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IMPROVING POINT OF INJURY TRAUMA CARE FOR IED VICTIMS

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Front cover photo

Somali security forces and emergency services evacuate an injured man from the scene of a car bomb explosion at a shopping mall in Mogadishu, Somalia, 4 February 2019.
Source: Feisal Omar/Reuters

Overview

This Briefing Paper presents the need for a comprehensive, whole-of-society approach[1] to counter-improvised explosive devices (C-IED), which supports emergency care for civilian improvised explosive device (IED) victims in low-resource settings (LRSs).[2] Victim assistance frameworks in humanitarian mine action (HMA) have traditionally emphasized providing support to existing disabilities rather than emergency interventions close to the point of injury. Optimizing emergency care is particularly important to maximize the survival of IED victims given the severe, multidimensional injuries inflicted. This Briefing Paper discusses the challenges and offers an overview of strategies used to reduce preventable death and disability in other contexts that could be effectively translated with context-appropriate adaptation to improve emergency care of civilian IED casualties in LRSs. This Briefing Paper also provides a foundation for future dialogue to identify mechanisms to strengthen cooperation between stakeholders engaged in C-IED and those involved in trauma care capacity-building in LRSs.

Key findings

- Victim assistance in mine action has historically focused on long-term rehabilitation. Approximately 40 per cent of casualties of explosive ordnance (EO), including IEDs, die of their injuries. This highlights the need for increased emphasis on immediate post-injury care to reduce preventable death and disability.
- IEDs inflict injuries characterized by greater severity, complexity, and higher mortality than conventional anti-personnel landmines, elevating the urgency of improving trauma care for civilian victims in LRSs.
- The US military's approach to reducing preventable death among combat casualties during the wars in Iraq and Afghanistan highlights numerous opportunities to improve trauma care for civilian IED victims. Context-appropriate adaptation is required to translate these interventions effectively to LRSs.
- HMA actors and others involved in a whole-of-society approach to C-IED can potentiate efforts to increase survival among civilian IED victims through initiatives such as the integration of layperson first responder training with EO and IED risk education.

Introduction

The threat of IED employment features prominently among the tactics utilized by violent extremist organizations and other armed actors to perpetuate instability and insecurity. IEDs have become a key tool in asymmetric warfare. IEDs are employed in the pursuit of many objectives, including destabilization of the state and governing authorities, exertion of control and influence, and creation of fear in a population. More than 80 per cent of civilian IED casualties occur in intrastate armed conflicts where IED attacks frequently take place in civilian spaces, such as public transport, markets, and places of worship (Overton and Torelli, 2023, p. 7). Although IEDs employed in certain contexts demonstrate technical sophistication, they are an attractive weapon to those operating in areas with resource constraints as they can achieve significant harm and instability through readily available components (Small Arms Survey, 2023).

The proliferation of IEDs and associated civilian harm led the UN Secretary-General to call for increased attention on countering the IED threat as a key recommendation in his 2023 report on assistance in mine action (UNGA, 2023). A cross-cutting approach is required to optimize effective responses to IED use within a state, balancing security responses as well as contributions from other government agencies and civil society organizations (CSOs). The range of efforts required to support a holistic C-IED strategy is generally considered preventative, responsive, or cross-cutting within any national C-IED enterprise. In 2020, UN General Assembly tasked the UN Institute for Disarmament Research with developing a C-IED voluntary self-assessment tool to support standardized assessments of states' IED threat preparedness capacity. In its current form, this tool does not contain any indicators related to victim assistance (VA) or trauma care for civilian casualties. The UN Secretary-General's 2024 report, *Countering the Threat Posed by Improvised Explosive Devices*, however, explicitly acknowledges VA as a component of C-IED and highlights gaps in acute post-injury care (UNGA, 2024).

The increase in civilian IED victims highlighted by the UN Secretary-General presents an urgent need to strengthen trauma care for civilian conflict casualties in LRSs. A multisectoral approach is required to address the current gap in high-quality emergency care proximate

to the point of injury (POI) for civilian IED victims. Such strategies should involve local, national, international, and multilateral health stakeholders, CSOs, HMA actors, and security forces with established casualty care capabilities to the extent that they are compatible with the protection of humanitarian principles.[3,4] There has been limited structured dialogue regarding strategies to incorporate emergency care as a component of VA in C-IED enterprises. While this Briefing Paper gives special consideration to IED victims, the improvements in trauma care discussed apply to casualties of all conflict-related injury types.

This Briefing Paper examines the challenges facing the inclusion of emergency care as a priority within VA and C-IED strategies before outlining the unique considerations around IED injuries in LRSs. Opportunities for reducing preventable death will then be framed utilizing the US military's analogous approach during the wars in Iraq and Afghanistan, presenting an overview of both barriers to direct translation of trauma care advances in LRSs and evidence-based alternatives that have been deployed in LRSs but have not yet been synthesized into a coherent system-wide approach.

Research for this paper was conducted through literature reviews on trauma care for civilian casualties in modern conflict settings, including the unique characteristics of IED injuries. A separate qualitative analysis of interviews with HMA sector experts was also conducted to formulate opportunities for enhanced engagement between health and protection stakeholders to reduce preventable deaths among civilian EO victims[5] (Wild et al., 2024e). These 19 key informant interviews were conducted across multiple disciplines intersecting with the care of civilian casualties of EO and explosive weapons, including HMA, trauma care, humanitarian funding agencies, and policy and advocacy.

Context

IEDs are often used in conflict to restrict freedom of movement by employing them on main supply routes and roads, leading to severe consequences for humanitarian access. This case has occurred in many settings, such as the Sahel, which necessitates establishing air corridors (UNGA, 2023, p. 2). In post-conflict settings, IED contamination may render it nearly impossible for internally displaced persons and

Box 1 Definitions

Clinical practice guidelines (CPGs): evidence-based guidelines for the management of combat-related trauma and are a core component of the Joint Trauma System (JTS) (JTS, 2023).

Coagulopathy: a bleeding or clotting dysfunction which can be induced by severe trauma (Moore et al., 2021).

Contracture: a tightening of soft tissues such as muscles, tendons, or skin that leads to limb deformity and disability.

Counter-improvised explosive device (C-IED) enterprise: the collective efforts aimed at countering IED threat, which can involve anything intended to predict, discover, detect, prevent, protect against, respond to or neutralize, recover from or exploit, mitigate against, or deter IED attacks.

Damage control resuscitation (DCR): a set of practices designed to address the life-threatening consequences of haemorrhage focused on early balanced blood transfusion prior to reaching surgical care (JTS, 2023).

Employment of improvised explosive devices (IEDs): activities relating to the supply, transport, manufacture, planning, emplacement, or execution of an attack, and those involved in financing and publicizing attacks, including those who facilitate such activities.

Forward surgical teams (FSTs): small mobile units stationed closer to the front lines than combat support hospitals to provide immediate life-saving surgical intervention for wounded military servicemembers.

Golden hour: a window crucial to survival in the immediate post-injury period (Kotwal et al., 2016).

Haemostatic agents: substances designed to help stop haemorrhage by promoting clot formation. They come in various forms such as powders and dressings.

Improvised explosive devices (IEDs): devices placed or fabricated in an improvised manner incorporating explosive material, destructive, lethal, noxious, incendiary, pyrotechnic materials or chemicals designed to destroy, disfigure, distract, or harass. They may incorporate military stores but are typically devised from non-military components (UNMAS, 2022).

Point of injury (POI): the scene where a person is injured prior to patient transport or evacuation to higher echelons of care (Hetzler, 2012).

Postpartum haemorrhage: often defined as the loss of more than 500 ml or 1,000 ml of blood following childbirth (Weeks, 2015).

Roles within the military trauma care continuum:

- **Role 1**: first responder for both medical and non-medical personnel at POI, as well as emergency care, such as tourniquet application;
- **Role 2**: far-forward care for life-saving procedures involving stabilization, including DCR and damage control surgery (DCS);
- **Role 3**: combat support hospitals with surgical and intensive care capabilities, the highest in-theatre level of care;
- **Role 4**: definitive care delivered outside the theatre of operations; and
- **Role 5**: surgical subspecialist reconstruction and long-term rehabilitation (NASEM, 2016).

Surgical debridement: surgical excision of nonviable tissue.

Tension pneumothorax: a life-threatening condition that occurs when air accumulates between the pleura, the lining of the thorax, and the lung, and can rapidly lead to cardiorespiratory arrest and death.

Tranexamic acid (TXA): a medication designed to stop bleeding by inhibiting the processes that break down blood clots.

Walking blood banks (WBBs): the use of fresh whole blood from donors to provide access to emergency blood transfusion in austere environments where blood storage is unavailable (Apelseth, Arsenovic, and Strandenes, 2022).

refugees to return to their homes. After the Syrian Democratic Forces recaptured Raqqa from the Islamic State of Iraq and Syria (ISIS), for example, approximately 80 per cent of the city was deemed uninhabitable due to IED contamination.

Globally, the proportion of civilian casualties from IEDs continues to increase. In 2022, IEDs were responsible for 46 per cent of all civilian casualties from EO, up from 38 per cent the year prior (UNGA, 2023, p. 2). In addition to the indiscriminate effects of IEDs in civilian spaces, civilians are deliberately targeted, including vulnerable groups such as children. Numerous groups, including ISIS and Boko Haram, utilize children as carriers of person-borne IEDs, with ISIS mainly targeting children with disabilities for this purpose (Wild et al., 2022, p. 2). In Nigeria, between 2018 and 2019, approximately 80 per cent of the nearly 60 children utilized as carriers of person-borne IEDs by Boko Haram were girls (UNGA, 2020, p. 5). Other methods used to target civilians include rigging IEDs to teddy bears and toy trucks during ISIS's retreat from Raqqa (Wild et al., 2022, p. 1).

Given that an estimated 40 per cent of EO casualties do not survive their injuries, increased emphasis on emergency casualty care is necessary to decrease preventable death and disability among victims (ICBL, 2023). Existing normative frameworks, such as the Anti-Personnel Mine Ban Convention (APMBC), could integrate initiatives designed to achieve this goal. The APMBC 'was the first disarmament or humanitarian law treaty to commit states to assist people harmed by a specific type of weapon. It initiated the creation of a strong emerging norm, which became a core binding legal obligation of the 2008 Convention on Cluster Munitions' (CCM) (ICBL, 2023, p. 75).[6] In 2008, a plan of action on VA was adopted under the Convention on Conventional Weapons (CCW) protocol V[7] on explosive remnants of war (ICBL, 2023, p. 75). More recent VA frameworks include the International Mine Action Standards (IMAS) 13.10, as well as the 2022 Political Declaration on Strengthening the Protection of Civilians from the Humanitarian Consequences Arising from the Use of Explosive Weapons in Populated Areas.[8] While each framework stipulates a responsibility to address the direct harms of EO, concrete strategies have not been developed completely.

Recognition of this gap led the UN Secretary-General to announce in his 2024 report on C-IED that '[i]mmediate post-blast care is vital to reducing preventable deaths and disabilities from improvised explosive device incidents' (UNGA, 2024). In this Briefing Paper, we present the context for this statement to lay the foundation for coordinated action.

Gaps addressed

The core components of VA in HMA include data collection and needs assessments, emergency and ongoing medical care, rehabilitation (including prosthetics and other assistive devices), psychological and psychosocial support, socio-economic inclusion, and the enactment of relevant laws and public policies (UNMAS, 2021, 2023; ICBL, 2023, p. 75). Historically, VA in mine action has focused on long-term physical and psychosocial rehabilitation to address the lifelong ramifications of EO injuries. While such assistance is critical, attention to emergency casualty care is at least as necessary.

The Oslo Action Plan, a five-year strategy for implementation of the APMBC, committed states to 'provide effective and efficient first aid to casualties in mine-affected communities, as well as other medical emergency services, and ongoing medical care' (RevCon4, 2019, p. 19). In practice, however, the VA community has made little progress towards establishing frameworks for coordination between HMA actors and health authorities to strengthen the emergency response to EO casualties close to the POI. This gap reflects numerous challenges inherent to conflict casualty care in LRSs, including limited prehospital transport capabilities or formal trauma systems, human and material constraints, and the remote locations where many EO incidents occur, far removed from health facilities (ICBL, 2023, p. 78).

Assistance provided to IED victims should be integrated under the existing VA pillar of HMA to leverage existing VA maturity, expertise, and programmes in EO-contaminated areas for the benefit of IED victims. Efforts to adapt existing VA programmes to meet the needs of IED victims, however, face challenges as the interface between C-IED and HMA is not yet fully mature. Traditionally, C-IED has been dominated by and seen as purely an endeavour of military and security forces, with the HMA community not part of such efforts owing to their humanitarian character and the need to protect humanitarian principles.[9] The APMBC defines a mine as 'a munition designed to be placed under, on, or near the ground or surface area and to be exploded by the presence, proximity, or contact of a person or a vehicle' (UN, 1997, art. 2.2). An anti-personnel mine (APM) is a subset that is 'designed to be exploded by the presence, proximity, or contact of a person and that will incapacitate, injure, or kill one or more persons' (UN, 1997, art. 2.1). APMs do not include those 'designed to be detonated by the presence, proximity, or contact of a vehicle as opposed to a person, that are equipped with anti-handling devices' (UN, 1997, art. 2.1).

APMs of an improvised nature, therefore, only consider the subset of IEDs that are victim-activated. IEDs detonated by alternative activation mechanisms such as timed, command-initiated, person-borne, vehicle-borne, or uncrewed aerial system-deployed devices fall outside the scope of the APMBC. Terminological distinctions focusing on mechanism-based rather than effect-based definitions pose issues regarding the clearance of IEDs and in fulfilling reporting purposes to the APMBC and other conventions, as distinction by device type is necessary. Whether victim-operated or not, IEDs have catastrophic effects through loss of life, limb, and livelihood, with HMA VA fully non-discriminatory as to all types of EO, including all types of IEDs that are the cause of injury.[10]

When establishing new or adapting existing VA programmes to support IED victims, the protection of the humanitarian principles underpinning established VA approaches needs to be upheld. Modern armed conflict is frequently characterized by hybrid and asymmetric warfare, posing challenges to the conventional paradigms of humanitarian intervention (Wren et al., 2019). These dynamics yield increasing tensions between the principle of humanity—the alleviation of human suffering—and the principles of neutrality, impartiality, and independence. Humanitarian principles must be rigorously safeguarded when elements of a national C-IED enterprise involve state security and defence forces or international coalitions. The ethical considerations surrounding C-IED and humanitarian principles merit dedicated attention in future work but are outside the scope of this paper.

> “IEDs often inflict injuries of greater severity and complexity compared to conventional explosive ordnance, with significant associated burden on health personnel and systems.”

Considerations for IED injuries in LRSs

IEDs often inflict injuries of greater severity and complexity compared to conventional EO, with significant associated burden on health personnel and systems.

Complexity of IED injuries

Blast victims frequently sustain multidimensional injuries, including mangled extremities and traumatic amputation, thermal injury, traumatic brain injury, and truncal injuries (DePalma et al., 2005; Champion, Holcomb, and Young, 2009; Stewart and Trujillo, 2020). Even among blast mechanisms, IEDs inflict particularly severe injuries. During the US-led wars in Iraq and Afghanistan between 2001 and 2010, while only 24 per cent of military casualties were caused by IEDs compared to 43 per cent by non-IED explosive mechanisms, 31 per cent of fatalities resulted from IED injuries compared to 9 per cent from non-IED explosives, illustrating their lethality (Kotwal et al., 2011). Victim-activated IEDs cause higher injury severity compared to conventional APMs. For example, one cohort of IED victims in Afghanistan had a seven times higher likelihood of suffering multiple amputations—70.0 versus 10.4 per cent—as well as more than a quarter of IED victims sustaining triple amputations compared to none among APM victims. In other studies, IED casualties who sustained multiple amputations had more than threefold higher mortality (Smith et al., 2017). Children are affected with severity, with approximately 90 per cent of paediatric IED victims suffering multiple amputations (Smith et al., 2017).

IED-related burns

IED blasts can generate temperatures of up to 3,000°C, although high variability is observed based on the mechanism (Page et al., 2017; Turker, 2016; Kauvar et al., 2006). IEDs are the most common cause of conflict-related burn injury among military servicemembers in modern warfare and cause particularly severe morbidity for victims (Atiyeh, Gunn, and Hayek, 2007). Among combat casualties from the US wars in Iraq and Afghanistan treated at the United States Army Institute of Surgical Research between 2003 and 2005, the proportion of all IED-related burn injuries rose from 18 per cent to 69 per cent (Kauvar et al., 2006). In these same theatres of war until 2018, approximately 70 to 80 per cent of combat-related burns were IED-related (Perez et al., 2023).

The management of severely blast-injured patients who also require burn resuscitation is complex. Burn victims with burn injuries that cover a large total body surface area require intensive care throughout the initial resuscitative phase, including close monitoring of haemodynamics, urine output, and body temperature. Severely burn-injured patients require numerous operative procedures for debridement and grafting with extremely labour-intensive wound care that can occupy numerous nursing personnel for hours each day. In the period after immediate stabilization, infectious risks remain the most common cause of death in burn patients, particularly when delays to surgical debridement are encountered, as is inevitably the case in LRSs.[11] The long-term rehabilitation of burn patients is equally time-intensive. It is essential to prevent life-altering disability such as contractures or tightening of soft tissues during healing that limits joint mobility.

Burns are, therefore, one of the only criteria on which triage decisions at US military treatment facilities (MTFs) differ between local civilians and military personnel. Whereas an identical standard of trauma care is typically applied to all patients, civilians with total body surface area burns greater than 60 per cent are treated ‘to the highest standard of care present in the respective host country’ (Gurney et al., 2022a). Frequently, this can mean palliative or comfort care provided to a victim. Unsurprisingly, civilian victims of war-related burns suffer disproportionately high mortality rates and vulnerable subpopulations, such as children, most of all. Syrian children with conflict-related burns, for example, suffered a mortality rate of nearly 50 per cent compared to three per cent among children with non-conflict-related burns (Sarsu and Budeyri, 2018; Wild et al., 2021).

Personal protective equipment

Analyses of casualty data from the US Department of Defense Trauma Registry and UK Joint Theatre Trauma Registry demonstrated extremities to be the most common anatomic region of injury among coalition[12] IED casualties (Ramasamy, Hill, and Clasper, 2009). This wounding pattern is partly due to the effects of personal protective equipment (PPE), such as helmets, combat body armour, and antiballistic eye protection (Smith et al., 2017; Ramasamy, Hill, and Clasper, 2009). The vast majority, approximately 94 to 100 per cent, of coalition military servicemembers sustain IED injuries while protected by individual PPE, as well as combat vehicles designed to resist anti-vehicle mines and IEDs. Casualties wearing helmets, body armour, and pelvic protection are 2.7, 4.1, and 10 times less likely to sustain explosive fragmentation injuries to the head, thorax or abdomen, and pelvis, respectively, than those without PPE (Breeze et al., 2015). Researchers have modelled the peak blast overpressure outside an armoured vehicle to be 28 times higher than inside. Clinically, this risk reduction is profound. If exposed to a 17 kg C_4[13] explosive charge, individuals inside the armoured vehicle would be most likely to experience relatively mild injuries, such as eardrum rupture. In contrast, those outside the vehicle would experience a 50 per cent chance

of death (Champion, Holcomb, and Young, 2009).

Civilians in conflict settings, as well as many local security forces[14] and defence personnel, are exposed to the consequences of IED injury with no such protection. Documentation of extremity-predominant injury patterns occurs among these populations, similar to military personnel. Unlike military personnel, however, the leading cause of this finding is most likely the low survival rate of victims with more severe injuries, who often do not survive reaching care at a health facility in LRSs and are, therefore, not represented in facility-based data (Wild et al., 2020).

Challenges in trauma care for IED victims in LRSs

Lack of PPE is only one of a myriad of factors complicating the care of civilian IED victims in LRSs. IED injuries are highly lethal even among military servicemembers, predominantly young, healthy men without pre-existing medical conditions. In contrast, civilian victims range from children to the elderly, pregnant women, and those with pre-existing medical conditions. When civilian victims experience exposure to IED blasts without protection from PPE or armoured vehicles, delays of hours to days in reaching a health facility are typical. Treatment at facilities is then often under-resourced concerning material equipment and adequately trained personnel. Compositely, such challenges drive the profound mortality disparities observed between civilian victims of EO in conflict and post-conflict settings compared to victims of blast injury treated at military treatment facilities and high-resource civilian trauma centres.[15,16]

No golden hour for civilians

In 2009, former US Secretary of Defense, Robert Gates, mandated the evacuation of critically injured US combat casualties within 60 minutes, recognizing the potential to improve patient outcomes through decreased time to definitive trauma care. This emphasis on the rapid evacuation of the injured brought increased awareness to the 'golden hour', referring to a window crucial to survival in the immediate post-injury period. Subsequent analyses of critically injured combat casualties before and after the implementation of this mandate demonstrated a reduction in case fatality rates from 13.7 to 7.6 per cent (Kotwal et al., 2016). The principles of rapid evacuation have been mirrored in civilian practices in high-resource settings (Smith and Conn, 2009).

In contrast, there is no golden hour for civilians in conflict settings, for whom average transport times are on the order of hours to days (Forrester et al., 2019). Organized prehospital transport systems are limited in LRSs, typically occurring by ad hoc means, including motorcycle or taxi, donkeys or other livestock, the backs of bystanders, or bicycle ambulance. After implementing the golden hour mandate, 75.2 per cent of US military missions achieved a less than 60-minute transport of critical combat casualties (Kotwal et al., 2016). Over four years at a humanitarian trauma hospital in Kabul, only 5.8 per cent of casualties arrived at the facility within one hour (Spagnolello et al., 2023).

Resource gaps: the example of damage control resuscitation

Along with constraints on survivability posed by prolonged prehospital transport time, many of the resuscitative capabilities[17] that exist within military and high-resource trauma systems are not available in LRSs. Damage control resuscitation (DCR) is a single example illustrative of the resource gaps faced by civilian casualties that contribute to unnecessarily high mortality. DCR refers to a balanced approach to the resuscitation of critically injured trauma patients whereby blood products are delivered in a physiologic ratio to prevent coagulopathy, or abnormal bleeding and clotting, that can occur in the setting of severe trauma (Cap et al., 2018). Advances in DCR were central to improving survivability among military servicemembers during the wars in Iraq and Afghanistan, including walking blood banks (WBBs) involving the collection of blood for immediate use at the site of need (Shackelford et al., 2017; Gurney et al., 2022b). While WBBs remain a feasible and context-appropriate strategy for improving access to blood in LRSs where blood banking capacity is inadequate, structured implementation mechanisms in conflict-affected settings are limited (Raykar et al., 2024).

Similarly, autotransfusion, a practice whereby a patient's lost blood is reinfused, is a potentially feasible approach to resuscitation in LRSs, yet is not a widely established practice (Palmqvist et al., 2022). As a result, the large-volume blood transfusions that are routinely part of the care of critically injured combat casualties in MTFs and high-resource civilian trauma centres are unavailable to civilian casualties in LRSs, limiting the survivability of complex injuries inflicted by IEDs (Abdella, Hajjeh, and Sibinga, 2018).

Inadequate adaptation of trauma care principles from high-resource settings to LRSs

It is not only the failure to translate trauma care advances from military and high-resource civilian practice to LRSs that perpetuates unnecessary harm but also the inappropriate translation of such advances. Tourniquet application is a core component of the US military's Tactical Combat Casualty Care (TCCC) training (CALL, 2017), a set of evidence-based practices in prehospital medicine designed to reduce mortality close to the POI and taught to all US military servicemembers in combat roles (Butler and Blackbourne, 2012). In a military context, prehospital tourniquet application has been strongly associated with decreased mortality among combat casualties (Kragh et al., 2009). This evidence has been widely translated to high-resource civilian settings through programmes to train laypersons in haemorrhage control techniques, such as the Stop the Bleed programme (Inaba et al., 2015).

Using tourniquets in LRSs with inadequate context-appropriate adaptation can cause permanent harm (Husum et al., 2004). The adage of 'high and tight'[18] is specific to combat environments where it is difficult to identify the precise location of bleeding, the casualty and the medical provider may be under active fire, and a tactical tourniquet must be placed rapidly to ensure effective haemorrhage control prior to rapid evacuation (Getrajdman and Inaba, 2021). The acceptability of this approach is based on an aeromedical evacuation capacity that can facilitate rapid transport of casualties to surgical care in a timeframe close to the golden hour. Haemorrhage control guidance prioritizing tourniquet

use, however, has been universally applied to managing casualties in LRSs with insufficient contextual adaptation.

Given the prolonged prehospital times that characterize care of the conflict-injured patient in most LRSs, inappropriate tourniquet application has led to an unquantified number of unnecessary amputations, even in conflicts—such as Ukraine—with relatively well-developed trauma care infrastructure (Holcomb et al., 2023). The potential harms in resource-constrained civilian healthcare systems are even higher when access to high-quality prosthetics is limited (Wild et al., 2024b). Trauma care advances in high-resource military and civilian settings must be translated to LRSs to reduce preventable death, yet also adapted in a context-appropriate manner to do so safely and effectively. One example is emphasizing alternative modes of haemorrhage control, such as direct manual pressure and wound packing.

Military approaches to reducing preventable death

During the wars in Iraq and Afghanistan, the US military revolutionized its trauma system to address the high proportion of preventable combat-related deaths that occurred in the prehospital setting (Blackbourne et al., 2012). Analyses of the US Department of Defense Trauma Registry's casualty data identified the leading causes of preventable death to be 'extremity haemorrhage, tension pneumothorax, and airway obstruction' (Kotwal et al., 2011). A series of interventions designed to target these causes resulted in a transformed military trauma care system known as the Joint Trauma System (JTS) (Eastridge et al., 2006; Blackbourne et al., 2012). Compositely, these advances are attributed to a 44 per cent mortality reduction throughout the course of the wars in Iraq and Afghanistan (Howard et al., 2019).

Trauma care advances wrought by wartime often become incorporated into civilian trauma systems in high-resource settings (Haider et al., 2015; Givens, Muck, and Goolsby, 2017). Based on experiences during the US wars in Iraq and Afghanistan, numerous military trauma care practices were adopted into the care of civilian trauma patients, including increased prehospital tourniquet application and recognition of the importance of DCR principles (Katsura et al., 2020). In contrast, there has not been any systematic translation of trauma care advances to improve emergency care for civilians with conflict-related injuries in LRSs where the need is greatest (Wren et al., 2019). The resulting mortality rate from blast injury in high-resource civilian trauma centres and MTFs is approximately 4.5 per cent and less than 2 per cent, respectively. It is approximately 40 per cent among civilian victims of blast injury in LRSs (Bochicchio et al., 2008; ICBL, 2023; Ritenour et al., 2010). This gap highlights a substantial rate of preventable death among civilian EO and IED casualties.

Integration of emergency care in assistance provided to IED victims: opportunities and policy considerations

While a range of factors renders it challenging to bring trauma care advances to civilian casualties in LRSs, doing so is both a possible and essential component of the protection of civilians in conflict. Despite the challenges posed by resource constraints, certain principles of the US military approach to system-wide improvement in trauma care practices developed during the wars in Iraq and Afghanistan can be adapted to LRSs. The advances achieved through the coordinated efforts of the JTS that collectively increased the survival of military combat casualties can be structured broadly into four conceptually simple categories to provide a conceptual roadmap:

1. **Bring life-saving care closer to the POI** (see Annexe, Table 1). In a military context, this has been achieved through TCCC and forward surgical teams (FSTs). A civilian equivalent to TCCC is layperson first responder (LFR) training, which involves the training of non-medical personnel in emergency first aid. The design of FSTs is to provide far-forward damage control surgery (DCS) prior to rapid evacuation to definitive care (Stinger and Rush, 2006). Although the intention of trauma stabilization points within the World Health Organization's (WHO) trauma care pathway is to bring emergency care and triage closer to the POI, no true FST analogue exists in civilian settings, as trauma stabilization points do not possess surgical capabilities (WHO, n.d.b).
2. **Bring the patient to higher levels of care faster** (see Annexe, Table 2). In a military context, this has been achieved by emphasizing the golden hour through rapid tactical evacuation of casualties to higher echelons of care. This gap will be one of the most challenging to address for civilian IED victims due to resource constraints. Networks of layperson transport systems, however, have reduced mortality in the context of other health emergencies, such as postpartum haemorrhage (Alaofe et al., 2020). Organized layperson transportation systems have utilized modes of transport, including the ad hoc modes of motorbikes, donkeys, and bicycle ambulances. Prehospital notification systems can also be implemented to alert receiving facilities of incoming casualties to improve the preparedness of trauma teams (Wild et al., 2024d).
3. **Bring higher-quality care to the patient** (see Annexe, Table 3). In a military context, this has been achieved partly through clinical practice guidelines (CPGs), a core component of the JTS performance improvement programme and evidence-based guidelines for managing combat-related trauma. While certain organization-specific protocols exist for casualty care in LRSs, such as the International Committee of the Red Cross's (ICRC) guidelines on the management of embedded ordnance (ICRC, 2022), no systematic effort has been made to develop a CPG library for this context. Other low-cost efforts to reduce variability in trauma care practices, such as the WHO Trauma Care Checklist (WHO, 2016), have been associated with reduced mortality (WHO, 2024). In addition to CPGs, other examples of clinical performance improvement include advances in DCR strategies. These strategies include WBBs and autotransfusion, as well as tranexamic acid—a haemostatic agent designed to help with clotting—which all hold a context-appropriate potential to increase access to blood transfusion in LRSs yet are not systematically implemented (Givens, Muck, and Goolsby, 2017). The work of the Blood DESERT Coalition (n.d.) lays the foundation for translating military DCR advances to least-resourced civilian environments.

4. **Injury prevention and system-wide quality improvement** (see Annexe, Table 4). The basis of the US military's ability to target the dominant causes of preventable death relies on the availability of standardized data to feed into 'tight decision-making cycles'. Iterative reviews of combat casualty care data have identified opportunities for quality improvement and benchmarked the impact of interventions designed to address these performance gaps (NASEM, 2016). The lack of comparable data sources for civilians injured in LRSs constrains efforts to improve trauma care in this environment (Wild et al., 2020; Wild and Wren, 2023). The WHO Emergency Medical Team Minimum Data Set and WHO Standardized Emergency Unit Trauma Form are positive steps towards improving data quality in public health emergencies, including in conflict settings.[19] Many actors providing trauma care to civilian victims with conflict-related injuries function outside of these tools, resulting in a lack of clear mechanisms for secure data-sharing or operationalization to improve the efficacy and quality of trauma care for civilian IED casualties. In contrast to a military environment, injury prevention strategies are likewise underutilized, and the use of PPE for civilians in conflict has yet to be explored (Hansen, forthcoming).

A responsibility to disseminate and scale evidence-based emergency care interventions

Given the dramatic differences in resource availability, the military's approach to combat casualty care cannot be directly translated to LRSs. It is possible, however, to translate the core principles of battlefield trauma care advances to the care of civilian IED casualties in LRSs with context-appropriate adaptations. Many trauma system components have been demonstrated to reduce mortality in LRSs, including LFR training, lay-person transportation networks, and emergency care toolkits and checklists, yet have not been systemically scaled in conflict settings.[20] Other components, such as DCR advances, including WBBs and autotransfusion, could feasibly be implemented in LRSs if enough coordinated attention were devoted to doing so (Jayaram, 2024).

The fact that the evidence for each of these components exists in disparate literature rather than being synthesized into a coherent bundle of trauma care interventions can create the impression that the resource limitations in LRSs are prohibitive to significantly improving trauma care for civilian casualties in such contexts. This impression is false. Substantial and attainable opportunities exist to reduce preventable death among civilian IED victims and should be urgently supported. Through existing operations, infrastructure, and capabilities, the community of practice involved in a whole-of-society approach to C-IED, including HMA actors, can potentiate such efforts in collaboration with health stakeholders.

Clarification of how to adapt and implement modern principles of DCR and DCS to the care of civilian IED casualties in LRSs is beyond the scope of this Briefing Paper. Doing so will require long-term engagement and concerted, collaborative research between a complex network of actors, including trauma care providers in high-resource settings and those providing casualty care in conflict-affected LRSs. Instead, existing frameworks that can help inform the translation of the JTS conceptual model for eliminating preventable death to the context of civilian casualties in LRSs are highlighted, as well as a selected example of how engagement from humanitarian protection actors can extend the reach of such efforts.

"Through a holistic approach to C-IED, those within the community of practice . . . can play a pivotal role in disseminating, scaling, and adopting such guidelines through multisectoral collaboration between protection and health actors."

The WHO's ECO Resolution and Emergency Care System Framework

In 2023, the World Health Assembly adopted WHO Resolution 76.2, or 'ECO Resolution', on emergency, critical, and operative care (ECO) (WHO, 2023).[21] This resolution aims to eliminate silos between trauma care and the broader health systems strengthening required to facilitate high-quality emergency care for patients with a range of severe life-threatening injuries or illnesses. ECO toolkits exist relevant to aspects of emergency care ranging from POI to the facility-level management of a severely injured trauma patient (WHO, n.d.a). The WHO Emergency Care System Framework (ECSF) delineates the full continuum of care required to ensure comprehensive management of injured patients in LRSs (WHO, 2018; n.d.b).

While the WHO ECO toolkits and prior work, including the WHO *Guidelines for Essential Trauma Care* (WHO, 2004), are essential references, they are technical advisory documents and best practice guidance. Implementation of these toolkits is a separate matter. Major gaps exist in the general application of these toolkits in LRSs, but above all, in settings of active conflict. Through a holistic approach to C-IED, those within the community of practice, including HMA actors, can play a pivotal role in disseminating, scaling, and adopting such guidelines through multisectoral collaboration between protection and health actors.

To address this gap in the context of HMA, the Explosive Weapons Trauma Care Collective (EXTRACCT) was founded. EXTRACCT is a multisectoral initiative hosted by the International Blast Injury Research Network at the University of Southampton that brings together academic experts in trauma and burn surgery, blast engineering, health systems modelling, and humanitarian practitioners within HMA (Wild et al., 2024c; 2024d). To establish the structure underpinning its activities, EXTRACCT undertook a three-part series of scoping work, including a systematic review, qualitative analysis of sector expert interviews, and modelling to develop the Civilian Casualty Care Chain. This care chain is a conceptual model for enhanced coordination between HMA actors and healthcare stakeholders to address the emergency care needs of EO casualties. The framework for this model was first presented at the 26th International Meeting of Mine Action National Directors and United Nations Advisors in Geneva in 2023 (UN, 2023; Wild et al., 2024b).

The Civilian Casualty Care Chain encompasses a spectrum of evidence-based approaches to reduce mortality among victims of EO that interface with the WHO ECSF. Integration of the care chain with HMA is possible, including LFR training and transport systems, pre-hospital provider trauma training and notification systems, and trauma care checklists. The utility of such a framework can fulfil Action 36 of the Oslo Action Plan for effective and efficient emergency responses to casualties of all types of EO, including IEDs (RevCon4, 2019).

LFR training: potentiating health sector efforts

TCCC was a key factor in the US military's ability to reduce preventable death on the battlefield, shifting care closer to the POI by training all personnel in emergency first aid. In resource-constrained civilian settings, layperson bystanders provide the vast majority of trauma care close to the POI (Mock et al., 2002; O'Connor et al., 2024). Delivery of LFR training has occurred in LRSs with a range of target populations, including commercial drivers and community members (Boeck et al., 2018; Eisner et al., 2020). One of the most impactful examples of LFR training in EO-affected settings is the Tromsø Mine Victim Centre's 'Village University'. Over five years, more than 5,000 people received LFR training to provide emergency field aid to trauma patients—particularly victims of landmine injury—in Iraq and Cambodia. Trauma-related mortality decreased from a pre-intervention level of 40 to approximately 15 per cent (Husum et al., 2003).

Despite this programme's successes, systematic scaling of LFR training has not yet occurred in conflict settings. The WHO has developed a community first aid responder curriculum as part of its ECO toolkit, piloted in conflict-affected settings such as Iraq and the Democratic Republic of the Congo (Diango et al., 2023). In collaboration with health stakeholders, the community of practice involved in C-IED, including HMA actors, can play a role in dissemination and scaling by leveraging EO and IED risk education programmes as platforms for delivering LFR training. EXTRACCT and the Mines Advisory Group (MAG) are currently piloting this approach among EO- and IED-affected communities in Burkina Faso (Wild et al., 2024c). Joint delivery of LFR training with IED risk education is only one example of how existing HMA and C-IED activities can be harnessed to improve trauma care for IED casualties in LRSs.

Conclusion

To address the higher death rates among civilian IED victims in LRSs, the authors recommend prioritizing emergency care from the POI to life-saving interventions at a health facility for IED victims. Using established VA mechanisms, policymakers should maximize efforts to strengthen emergency care capabilities under the APMBC. The Fifth Review Conference of the States Parties to the APMBC in November 2024 (APMBC, n.d.) should consider adopting a commitment to improve emergency care as a core component of VA through efforts such as LFR training. C-IED strategies must recognize emergency care elements of VA as a component of holistic approaches. Both national C-IED self-assessment tools and national HMA strategies or action plans should include trauma care capacity indicators. Making trauma care a measurable aspect of VA reporting can strengthen national capacities for emergency medical responses.

The community of practice involved in C-IED, including international and national defence and security entities in appropriate collaboration with HMA actors, should examine how to most effectively harness existing networks and capabilities to support the development of emergency care capabilities in LRSs. Building on work conducted within HMA, a series of scoping exercises among C-IED communities is required to support this process. Examining case studies that illustrate the successful integration of trauma care into VA frameworks in LRSs would provide practical value and demonstrate feasibility. Such future work can seek to distil detailed guidance on implementation across different contexts, particularly in resource-constrained environments.

Execution of this responsibility will require long-term, dedicated attention and coordinated action from a range of actors in humanitarian health and protection. This Briefing Paper is only the first step in establishing a foundation for the multisectoral dialogue required. Responsibility for such efforts lies largely with local, international, and multilateral health stakeholders. Through a holistic approach to C-IED, however, coordinated engagement between the community of practice, including HMA actors, can potentiate implementation and help ensure evidence-based trauma care improvements reach those with the greatest burden and least protection.

Abbreviations and acronyms

APM Anti-personnel mine

APMBC Anti-Personnel Mine Ban Convention

C-IED Counter-improvised explosive devices

CCM Convention on Cluster Munitions

CCW Convention on Conventional Weapons

CPG Clinical practice guidelines

CSO Civil society organization

DCR Damage control resuscitation

DCS Damage control surgery

ECO Emergency, critical, and operative care

ECSF Emergency Care System Framework

EO Explosive ordnance

EORE Explosive ordnance risk education

EXTRACCT Explosive Weapons Trauma Care Collective

FST Forward surgical team

HMA Humanitarian mine action

ICRC International Committee of the Red Cross

IED Improvised explosive device

IMAS International Mine Action Standards

IO International organization
ISIS Islamic State of Iraq and Syria
JTS Joint Trauma System
LFR Layperson first responder
LRS Low-resource setting
MDS WHO Emergency Medical Team Minimum Data Set
MSF Médecins Sans Frontières
MTF Military treatment facility
NATO North Atlantic Treaty Organization
NGO Non-governmental organization
POI Point of injury
PPE Personal protective equipment
TCCC Tactical Combat Casualty Care
TXA Tranexamic acid
VA Victim assistance
WBB Walking blood bank
WFWB Warm fresh whole blood
WHO World Health Organization

Notes

1 This can include multiple elements of state security, defence, government departments, ministries, offices, agencies, and civil society organizations (CSOs)—including NGOs and international organizations (IOs), commercial and industry entities, and international and regional organizations. Whole-of-society C-IED approaches often have stakeholders with complex institutional structures and procedures requiring internal coherence and a cooperative and collaborative culture between members to support effective C-IED efforts through a shared understanding of the improvised explosive device (IED) threat faced and facilitation for their ways of working. All humanitarian organizations, for example, will need to ensure all others they are required to support or work with respect and do not compromise humanitarian principles.

2 See CDMRP (n.d.).

3 Such multisectoral approaches to providing high-quality emergency care, proximate to the POI, can have complex institutional structures and procedures among those involved owing to differences between their respective ways of working and the context in which they undertake their work. In all cases, the approach needs to be done in a conflict-sensitive manner, facilitating the respective ways of working of those involved. 'Owing to the nature of the contexts that they work in, [explosive ordnance risk education (EORE)] operators are required to work in a conflict sensitive manner and to take the utmost care not to put the community they work in and the EORE staff, at risk of harm or hardship as a consequence of their interventions. EORE is delivered in line with the core humanitarian principles of humanity, neutrality, impartiality and independence' (UNMAS, 2022). 'All EORE operations should take a conflict-sensitive approach and be implemented in line with the principles of "do no harm"' (UNMAS, 2022), as some activities could potentially cause unintentional harm to beneficiaries, communities, or personnel.

4 A suitable entity within a state's healthcare system may be the best lead for VA with a whole-of-society approach to C-IED. Another approach could involve a national mine action authority or equivalent national authorities competent in mine action, including VA coordinators and focal points in developing elements within a national C-IED enterprise to assist IED victims. Such VA coordinators or focal points can act as the point of contact with NGO and IO community members supporting or providing VA. Including VA coordinators and focal points can also be beneficial in supporting information-sharing on casualties and bringing military or security forces to support civilians in areas not accessible for humanitarian response during conflict.

5 'Victims' in this context refer to direct victims or casualties of EO rather than indirect victims (UNMAS, 2021).

6 See UN (1997, art. 6.3; 2008).

7 See UN (1980).

8 See UNMAS (2021); Ireland (2022).

9 As outlined previously, this Briefing Paper advocates for widening the lens in terms of who are part of the community of practice under a whole-of-society approach to C-IED.

10 VA has always been much broader than a mechanism-based scope of the type of EO which causes injury. VA in the APMBC and the CCM is non-discriminatory and applicable to casualties of all conflict-related injury types regardless of the device that caused the injury (UN, 1997; 2008). Using the definition of EO in IMAS 4.10 (UNMAS, 2003), VA refers to the assistance provided to victims of all forms of EO, which include mines, cluster munitions, unexploded ordnance, abandoned ordnance, boobytraps and other devices —as defined by the Protocol on Prohibitions or Restrictions on the Use of Mines, Booby-Traps, and Other Devices ('Amended Protocol II')—as well as IEDs (UN, 1996).

11 See Atiyeh, Gunn, and Hayek (2007); Sandhu, Herron, and Martin (2022).

12 Coalition personnel during the US-led wars in the Iraq and Afghanistan conflicts included both NATO and non-NATO militaries, as well as host nation security and defence forces (Gurney et al., 2022a).

13 C4 or C-4 is a US military plastic explosive composed of approximately 91 per cent royal demolition explosive (RDX) (US GAO, 1990).

14 For an analysis of injury patterns among civilians and non-NATO coalition personnel during the wars in Iraq and Afghanistan, see Gurney et al. (2022a).

15 High-resource civilian centres refer to trauma care provided to civilians in high-income countries, such as the United States or the United Kingdom. Intact trauma systems characterize such environments, including organized prehospital transport with advanced prehospital provider capabilities and adequate resources at the health facility level. In contrast, humanitarian trauma care, including care rendered by international NGOs such as the International Committee of the Red Cross (ICRC) or Médecins Sans Frontières (MSF), occurs in the context of significant resource limitations and fragile healthcare systems.

16 See ICBL (2023); Nunziato, Riley, and Johnson (2021); Pizzino et al. (2023); Ritenour et al. (2010).

17 In trauma care, resuscitation refers to the rapid assessment and stabilization of life-threatening injuries, including the transfusion of blood products to restore normal physiology.

18 A tourniquet should be placed as proximally on an affected extremity as possible.

19 See WHO (n.d.c); WHO CHD (n.d.).

20 Mock (2011); Reynolds et al. (2017); Wild et al. (2024d); Wren et al. (2019).

21 ECO designates all acute post-injury care, encompassing immediate casualty stabilization, critical care requirements, and operative management.

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Annexe

Military approach to reducing preventable death and the implications or barriers to translating these advances to civilian approaches in low-resource settings

Tables 1–4 are to be interpreted as a whole: they collectively address the US military's approach to reducing preventable death, and capture the implications and barriers of translating these advances to LRSs.

Table 1 Bring life-saving care closer to the POI (Military Roles 1–2)

Military trauma systems component	Component description	Analogous intervention in LRSs	Intervention description	Gaps and challenges in LRSs
Tactical Combat Casualty Care (TCCC)	TCCC emerged from a US Special Operations project to reduce preventable pre-hospital deaths. It trains both medics and non-medical personnel in life-saving interventions focused on the three main causes of preventable prehospital death (extremity haemorrhage, tension pneumothorax, and airway obstruction).	Layperson first responder (LFR) training.	Training of non-professionalized community members in emergency first aid.	• Lack of intact echelons of more advanced care for casualty evacuation. • No systematic approach to LFR training in low-resource settings (LRSs). • Insufficient contextual adaptation of recommendations designed for high-resource settings, such as tourniquet application.
Forward surgical teams (FSTs)	FSTs provide far-forward damage control resuscitation (DCR) and damage control surgery (DCS) prior to rapid evacuation to definitive care facilities.	Trauma stabilization points within the WHO's trauma care pathway.	Trauma stabilization points in the context of civilian trauma care are significantly more limited in procedural scope than FSTs but provide emergency care and triage close to the point of injury (POI).	• The operational and ethical challenges of negotiating security near the front lines. • Limited options for DCR. • Limited capacity for DCS. • Limited critical care capabilities. • Lack of formalized evacuation.

Sources: Butler and Blackbourne (2012); CALL (2017); Spiegel et al. (2018); Stinger and Rush (2006); WHO (n.d.b)

Table 2 Bring the patient to higher levels of care faster (Military Roles 1–2)

Military trauma systems component	Component description	Analogous intervention in LRSs	Intervention description	Gaps and challenges in LRSs
'Golden hour'	Rapid tactical evacuation of casualties to higher echelons of care.	LFR transportation systems.	Organized LFR transportation systems have been utilized with alternative modalities, including the ad hoc modes of motorbikes, donkeys, and bicycle ambulances. Such transportation systems have predominantly been explored in settings such as maternal mortality and postpartum haemorrhage, as well as other health emergencies (including snake bites).	• Remote environments in which many incidents occur with limited infrastructure. • Lack of clear referral pathways. • Lack of inquiry into the potential role of LFR transportation networks for conflict casualties. • Lack of reliable communications strategies (e.g. cellular network). Community radio systems have been used to address this in certain contexts.

Sources: Alaofe et al. (2020); Wild et al. (2024d)

Table 3 Bring higher-quality care to the patient (Military Roles 1–4)

Military trauma systems component	Component description	Analogous intervention in LRSs	Intervention description	Gaps and challenges in LRSs
Clinical practice guidelines (CPGs)	CPGs are evidence-based guidelines for the management of combat-related trauma. They are a core component of the Joint Trauma System (JTS) performance improvement programme, subject to iterative review by subject experts.	Organization-specific guidance on conflict-related injuries exists, such as the International Committee of the Red Cross (ICRC) guidelines on removing embedded ordnance from patients.	Specific organizations, such as the ICRC and Médecins Sans Frontières (MSF), have developed protocols and guidelines for managing specific injury types. Sector-wide standards or CPGs do not exist.	• Lack of a shared trauma registry for civilian casualties in LRSs. • Lack of sector-wide quality improvement strategies and coordination.
Advances in DCR	Clinical advances in DCR had a significant role in mortality reduction within military trauma systems, including haemostatic agents, balanced resuscitation strategies, permissive hypotension, tranexamic acid (TXA), and warm fresh whole blood (WFWB).	WFWB, TXA, and autotransfusion.	While the use of TXA as a haemostatic agent and whole blood and autotransfusion have been explored as strategies for increasing access to blood transfusion in LRSs, they have yet to be implemented systematically or made widely available in the current state.	• Lack of standardization in the organization and implementation of WFWB. • Lack of equipment for autotransfusion. • Lack of provider familiarity with TXA administration and rarity of casualties reaching care within the recommended post-injury period.

Sources: Givens, Muck, and Goolsby (2017); ICRC (2022); JTS (2023); Robbel et al. (2022); WHO (2016; 2024)

Table 4 Injury prevention and system-wide quality improvement (Military Roles 1–4)

Military trauma systems component	Component description	Analogous intervention in LRSs	Intervention description	Gaps and challenges in LRSs
Personal protective equipment (PPE)	Increased availability and use of PPE—including helmets, body armour, and goggles—have reduced injury risk among military personnel.	None.	PPE is not available to civilians in conflict settings.	• This intervention has not been explored and is unlikely to be resource-feasible. • In the absence of PPE, alternative injury prevention strategies for civilians in conflict should be explored and strengthened.
US Department of Defense Trauma Registry and the UK Joint Theatre Trauma Registry	Standardized data collection throughout the US military trauma care system has allowed continuous analyses of casualty data to facilitate quality improvement processes and interventions designed to target preventable death.	WHO Emergency Medical Team Minimum Data Set (MDS).	While the WHO Emergency Medical Team has developed an MDS, other actors providing humanitarian trauma care in conflict—such as the MSF, ICRC, local healthcare facilities, and other international NGOs—do not utilize a standardized data collection, sharing, or analysis approach. There is no analogous registry for humanitarian trauma care in conflict.	• Lack of standardized variables and an approach to data collection among actors providing humanitarian trauma care in conflict. • In many LRSs, there are inconsistent baseline practices or infrastructure for data collection, even outside of times of active conflict. • An absence of provisions for secure data sharing to facilitate system-wide quality improvement. • Lack of context-appropriate perioperative mortality risk scores to benchmark quality of care and observed-to-expected mortality ratios.

Sources: NASEM (2016); Wild et al. (2020); Wild and Wren (2023); WHO (n.d.d)

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