracts of the remaining 3501 records were screened for relevance. Of those, 3062 records were irrelevant (87%). Full texts of the remaining 439 reports were reviewed (13%). Three hundred and fifty-three full-text reports (10%) were excluded: 166 records did not present epidemiology, processes, or outcomes of interest, 67 did not describe populations of interest, 43 described injuries in only one anatomic region, 27 did not present primary data, 20 were written before 2001, 10 did not report conflict-related injuries, 8 full texts were unavailable, 6 were previously undetected duplicate reports, and 6 were editorials or narrative discussions without data. 86 full-text reports met inclusion criteria; 3 additional reports were identified from reference lists. After inspection of data sources and date ranges, 40 reports were excluded for presenting duplicative registry data. A total of 49 reports comprised the final narrative analysis.

Search results

The 49 reports included in our analysis described the injuries of 58,578 patients and represented 18 conflicts (Fig. 2). Reports that presented data from conflicts in the Middle East (Afghanistan, Iraq, Israel, Palestine, Kuwait, Pakistan, Syria) accounted for 49,689 (84.8%) of patients. Conflicts in North Africa (Libya, Egypt) and sub-Saharan Africa (Nigeria, Central African Republic) accounted for only 3975 patients (6.8%) and 602 patients (1.0%), respectively. Twenty-six reports described 35,919 patients (61.3%) cared for at urban health facilities, 8 reports described 14,372 patients (24.5%) cared for at multiple/unknown facility types, 9 reports described 5104 patients (8.7%) cared for at rural health facilities, and 7 reports described 2939 patients (5.0%) cared for at semi-urban health facilities.

Types of facilities

The types of trauma care in our analysis included: US or NATO military treatment facilities (15 reports, 30.6%); local academic health centers (10, 20.4%); government or public hospitals (8, 16.3%); and humanitarian non-governmental organizations (NGO) or the International Committee of the Red Cross (ICRC) (6, 12.2%). NGO health programs reported the largest number of patients in our sample (27,170 patients; 46.3%). Five reports (10.2%) did not describe injuries at a health-care facility (e.g., reviews of autopsy records). The six remaining reports (12.2%) presented data from multiple types of health facilities (Supplementary Table 1).

Demographics

79.3% of patients were male, and 34.7% were under age 18 years. Median age was 26 years [interquartile range

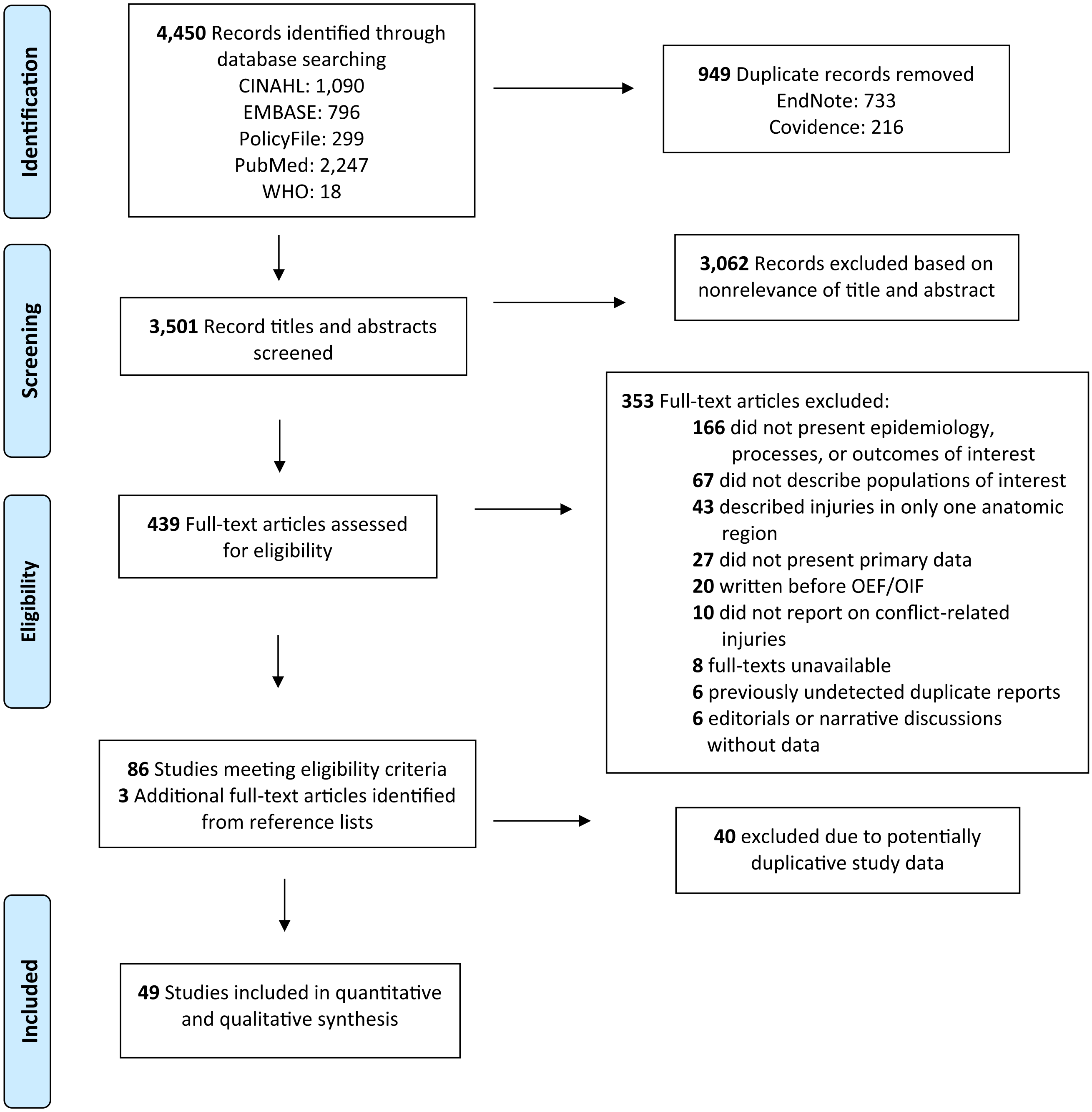

Fig. 1 PRISMA diagram of report selection

(IQR) 22.8–27.6 years; range 1 month–79 years]; however, only 20.4% of reports presented median age. Though 48 reports (98.0%) presented data on patient age, lack of standardized age ranges prevented further analysis. Combatant status was specified for 18,299 (31.2%) of patients. Of this subset, 17,601 were civilians (30.0% of overall sample) and 698 were local combatants (1.2%). The remaining patients had no designation as to civilian or combatant status (40,279; 68.8%).

Mechanisms and anatomic locations of injury

Blast injuries and gunshot wounds predominated, accounting for 50.2% and 22.0% of injuries, respectively, followed by unspecified blunt trauma (4.1%), assault

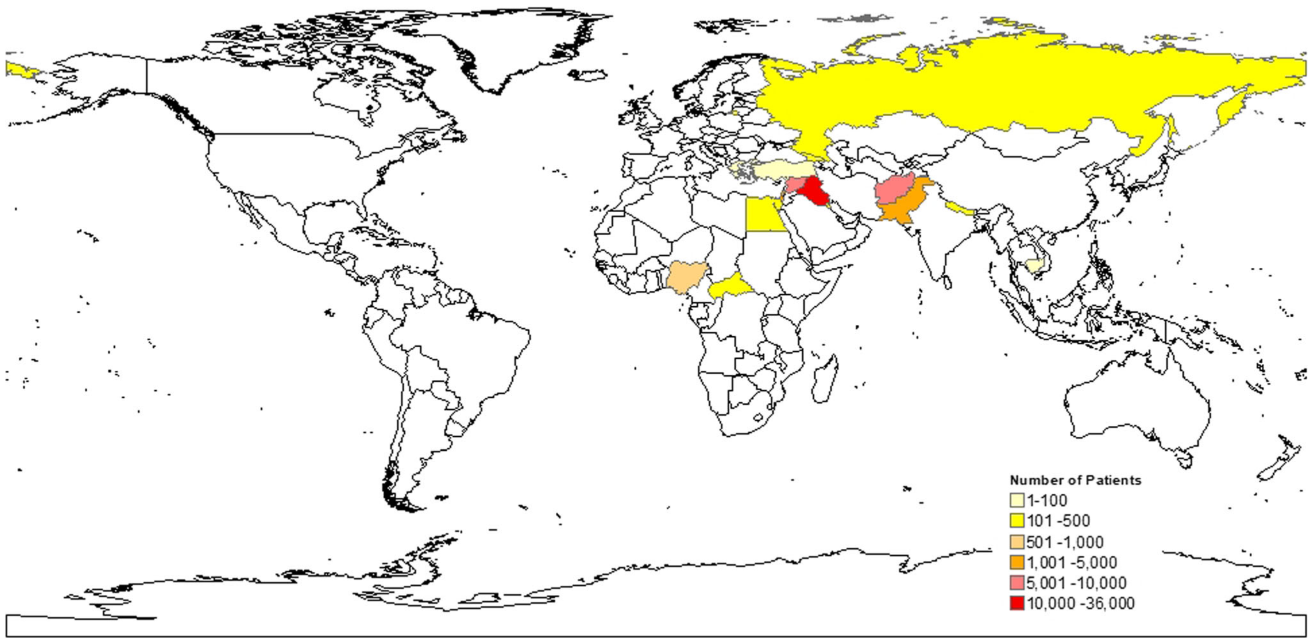

Fig. 2 Geographic distribution of conflicts represented in analysis

(3.9%), unspecified penetrating trauma (3.4%), and burns (3.3%) (Table 1). Extremity injuries (33.5% of injuries), injuries to the head and neck (18.0%), and superficial/soft tissue wounds (14.0%) were the most frequent anatomic regions of injury. Thoracic and abdominopelvic injuries accounted for 10.4% and 7.5%, respectively. Mechanisms and anatomic regions of injury differed across conflict settings (Fig. 3, Supplementary Table 2). Blast injuries were more frequent in rural settings, accounting for 70.3% of injuries compared to only 18.7% in urban centers ($P < 0.001$). A higher frequency of gunshot wounds was observed in urban and semi-urban settings (42.2% and 26.7% of injuries) compared to only 7.5% in rural settings ($P < 0.001$). Unspecified blunt trauma caused 34.9% of injuries in semi-urban settings compared to only 0.2% in urban centers ($P < 0.001$). Head and neck injuries accounted for approximately 20% of injuries in urban and semi-urban settings (20.6% and 21.5%, respectively), compared to 5.9% in rural settings ($P < 0.001$).

Mortality and other outcomes

Overall in-hospital mortality was 5.6% (range 1.6–15.6%). Mortality was lowest in urban centers and highest in semi-urban settings ($P < 0.001$; Supplementary Table 2). Only one report (2.0%) presented data on functional status at discharge, using an adapted Functional Independence Measure scoring system [26]. No report described data collected after discharge.

Comparison to US military service members

Blast and extremity injuries were also the most frequent mechanism and anatomic region of injury among US military personnel, and gunshot wounds were the second most common mechanism (19.9% among US military personnel compared to 22.0% among civilians and local combatants). Blast injuries accounted for a greater proportion of injuries among US military personnel (74.4% compared to 50.2% in our overall sample; $P < 0.001$), as did extremity injuries (51.9% vs. 33.5%; $P < 0.001$). Head and abdominopelvic injuries occurred more frequently among US military personnel (28.1% and 10.1%, respectively) in comparison with our sample (18.0% and 7.5%; $P < 0.001$).

Reported data element consistency

Due to limited data, it was not possible to present meaningful information on care processes, resource utilization, or outcomes other than mortality. Of the data elements we intended to analyze a priori, only six (age, sex, mechanism, anatomic region of injury, Injury Severity Score (ISS), and mortality) were presented by greater than 25% of reports (Table 2). Though 18 reports (36.7%) presented data on ISS, these data were not available for pooled analysis as they were described using non-standardized ranges. Only 3 reports (6.1%) presented median ISS. Few reports presented data on other measures of injury severity including Glasgow Coma Score (GCS) (6 reports, 12.2%); Trauma and Injury Severity Score (TRISS) (4 reports, 8.2%); or

Table 1 Overall sample: demographic characteristics and injury patterns

	Patients $N = 58{,}578$	Patients (%)	Reports presenting variable (%)[a]	Comparison to US military service members[b] (%)	P value
Demographics					
Gender					
Male	46,464	79.3	79.6	98.5	<0.001
Not reported	1736	3.0	21.4	–	
Age					
<18 years	20,275	34.7	55.1	–	
Not reported	906	1.5	2.0	–	
Combatant status					
Not specified[c]	40,279	68.8	69.4	–	
Civilians	17,601	30.0	30.6	–	
Local combatants	698	1.2	10.2	–	
Mechanism of injury			79.5		
Blast	14,729	50.2	57.1	74.4	<0.001
Land mine	4101	14.0	22.4	–	
Bomb	1490	5.1	16.3	–	
Improvised explosive device (IED)	244	0.8	16.3	–	
Unexploded ordnance (UXO)	122	0.4	14.3	–	
Gunshot wound (GSW)	6467	22	59.2	19.9	<0.001
Other/unspecified	2542	8.7	32.6	3.1	<0.001
Blunt (not specified)	1195	4.1	22.4	–	
Assault	1132	3.9	22.4	–	
Penetrating (not specified)	993	3.4	22.4	–	
Burn	978	3.3	34.7	–	
Stabbing	465	1.6	20.0	–	
Anatomic region of injury[d]			85.7		
Head/neck	6042	18.0	73.4	28.1	<0.001
Face	2186	6.5	26.5	–	
Chest, thorax	3508	10.4	67.3	9.9	<0.001
Abdominal, pelvic	2505	7.5	55.1	10.1	<0.001
Extremity	11,245	33.5	81.6	51.9	<0.001
Traumatic amputation	3182	9.5	18.3	–	
Other (i.e., multiple, not further specified)	5415	16.1	38.8	–	
Superficial/soft tissue	4715	14.0	14.3	–	
Injury Severity Score (ISS)[e]					
Median	9	–	6.1	–	
Mean	10.8	–	24.5	–	
Outcomes					
Functional or disability assessment	1420	2.4	2.0	–	
In-hospital Mortality	3293	5.6	75.5	–	

[a]49 reports included in analysis

[b]Data on US military personnel from Belmont et al. [15]

[c]Excludes US, NATO, or coalition military personnel; however, civilian/local combatant status not specified by source report

[d]For anatomic region of injury, studies present data on multiple injuries per patient if present; # of injuries may be $>n$

[e]Due to lack of standardized ISS ranges presented by reports, we were unable to present interquartile range (IQR) or total range. Median and mean ISS for the overall sample were calculated using values for those studies that presented median and mean ISS weighted by the number of patients in each study sample

–, Signifies variable not applicable or not reported

Total Body Surface Area (TBSA) (1 report, 2.0%). Few reports (8.2%) presented pre-hospital data. Fewer than 25% of reports presented data on resource utilization metrics such as need for blood transfusion (22.4%), critical care needs (16.3%), length of hospital stay (10.2%), or mechanical ventilation (4.1%).

Discussion

We described conflict-related injuries sustained by civilians and local combatants in twenty-first century conflict to aid planning and organization of trauma systems addressing these populations' needs. Our analysis identified four main findings: (1) unsystematic collection of data elements and heterogeneous reporting limits generalizable conclusions; (2) civilians bear a significant burden of conflict-related morbidity and mortality, with children accounting for 34.7% of injured patients; (3) differences in mechanisms and anatomic regions of injury exist between conflict settings; and (4) blast mechanisms cause the majority of injuries, with a predominance of extremity injuries.

Fewer than 25% of reports in our analysis presented minimum trauma registry data elements (e.g., measures of injury severity, resource utilization, outcomes other than mortality). When these data elements were described, they were often presented using nonstandard groupings, which prevented pooled analysis. This gap could be addressed by a minimum trauma dataset designed for operational research and quality improvement in conflict and humanitarian settings [27]. While some humanitarian health agencies maintain their own repositories of patient data, this information is not collected using a standardized data dictionary and is often inaccessible to outside agencies [28, 29]. Although it may not be reasonable to expect stressed local health facilities to engage in a centralized trauma registry, humanitarian NGOs and contracted medical providers operating in conflict settings should participate in shared data collection. The protection of patient security is of utmost importance, and any framework for sharing de-identified data with the objective of improving the quality of humanitarian response must be implemented with strict privacy safeguards.

Despite the challenges posed by resource limitations, systematic data collection is essential to improve the care provided in conflict settings. In military and high-resource civilian contexts, trauma systems advances and impact assessments have depended on system-wide data collection through the DODTR, hospital-based trauma registries, and American College of Surgeons National Trauma Data Bank [10, 13]. A landmark military study querying the Joint Theater Trauma Registry to identify causes of preventable death prompted changes in combat casualty care that reduced mortality to its lowest in any theater of war [30, 31]. No equivalent registry exists in the humanitarian sector. As a result, adequate data do not currently exist to guide efforts to improve the quality of humanitarian care in conflict. The World Health Organization and Global Alliance for Care of the Injured are currently working to produce a minimum trauma dataset to facilitate the implementation of trauma registries in countries of all economic categories, including low-resourced humanitarian contexts [32].

Civilians bear a significant burden of morbidity and mortality in conflict zones. Though data on combatant status were presented by only 31% of reports in our sample, 96% of the patients for whom combatant status was specified were civilians, nearly 35% of whom were children. This finding is consistent with previously published reports. During the 2016–2017 Mosul offensive, 46% of patients treated at a trauma center in Erbil were civilians [33]. During the active phase of OEF, civilians accounted for nearly 34% of combat casualties treated by one forward surgical team (FST) compared to approximately 26% coalition forces [34]. Moreover, pediatric patients sustain a substantial proportion of conflict-related injuries. Between 2011 and 2016, more than a quarter of Syrian barrel bomb victims were children [1]. During a 2017 offensive, over 40% of patients treated at an MSF hospital in Syria were under the age of 18 years [35]. The implications of this finding include the need to adequately resource hospitals with pediatric equipment and personnel with pediatric expertise [36].

Mechanisms of injury differed between conflict settings. Blasts accounted for up to 70% of injuries presenting to care in rural settings compared to 50% in our overall sample and only 19% in urban centers. Blast injuries also accounted for 90% of injuries treated at "multiple/unknown" facility types, which may represent urban populations given that over 14,000 patients were described by 8 reports in this category. Indiscriminate shelling and the use of barrel bombs in densely populated urban areas severely impact civilian populations [1, 37]. For example, 90% of injuries among civilians wounded during the ISIL occupation of Mosul were caused by blast injuries and shelling [5]. Between 2011 and 2016, approximately 97% of all barrel bomb deaths in Syria were civilians, compared to only 3% combatants [1]. In contrast, the high proportion of rural injuries caused by blast mechanisms may be attributable to the prevalence of landmines and improvised explosive devices [38–41]. Though rural and urban trauma patients have been compared in non-conflict settings, differences between patients in rural and urban conflict settings have not been systematically characterized [42]. These differences may have implications for context-

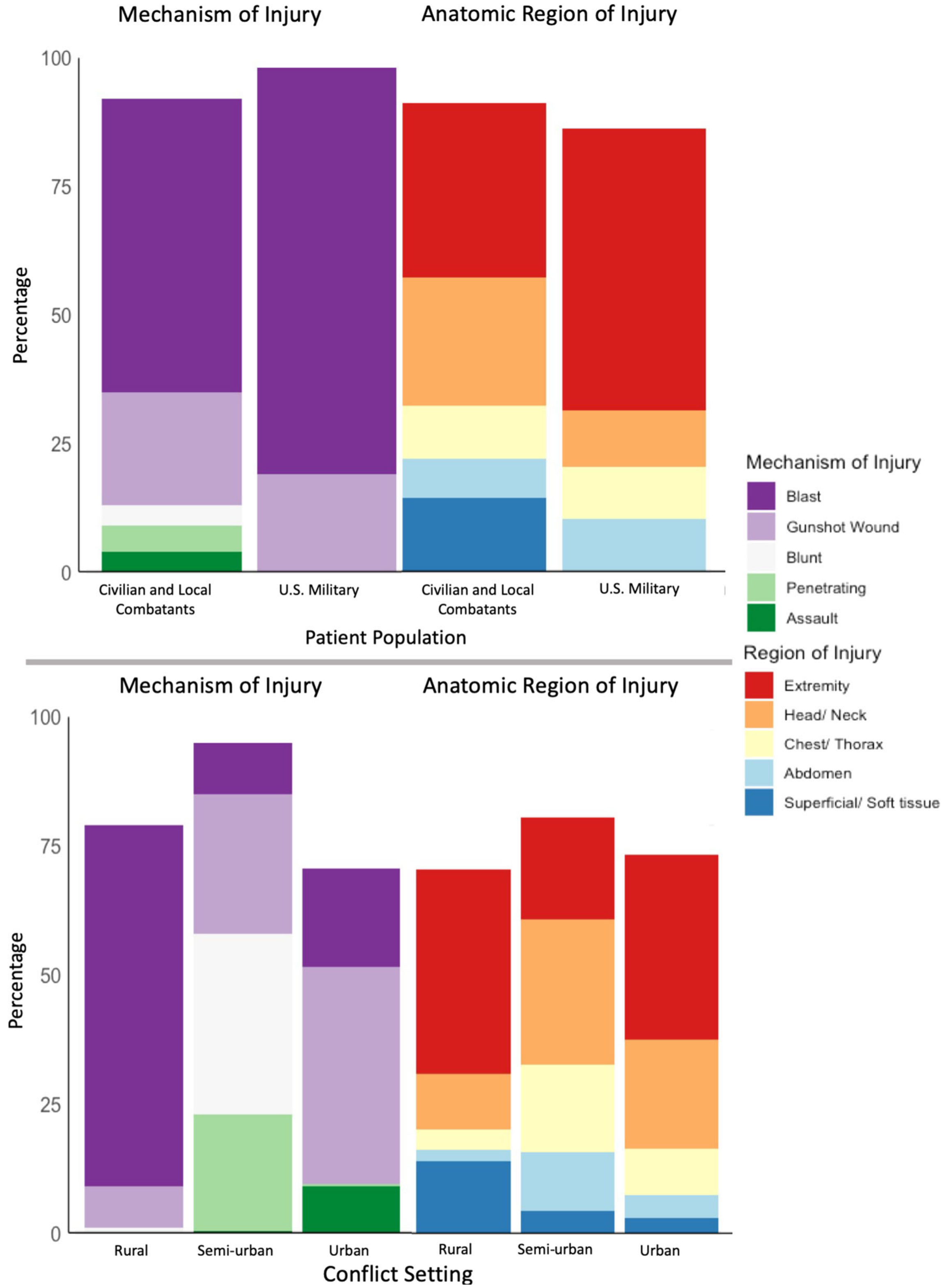

Fig. 3 Mechanisms and anatomic regions of injury. **a** Comparison between US military personnel ("other" was excluded as a category from rankings for both mechanism and anatomic region; data on US military personnel from Belmont et al. [15]). **b** Comparison between conflict settings

Table 2 Reporting of common trauma registry data elements

	Reports, n = 49	Reports (%)
Patient demographics		
Age (any data)	48	98.0
Median	10	20.4
<18 years	27	55.1
Sex	39	79.6
Injury characteristics		
Anatomic region of injury	42	85.7
Mechanism of injury	39	79.6
Measures of injury severity[b]		
Injury Severity Score (ISS)	18	36.7
Median	3	6.1
Total body surface area (TBSA)	1	2.0
Median	0	0
Glasgow Coma Score (GCS)	6	12.2
Median	1	2.0
Kampala Trauma Score (KTS)	0	0
Trauma and Injury Severity Score (TRISS)	4	8.2
South African Triage Score (SATS)	2	4.1
Process metrics and resource utilization		
Pre-hospital time	3	6.1
Pre-hospital mode of transport	4	8.2
Duration of hospital stay	5	10.2
ICU admission	8	16.3
ICU days	0	0
Blood transfusion	11	22.4
Mechanical ventilation	2	4.1
Operative procedures	3	6.1
Complications	6	12.2
Outcomes		
Mortality	37	75.5
Functional status/disability at discharge	1	2

Data elements derived from: NTDB, IDB-JAMIE Minimum Data Set (IDB-MDS) of the EU Health Programme, Bi-National Trauma Minimum Dataset (BNTMDS) for Australia and New Zealand [50–52]

[a]Refers to any data presented on variable of interest unless otherwise specified

specific planning of humanitarian response and merit further research.

Blast mechanisms cause the majority of injuries sustained by civilians and military personnel in contemporary armed conflict, with extremity wounds predominant among both populations [43]. The management of blast injuries is complex and requires multidisciplinary care [44–46]. Understanding the needs unique to blast injuries is critical to prepare training and resourcing efforts for facilities providing care in conflict settings. Whereas the decreased prevalence of thoracoabdominal trauma among US and NATO military service members has been attributed to improvements in body armor, the prevalence of extremity injuries among patients in our sample may be due to survivorship bias [15]. Given civilians' reliance on ad hoc transport with prolonged transport times, patients with significant thoracic and abdominopelvic trauma are unlikely to present alive for care. Previous reports, including data from civilian casualties treated during the 2016–2017 Mosul offensive, observed a similarly low (7%) rate of thoracic trauma [33]. The low prevalence of thoracoabdominal injuries in our sample suggests that in the current state, most truncal injuries are non-survivable. To decrease pre-hospital mortality, rapid transport times should be prioritized, as well as systems innovations to move the first point of care as far forward as the security environment permits [47, 48]. To address this gap, the Stanford Humanitarian Surgical Response in Conflict Working Group recently presented a consensus- and evidence-based humanitarian response to minimize preventable death and disability in conflict settings [49].

Several limitations deserve mention. First, the lack of reports detailing specific data elements and the heterogeneity of variables presented limited pooled analysis and prevented us from drawing conclusions regarding many data elements of interest. Second, conflicts in the Middle East constituted 75.5% of reports and nearly 85% of patients in our analysis. Conflicts from other geographic regions may be characterized by different warfare tactics and injury epidemiologies. Third, though we utilized an objective method to classify conflict settings, health facilities located in urban or semi-urban areas may receive patients from large catchment areas, representing a more rural population. Lastly, while our search strategy included terms to capture reports that detailed injuries of local combatants, few reports described this population. Despite these limitations, the findings may be used to advocate for a minimum trauma dataset in conflict and humanitarian settings and highlight important epidemiological characteristics of civilians and local combatants injured in conflict.

Conclusions

Currently available data are inadequate to inform humanitarian health systems operating in conflict. A minimum trauma dataset such as that being put forward by the WHO could prove useful for resource allocation and quality improvement in conflict settings. However, to be operational, this must contain a limited number of high-yield data elements with appropriate security safeguards and be accompanied by ongoing data analysis for adaptation to a rapidly changing environment [49].

Humanitarian care in armed conflict is delivered in resource-limited environments with increasingly complex security threats [8]. Though the urgent clinical needs of any one patient may supersede the act of data collection, entire populations depend on the success of a system. A trauma registry utilized by all humanitarian medical teams is imperative to reduce preventable morbidity and mortality among populations in conflict.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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