

NTRAP TRAUMA SYSTEMS PANEL LITERATURE REVIEW

NEWLY ADDED

The National Trauma Research Repository. Smith et al. Shock, Vol. 46, Supplement 1, pp. 37-41, 2016.
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Despite being the leading cause of death in the United States for individuals 46 years and younger and the primary cause of death among military service members, trauma care research has been underfunded for the last 50 years. Sustained federal funding for a coordinated national trauma clinical research program is required to advance the science of caring for the injured. The Department of Defense is committed to funding studies with military relevance; therefore, it cannot fund pediatric or geriatric trauma clinical trials. Currently, trauma clinical trials are often performed within a single site or a small group of trauma hospitals, and research data are not available for secondary analysis or sharing across studies. Datasharing platforms encourage transfer of research data and knowledge between civilian and military researchers, reduce redundancy, and maximize limited research funding.

Surgeon preparedness for mass casualty events: adapting essential military surgical lessons for the home front. Remick, et al. American Journal of Disaster Medicine, Vol. 11, No. 2.

DOI:10.5055/ajdm.2016.0228

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Military surgeons have gained familiarity and experience with mass casualty events (MCEs) as a matter of routine over the course of the last two conflicts in Afghanistan and Iraq. Over the same period of time, civilian surgeons have increasingly faced complex MCEs on the home front. Our objective is to summarize and adapt these combat surgery lessons to enhance civilian surgeon preparedness for complex MCEs on the home front. The authors describe the unique lessons learned from combat surgery over the course of the wars in Afghanistan and Iraq and adapt these lessons to enhance civilian surgical readiness for a MCE on the home front.

A reassessment of the impact of trauma systems consultation on regional trauma system development. Winchell et al. JTACS, Vol. 78, No. 6. 2015 DOI: 10.1097/TA.0000000000000653

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Previous studies have shown that trauma systems decrease morbidity and mortality after injury, but progress in system development has been slow and inconsistent. This study evaluated the progress in 20 state or regional systems following a consultative visit conducted by the Trauma Systems Evaluation and Planning Committee (TSEPC) of the Committee on Trauma, expanding on a previous study published in 2008, which demonstrated significant progress in six systems following consultation. There was significant improvement in approximately 80% of systems evaluated within 60 months following the consultation. There was no progress in five of six systems reevaluated over 80 months after consultation, and all four systems evaluated over 100 months after consultation showed erosion of progress. Significant improvements were seen in 10 of the 16 individual indicators, with the greatest gains related to system standards, data systems, performance improvement, prehospital triage criteria, and linkages with public health. Consistent with the 2008 study, the two indicators related to financing for the trauma system showed no improvement.

A National Trauma Care System to Achieve Zero Preventable Deaths after Injury. Berwick, et al. JAMA, Vol. 316, No. 9. 2016. doi:10.1001/jama.2016.8524.

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The progress made by the military's trauma system by applying learning health system principles is remarkable but fragile. Valuable wartime advances and lessons learned are at risk of being lost, and regression and inconsistency do a great disservice to the US Armed Forces service members. In addition, the hundreds of thousands of civilians who have sustained trauma deserve the benefits of care improvements achieved in military medicine. The nation should and, with proper leadership, can do better for the soldiers, sailors, airmen, and marines it sends into harm's way. And every US resident should have the best possible chance for survival and functional recovery after injury. When it comes to trauma care, where people live ought not to determine if they live.

CIVILIAN TRAUMA SYSTEMS

01. Impact of Trauma System Structure on Injury Outcomes: A Systematic Review and Meta-Analysis.

Moore L, et al.; International Injury Care Improvement Initiative. World J Surg. 2018 May;42(5):1327-1339. doi: 10.1007/s00268-017-4292-0.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/29071424>

BACKGROUND:

The effectiveness of trauma systems in decreasing injury mortality and morbidity has been well demonstrated. However, little is known about which components contribute to their effectiveness. We aimed to systematically review the evidence of the impact of trauma system components on clinically important injury outcomes.

METHODS:

We searched MEDLINE, EMBASE, Cochrane CENTRAL, and BIOSIS/Web of Knowledge, gray literature and trauma association Web sites to identify studies evaluating the association between at least one trauma system component and injury outcome. We calculated pooled effect estimates using inverse-variance random-effects models. We evaluated quality of evidence using GRADE criteria.

RESULTS:

We screened 15,974 records, retaining 41 studies for qualitative synthesis and 19 for meta-analysis. Two recommended trauma system components were associated with reduced odds of mortality: inclusive design (odds ratio [OR] = 0.72 [0.65-0.80]) and helicopter transport (OR = 0.70 [0.55-0.88]). Pre-Hospital Advanced Trauma Life Support was associated with a significant reduction in hospital days (mean difference [MD] = 5.7 [4.4-7.0]) but a nonsignificant reduction in mortality (OR = 0.78 [0.44-1.39]). Population density of surgeons was associated with a nonsignificant decrease in mortality (MD = 0.58 [-0.22 to 1.39]). Trauma system maturity was associated with a significant reduction in mortality (OR = 0.76 [0.68-0.85]). Quality of evidence was low or very low for mortality and healthcare utilization.

CONCLUSIONS:

This review offers low-quality evidence for the effectiveness of an inclusive design and trauma system maturity and very-low-quality evidence for helicopter transport in reducing injury mortality. Further research should evaluate other recommended components of trauma systems and non-fatal outcomes and explore the impact of system component interactions.

02. Saving lives, limbs and livelihoods: considerations in restructuring a national trauma service.

Mohan HM, et al. Ir J Med Sci. 2015 Sep;184(3):659-66. doi: 10.1007/s11845-014-1234-9.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/25481642>

STUDY HYPOTHESIS:

Level 1 trauma centers reduce mortality and improve functional outcomes in major trauma. Despite this, many countries, including Ireland, do not have officially designated major trauma centers (MTC). This study aimed to examine international trauma systems, and determine how to "best fit" trauma care in a small country (Ireland) to international models.

METHODS:

The literature was reviewed to examine international models of trauma systems. An estimate of Irish trauma burden and distribution was made using data from the Road Safety Authority (RSA) on serious or fatal RTAs. Models of a restructured trauma service were constructed and compared with international best practice.

RESULTS:

Internationally, a major trauma center surrounded by a regional trauma network has emerged as the gold standard in trauma care. In Ireland, there are no nationally coordinated trauma networks and care is provided by 26 acute hospitals with a mean distance to hospital from RTAs of 20.6 km \pm 15.6. Based on our population, Ireland needs two Level 1 MTCs (in the two areas of major population density in the east and south), with robust surrounding trauma networks including Level 2 or 3 trauma centers. With this model, the estimated mean number of cases per Level 1 MTC per year would be 628, with a mean distance to MTC of 80.5 \pm 59.2 km, (maximum distance 263.5 km).

CONCLUSION:

Clearly designated and adequately resourced MTCs with trauma networks are needed to improve trauma outcomes, with concomitant investment in pre-hospital infrastructure.

03. Trauma care and development assistance: opportunities to reduce the burden of injury and strengthen health systems. Stewart B, et al. Bull World Health Organ. 2019 May 1;97(5):371-373. doi: 10.2471/BLT.18.213074.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/31551634>

No abstract

04. Towards resilient health systems: opportunities to align surgical and disaster planning. Pyda J, et al. BMJ Glob Health. 2019 Jun 14;4(3):e001493. doi: 10.1136/bmjgh-2019-001493. eCollection 2019.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/31275620>

Natural disasters significantly contribute to human death and suffering. Moreover, they exacerbate pre-existing health inequalities by imposing an additional burden on the most vulnerable populations. Robust local health systems can greatly mitigate this burden by absorbing the extraordinary patient volume and case complexity immediately after a disaster. This resilience is largely determined by the predisaster local surgical capacity, with trauma, neurosurgical, obstetrical and anaesthesia care of particular importance. Nevertheless, the disaster management and global surgery communities have not coordinated the development of surgical systems in low/middle-income countries (LMIC) with disaster resilience in mind. Herein, we argue that an appropriate peridisaster response requires coordinated surgical and disaster policy, as only local surgical systems can provide adequate disaster care in LMICs. We highlight three opportunities to help guide this policy collaboration. First, the Lancet Commission on Global Surgery and the Sendai Framework for Disaster Risk Reduction set forth independent roadmaps for global surgical care and disaster risk reduction; however, ultimately both advocate for health system strengthening in LMICs. Second, the integration of surgical and disaster planning is necessary. Disaster risk reduction plans could recognise the role of surgical systems in disaster preparedness more explicitly and pre-emptively identify deficiencies in surgical systems. Based on these insights, National Surgical, Obstetric, and Anesthesia Plans, in turn, can better address deficiencies in systems and ensure increased

disaster resilience. Lastly, the recent momentum for national surgical planning in LMICs represents a political window for the integration of surgical policy and disaster risk reduction strategies.

05. Streamlining pre- and intra-hospital care for patients with severe trauma: a white paper from the European Critical Care Foundation. Longrois D, et al. Eur J Trauma Emerg Surg. 2019 Feb;45(1):39-48. doi: 10.1007/s00068-018-1053-1.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/30542747>

PURPOSE:

Major trauma remains a significant cause of morbidity and mortality in the developed and developing world. In 2013, nearly 5 million people worldwide died from their injuries, and almost 1 billion individuals sustained injuries that warranted some type of healthcare, accounting for around 10% of the global burden of disease in general. Behind the statistics, severe trauma takes a major toll on individuals, their families and healthcare systems. Management of the patient with severe trauma requires multiple interventions in a highly time-sensitive context and fragmentation of care, characterised by loss of information and time among disciplines, departments and individuals, both outside the hospital and within it, is frequent. Outcomes may be improved by better streamlining of pre- and intra-hospital care.

METHODS:

We describe the basis for development of a multi-stakeholder consortium by the European Critical Care Foundation working closely with a number of European Scientific Societies to address and overcome problems of fragmentation in the care of patients with severe trauma.

RESULT:

The consortium will develop and introduce an information management system adapted to severe trauma, which will integrate continuous monitoring of vital parameters and point-of-care diagnostics. The key innovation of the project is to harness the power of information technologies and artificial intelligence to provide computer-enhanced clinical evaluation and decision-support to streamline the multiple points at which information and time are potentially lost.

CONCLUSIONS:

The severe trauma management platform thus created could have multiple benefits beyond its immediate use in managing the care of injured patients.

06.A review of the landscape: Challenges and gaps in trauma response to civilian high threat mass casualty incidents. Callaway DW. J Trauma Acute Care Surg. 2018 Jun;84(6S Suppl 1):S21-S27. doi: 10.1097/TA.0000000000001811.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/29370053>

The ultimate goal of the emergency response and trauma system is to reduce potentially preventable death from trauma. Tremendous advances in trauma care emerged from the past 15 years of United States' combat engagements around the globe. Unfortunately, combat and insurgency tactics have also metastasized to the civilian world, resulting in increasingly complex and dynamic acts of intentional mass violence. These high threat active violent incidents (AVIs) pose significant preparedness, response, and clinical care challenges to the civilian healthcare systems. Currently, there are several operational and policy gaps that limit the successful preparedness and response to AVIs and dynamic MCIs in the United States.

07.Global lessons: developing military trauma care and lessons for civilian practice. Woolley T, et al. Br J Anaesth. 2017 Dec 1;119(suppl_1):i135-i142. doi: 10.1093/bja/aex382.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/29161399>

The wars in Iraq and Afghanistan have helped to shape the modern Defence Medical Services. Many lessons were learnt including the need for rapid haemorrhage control, senior decision-making and the evolution of deployed transfusion support. These changes were implemented simultaneously with a coherent, end-to-end medical plan from point of wounding through to rehabilitation. Implementation of the medical plan is harmonious with the NHS trauma pathway, and is key to ensuring effective delivery. Military anaesthetists have a long pre-deployment training pathway starting with a Certificate of Completion of Training (CCT) in anaesthesia and/or critical care, and with an emphasis on military skills related to their specific role. Pre-deployment training includes additional skill training, team training and finally whole hospital collective training. This pathway ensures ongoing and continuing competence on an individual basis, and assurance that hospital management systems and clinical staff can function effectively as a deploying unit.

08. Trauma Systems: Origins, Evolution, and Current Challenges. Pigneri DA, et al. *Surg Clin North Am.* 2017 Oct;97(5):947-959. doi: 10.1016/j.suc.2017.06.011.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28958366>

Trauma is the leading cause of death among patients 46 years or younger, and having a system in place for the care of the injured is of paramount importance to the health of a community. The growth and development of civilian trauma systems has not been an easy process. The concept of regionalized health care that the trauma system models has been emulated by other specialized and time-sensitive areas of medicine, notably stroke and acute cardiac events. Continued process improvement, public education, support and involvement, a sound infrastructure, and integrated technology should remain our focus.

09. Military trauma training at civilian centers: a decade of advancements. Thorson CM, et al. *J Trauma Acute Care Surg.* 2012 Dec;73(6 Suppl 5):S483-9. doi: 10.1097/TA.0b013e31827546fb.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/23192074>

In the late 1990s, a Department of Defense subcommittee screened more than 100 civilian trauma centers according to the number of admissions, percentage of penetrating trauma, and institutional interest in relation to the specific training missions of each of the three service branches. By the end of 2001, the Army started a program at University of Miami/Ryder Trauma Center, the Navy began a similar program at University of Southern California/Los Angeles County Medical Center, and the Air Force initiated three Centers for the Sustainment of Trauma and Readiness Skills (C-STARS) at busy academic medical centers: R. Adams Cowley Shock Trauma Center at the University of Maryland (C-STARS Baltimore), Saint Louis University (C-STARS St. Louis), and The University Hospital/University of Cincinnati (C-STARS Cincinnati). Each center focuses on three key areas, didactic training, state-of-the-art simulation and expeditionary equipment training, as well as actual clinical experience in the acute management of trauma patients. Each is integral to delivering lifesaving combat casualty care in theater. Initially, there were growing pains and the struggle to develop an effective curriculum in a short period. With the foresight of each trauma training center director and a dynamic exchange of information with civilian trauma leaders and frontline war fighters, there has been a continuous evolution and improvement of each center's curriculum. Now, it is clear that the longest military conflict in US history and the first of the 21st century has led to numerous innovations in cutting edge trauma training on a comprehensive array of topics. This report provides an overview of the decade-long evolutionary process in providing the highest-quality medical care for our injured heroes.

10. Spatial methods for evaluating critical care and trauma transport: A scoping review. Vasilyeva K, et al. J Crit Care. 2018 Feb;43:265-270. doi: 10.1016/j.jcrc.2017.08.039.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28950247>

PURPOSE:

The objective of this scoping review is to inform future applications of spatial research regarding transportation of critically ill patients. We hypothesized that this review would reveal gaps and limitations in the current research regarding use of spatial methods for critical care and trauma transport research.

MATERIALS AND METHODS:

Four online databases, Ovid Medline, PubMed, Embase and Scopus, were searched. Studies were selected if they used geospatial methods to analyze a patient transports dataset. 12 studies were included in this review.

RESULTS:

Majority of the studies employed spatial methods only to calculate travel time or distance even though methods and tools for more complex spatial analyses are widely available. Half of the studies were found to focus on hospital bypass, 2 studies focused on transportation (air or ground) mode selection, 2 studies compared predicted versus actual travel times, and 2 studies used spatial modeling to understand spatial variation in travel times.

CONCLUSIONS:

There is a gap between the availability of spatial tools and their usage for analyzing and improving medical transportation. The adoption of geospatially guided transport decisions can meaningfully impact healthcare expenditures, especially in healthcare systems looking to strategically control expenditures with minimum impact on patient outcomes.

11. Preparing Global Trauma Nurses for Leadership Roles in Global Trauma Systems.

Muñiz SA, et al. J Trauma Nurs. 2017 Sep/Oct;24(5):306-311. doi: 10.1097/JTN.0000000000000310.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/28885519>

Trauma leads to 5.7 million annual deaths globally, accounting for 25%-33% of global unintentional deaths and 90% of the global trauma burden in low- and middle-income countries. The Lancet Commission on Global Surgery and the World Health Organization assert that emergent and essential surgical capacity building and trauma system improvement are essential to address the global burden of trauma. In response, the Rutgers Global Surgery program, the School of Nursing and Medicine, and the Robert Wood Johnson University Hospital faculty collaborated in the first Interprofessional Models in Global Injury Care and Education Symposium in June 2016. This 2-week symposium combined lectures, high-fidelity simulation, small group workshops, site visits to Level I trauma centers, and a 1-day training course from the Panamerican Trauma Society. The aim was to introduce global trauma nurses to trauma leadership and trauma system development. After completing the symposium, 10 nurses from China, Colombia, Kenya, Puerto Rico, and Uruguay were surveyed. Overall, 88.8% of participants reported high levels of satisfaction with the program and 100% stated being very satisfied with trauma lectures. Symposia, such as that developed and offered by Rutgers University, prepare nurses to address trauma within system-based care and facilitate trauma nursing leadership in their respective countries.

12. Trauma systems around the world: A systematic overview. Dijkink S, et al.

J Trauma Acute Care Surg. 2017 Nov;83(5):917-925. doi: 10.1097/TA.0000000000001633.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/28715361>

BACKGROUND:

Implementation of trauma care systems has resulted in improved patient outcomes, but international differences obviously remain. Improvement of care can only be established if we recognize and clarify these differences. The aim of the current review is to provide an overview of the recent literature on the state of trauma systems globally.

METHODS:

The literature review over the period 2000 to 2016 was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines. Prehospital care, acute hospital care and quality assurance were classified using the World Health Organization Trauma System Maturity Index in four levels from I (least mature) to IV (most mature).

RESULTS:

The search yielded 93 articles about trauma systems in 32 countries: 23 high-income (HI), 8 middle-income (MI) countries and 1 low-income (LI) country. Trauma-related mortality was highest in the MI and LI countries. Level IV prehospital care with Advanced Life Support was established in 19 HI countries, in contrast to the MI and LI countries where this was only reported in Brazil, China, and Turkey. In 18 HI countries, a Level III/IV hospital-based trauma system was implemented, whereas in nine LI- and MI countries Level I/II trauma systems were seen, mostly lacking dedicated trauma centers and teams. A national trauma registry was implemented in 10 HI countries.

CONCLUSION:

Despite the presence of seemingly sufficient resources and the evidence-based benefits of trauma systems, only nine of the 23 HI countries in our review have a well-defined and documented national trauma system. Although 90% of all lethal traumatic injuries occur in middle and LI countries, according to literature which our study is limited to, only few of these countries hold formal trauma system or trauma registry. Much can be gained concerning trauma systems in these countries, but unfortunately, the economic situation of many countries may render trauma systems not at their top priority list.

13. Development of a Unifying Target and Consensus Indicators for Global Surgical Systems Strengthening: Proposed by the Global Alliance for Surgery, Obstetric, Trauma, and Anaesthesia Care (The G4 Alliance). Haider A, et al. World J Surg. 2017 Oct;41(10):2426-2434.

doi: 10.1007/s00268-017-4028-1.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28508237>

After decades on the margins of primary health care, surgical and anaesthesia care is gaining increasing priority within the global development arena. The 2015 publications of the Disease Control Priorities third edition on Essential Surgery and the Lancet Commission on Global Surgery created a compelling evidenced-based argument for the fundamental role of surgery and anaesthesia within cost-effective health systems strengthening global strategy. The launch of the Global Alliance for Surgical, Obstetric, Trauma, and Anaesthesia Care in 2015 has further coordinated efforts to build priority for surgical care and anaesthesia. These combined efforts culminated in the approval of a World Health Assembly resolution recognizing the role of surgical care and anaesthesia as part of universal health coverage. Momentum gained from these milestones highlights the need to identify consensus goals, targets and indicators to guide policy implementation and track progress at the national level. Through an open consultative process that incorporated input from stakeholders from around the globe, a global target calling for safe surgical and anaesthesia care for 80% of the world by 2030 was proposed. In order to achieve this target, we also propose 15 consensus indicators that build on existing

surgical systems metrics and expand the ability to prioritize surgical systems strengthening around the world.

14. Prehospital notification for major trauma patients requiring emergency hospital transport: A systematic review. Synnot A, et al.; Australia-India Trauma System Collaboration. J Evid Based Med. 2017 Aug;10(3):212-221. doi: 10.1111/jebm.12256.

PDF: No free pdf available

URL: <https://www.ncbi.nlm.nih.gov/pubmed/28467026>

OBJECTIVE:

This systematic review aimed to determine the effect of prehospital notification systems for major trauma patients on overall (<30 days) and early (<24 hours) mortality, hospital reception, and trauma team presence (or equivalent) on arrival, time to critical interventions, and length of hospital stay.

METHODS:

Experimental and observational studies of prehospital notification compared with no notification or another type of notification in major trauma patients requiring emergency transport were included. Risk of bias was assessed using the Cochrane ACROBAT-NRSI tool. A narrative synthesis was conducted and evidence quality rated using the GRADE criteria.

RESULTS:

Three observational studies of 72,423 major trauma patients were included. All were conducted in high-income countries in hospitals with established trauma services, with two studies undertaking retrospective analysis of registry data. Two studies reported overall mortality, one demonstrating a reduction in mortality; (adjusted odds ratio (OR) 0.61, 95% confidence interval (CI) 0.39 to 0.94, 72,073 participants); and the other demonstrating a nonsignificant change (OR 0.61, 95% CI 0.23 to 1.64, 81 participants). The quality of this evidence was rated as very low.

CONCLUSION:

Limited research on the topic constrains conclusive evidence on the effect of prehospital notification on patient-centered outcomes after severe trauma. Composite interventions that combine prehospital notification with effective actions on arrival to hospital such as trauma bay availability, trauma team presence, and early access to definitive management may provide more robust evidence towards benefits of early interventions during trauma reception and resuscitation.

15. Effectiveness of regionalization of trauma care services: a systematic review. Vali Y, et al. Public Health. 2017 May;146:92-107. doi: 10.1016/j.puhe.2016.12.006.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28404479>

OBJECTIVES:

Improving trauma systems in various forms has always been an important aspect of health policy. While several papers have reported the implementation of a structured trauma system of care, research evidence on the effectiveness of such regionalization for improvement in trauma outcome is limited.

STUDY DESIGN:

Systematic review.

METHOD:

Medline, EMBase, EconLit and Health Management Information Consortium were searched, using sensitive search terms, for interventional studies that reported a trauma regionalization system as their intervention, and compared important outcomes such as mortality and preventable deaths. At least two authors assessed eligibility for inclusion and risk of bias, and extracted data from the included studies.

As meta-analysis was not possible for all studies, two controlled before-after studies were included in the meta-analysis, and a narrative analysis was conducted for the other studies.

RESULTS:

After title and abstract sifting, 66 papers were retrieved. After reading the full texts, a total of 24 studies from the USA, UK, Canada, Australia, and the Netherlands were included in this review. In spite of variation in study specifications, most were before-after studies with a high risk of bias. Although a reduction in mortality was shown in most studies, only two studies were eligible for meta-analysis, and the results showed a significant reduction in mortality after implementation of an organized trauma system (odds ratio 0.840, 95% confidence interval 0.756-0.924; $P = 0.00$).

CONCLUSION:

Correlation was found between a regionalized network of trauma care and a reduction in trauma-related mortality, based on studies that did not exclude the effects of other concurrent changes on observed reductions. It is recommended that more studies with robust research designs should be conducted in a more diverse range of countries to assess the effectiveness of regionalization. Despite this limitation, the present findings support the regionalization of trauma care services.

16. Review of military and civilian trauma registries: Does consensus matter? van Dongen TT, et al. *J Trauma Acute Care Surg.* 2017 Mar;82(3):596-604. doi: 10.1097/TA.0000000000001341.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/28225742>

BACKGROUND:

Structural collection of data from combat injuries is important to improve provided care and the outcome of (combat) casualties. Trauma registries are used in civilian and military health care systems for systematic administration of injury data. However, these registries often use different methods of data management, compromising international comparison of trauma systems. The aim of this review is to aid in reaching international (coalition-wide) consensus for compatible data collection methods with uniform definitions, which is needed for transnational research and subsequent improvement of medical support organizations.

METHODS:

In this descriptive review, we analyzed different data sets from trauma systems within the American-European context, and included data variables from civilian and military trauma registries. These data sets were analyzed to identify a core set of variables fundamental to describing the tactical context, epidemiology, injury mechanism, injury severity, key treatment, and outcome.

RESULTS:

A total of 1,672 unique variables, of which 536 military specific, were identified and divided in 11 elemental categories of medical care (patient info, incident info, injury diagnoses, prehospital care, emergency department, imaging, surgical treatment, intensive care, ward, discharge and outcome) and three military-specific categories (forward medical evacuation, prehospital medical treatment facility, and discharge out of theater). A total of 203 key variables were identified and considered fundamental for effective (military) trauma research.

CONCLUSION:

Well-established and reliable trauma registries and databases are fundamental in (military) trauma care. We recommend implementation of a (concurrent) UN/NATO wide registry system with a track and follow-up system to further improve the quality of care and registration of casualties. Further research should focus on real time aids available on the battlefield and direct storage/upload in trauma databases in theater. Ultimately, sound and valid data support medical decision process and evaluation necessary to save lives on the battlefield.

17. Machine learning and new vital signs monitoring in civilian en route care: A systematic review of the literature and future implications for the military. Liu NT, Salinas J. J Trauma Acute Care Surg. 2016 Nov;81(5 Suppl 2 Proceedings of the 2015 Military Health System Research Symposium):S111-S115.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/26670115>

BACKGROUND:

Although air transport medical services are today an integral part of trauma systems in most developed countries, to date, there are no reviews on recent innovations in civilian en route care. The purpose of this systematic review was to identify potential machine learning and new vital signs monitoring technologies in civilian en route care that could help close civilian and military capability gaps in monitoring and the early detection and treatment of various trauma injuries.

METHODS:

MEDLINE, the Cochrane Database of Systematic Reviews, and citation review of relevant primary and review articles were searched for studies involving civilian en route care, air medical transport, and technologies from January 2005 to November 2015. Data were abstracted on study design, population, year, sponsors, innovation category, details of technologies, and outcomes.

RESULTS:

Thirteen observational studies involving civilian medical transport met inclusion criteria. Studies either focused on machine learning and software algorithms (n = 5), new vital signs monitoring (n = 6), or both (n = 2). Innovations involved continuous digital acquisition of physiologic data and parameter extraction. Importantly, all studies (n = 13) demonstrated improved outcomes where applicable and potential use during civilian and military en route care. However, almost all studies required further validation in prospective and/or randomized controlled trials.

CONCLUSION:

Potential machine learning technologies and monitoring of novel vital signs such as heart rate variability and complexity in civilian en route care could help enhance en route care for our nation's war fighters. In a complex global environment, they could potentially fill capability gaps such as monitoring and the early detection and treatment of various trauma injuries. However, the impact of these innovations and technologies will require further validation before widespread acceptance and prehospital use.

LEVEL OF EVIDENCE:

Systematic review, level V.

18. Uptake of the World Health Organization's trauma care guidelines: a systematic review.

LaGrone L, et al. Bull World Health Organ. 2016 Aug 1;94(8):585-598C. doi: 10.2471/BLT.15.162214.

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URL: <https://www.ncbi.nlm.nih.gov/pubmed/27516636>

OBJECTIVE:

To understand the degree to which the trauma care guidelines released by the World Health Organization (WHO) between 2004 and 2009 have been used, and to identify priorities for the future implementation and dissemination of such guidelines.

METHODS:

We conducted a systematic review, across 19 databases, in which the titles of the three sets of guidelines - Guidelines for essential trauma care, Prehospital trauma care systems and Guidelines for trauma quality improvement programmes - were used as the search terms. Results were validated via citation analysis and expert consultation. Two authors independently reviewed each record of the guidelines' implementation.

FINDINGS:

We identified 578 records that provided evidence of dissemination of WHO trauma care guidelines and 101 information sources that together described 140 implementation events. Implementation evidence could be found for 51 countries - 14 (40%) of the 35 low-income countries, 15 (32%) of the 47 lower-middle income, 15 (28%) of the 53 upper-middle-income and 7 (12%) of the 59 high-income. Of the 140 implementations, 63 (45%) could be categorized as needs assessments, 38 (27%) as endorsements by stakeholders, 20 (14%) as incorporations into policy and 19 (14%) as educational interventions.

CONCLUSION:

Although WHO's trauma care guidelines have been widely implemented, no evidence was identified of their implementation in 143 countries. More serial needs assessments for the ongoing monitoring of capacity for trauma care in health systems and more incorporation of the guidelines into both the formal education of health-care providers and health policy are needed.

19. Paediatric trauma systems and their impact on the health outcomes of severely injured children:

An integrative review. McCarthy A, et al. *Injury*. 2016 Mar;47(3):574-85. doi:

10.1016/j.injury.2015.12.028.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26794709>

BACKGROUND:

Injury is a leading cause of death and disability for children. Regionalised trauma systems have improved outcomes for severely injured adults, however the impact of adult orientated trauma systems on the outcomes of severely injured children remains unclear.

AIMS:

This research aims to identify the impact of trauma systems on the health outcomes of children following severe injury.

METHODS:

Integrative review with data sourced from Medline, Embase, CINAHL, Scopus and hand searched references. Abstracts were screened for inclusion/exclusion criteria with fifty-nine articles appraised for quality, analysed and synthesised into 3 main categories.

RESULTS:

The key findings from this review include: (1) a lack of consistency of prehospital and in-hospital triage criteria for severely injured children leading to missed injuries, secondary transfer and poor utilisation of finite resources; (2) severely injured children treated at paediatric trauma centres had improved outcomes when compared to those treated at adult trauma centres, particularly younger children; (3) major causes of delays to secondary transfer are unnecessary imaging and failure to recognise the need for transfer; (4) a lack of functional or long term outcomes measurements identified in the literature.

CONCLUSIONS:

Research designed to identify the best processes of care and describe the impacts of trauma systems on the long-term health outcomes of severely injured children is required. Ideally all phases of care including prehospital, paediatric triage trauma criteria, hospital type and interfacility transfer should be included, focusing on timeliness and appropriateness of care. Outcome measures should include long term functional outcomes in addition to mortality.

20. Lessons learned from the casualties of war: battlefield medicine and its implication for global trauma care. Chatfield-Ball C, et al. *J R Soc Med*. 2015 Mar;108(3):93-100. doi:

10.1177/0141076815570923.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/25792616>

According to the Global Burden of Disease, trauma is now responsible for five million deaths each year. High-income countries have made great strides in reducing trauma-related mortality figures but low-middle-income countries have been left behind with high trauma-related fatality rates, primarily in the younger population. Much of the progress high-income countries have made in managing trauma rests on advances developed in their armed forces. This analysis looks at the recent advances in high-income military trauma systems and the potential transferability of those developments to the civilian health systems particularly in low-middle-income countries. It also evaluates some potential lifesaving trauma management techniques, proven effective in the military, and the barriers preventing these from being implemented in civilian settings.

21. Effectiveness of prehospital trauma triage systems in selecting severely injured patients: Is comparative analysis possible? van Rein EAJ, et al. *Am J Emerg Med.* 2018 Jun;36(6):1060-1069. doi: 10.1016/j.ajem.2018.01.055.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/29395772>

INTRODUCTION:

In an optimal trauma system, prehospital trauma triage ensures transport of the right patient to the right hospital. Incorrect triage results in undertriage and overtriage. The aim of this systematic review is to evaluate and compare prehospital trauma triage system quality worldwide and determine effectiveness in terms of undertriage and overtriage for trauma patients.

METHODS:

A systematic search of Pubmed/MEDLINE, Embase, and Cochrane Library databases was performed, using "trauma", "trauma center," or "trauma system", combined with "triage", "undertriage," or "overtriage", as search terms. All studies describing ground transport and actual destination hospital of patients with and without severe injuries, using prehospital triage, published before November 2017, were eligible for inclusion. To assess the quality of these studies, a critical appraisal tool was developed.

RESULTS:

A total of 33 articles were included. The percentage of undertriage ranged from 1% to 68%; overtriage from 5% to 99%. Older age and increased geographical distance were associated with undertriage. Mortality was lower for severely injured patients transferred to a higher-level trauma center. The majority of the included studies were of poor methodological quality. The studies of good quality showed poor performance of the triage protocol, but additional value of EMS provider judgment in the identification of severely injured patients.

CONCLUSION:

In most of the evaluated trauma systems, a substantial part of the severely injured patients is not transported to the appropriate level trauma center. Future research should come up with new innovative ways to improve the quality of prehospital triage in trauma patients.

22. Does the use of dedicated dispatch criteria by Emergency Medical Services optimise appropriate allocation of advanced care resources in cases of high severity trauma? A systematic review.

McQueen C, et al. *Injury.* 2015 Jul;46(7):1197-206. doi: 10.1016/j.injury.2015.03.033.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/25863418>

BACKGROUND AND OBJECTIVES:

The deployment of Enhanced Care Teams (ECTs) capable of delivering advanced clinical interventions for patients at the scene of incidents is commonplace by Emergency Medical Services in most developed countries. It is unclear whether primary dispatch models for ECT resources are more efficient at targeting deployment to patients with severe trauma than secondary dispatch, following requests from

EMS personnel at scene. The objective of this study was to review the evidence for primary and secondary models in the targeted dispatch of ECT resources to patients with severe traumatic injury.

METHODS:

This review was completed in accordance with a protocol developed using the PRISMA guidelines. We conducted a search of the MEDLINE, EmBase, Web of Knowledge/Science databases and the Cochrane library, focused on subject headings and keywords involving the dispatch of ECT resources by Emergency Medical Services. Design and results of each study were described. Heterogeneity in the design of the included studies precluded the completion of a meta-analysis. A narrative synthesis of the results therefore was performed.

RESULTS:

Five hundred and forty-eight articles were screened, and 16 were included. Only one study compared the performance of the different models of dispatch. A non-statistically significant reduction in the length of time for HEMS resources to reach incident scenes of 4min was found when primary dispatch protocols were utilised compared to requests from EMS personnel at scene. No effect on mortality; severity of injury or proportion of patients admitted to intensive care was observed. The remaining studies examined the processes utilised within current primary dispatch models but did not perform any comparative analysis with existing secondary dispatch models.

CONCLUSIONS:

This review identifies a lack of evidence supporting the role of primary dispatch models in targeting the deployment of Enhanced Care Teams to patients with severe injuries. It is therefore not possible to identify a model for ECT dispatch within pre-hospital systems that optimises resource utilisation. Further studies are required to assess the efficiency of systems utilised at each stage of the process used to dispatch Enhanced Care Team resources to incidents within regionalised pre-hospital trauma systems.

23. Methodology to reliably measure preventable trauma death rate. Drake SA, et al. Trauma Surg Acute Care Open. 2017 May 31;2(1):e000106. doi: 10.1136/tsaco-2017-000106. eCollection 2017.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/29766101>

This article describes a methodology to establish a trauma preventable death rate (PDR) in a densely populated county in the USA. Harris County has >4 million residents, encompasses a geographic area of 1777 square miles and includes the City of Houston, Texas. Although attempts have been made to address a national PDR, these studies had significant methodological flaws. There is no national consensus among varying groups of clinicians for defining preventability or documenting methods by which preventability is determined. Furthermore, although trauma centers routinely evaluate deaths within their hospital for preventability, few centers compare across regions, within the prehospital arena and even fewer have evaluated trauma deaths at non-trauma centers. Comprehensive population-based data on all trauma deaths within a defined region would provide a framework for effective prevention and intervention efforts at the regional and national levels. The authors adapted a military method recently used in Southwest Asia to determine the potential preventability of civilian trauma deaths occurring across a large and diverse population. The project design will allow a data-driven approach to improve services across the entire spectrum of trauma care, from prevention through rehabilitation.

24. Gender Disparities in Trauma Care: How Sex Determines Treatment, Behavior, and Outcome.

Marcolini EG, et al. Anesthesiol Clin. 2019 Mar;37(1):107-117. doi: 10.1016/j.anclin.2018.09.007.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/30711224>

Trauma data bank and other research reveal sex disparities in trauma care. Risk-taking behaviors leading to traumatic injury have been associated with sex, menstrual cycle timing, and cortisol levels. Trauma patient treatment stratified by sex reveals differences in access to services at trauma centers as well as specific treatments, such as venous thromboembolism prophylaxis and massive transfusion component ratios. Trauma patient outcomes, such as in-hospital mortality, multiple organ failure, pneumonia, and sepsis are associated with sex disparities in the general trauma patient. Outcome after general trauma and specifically traumatic brain injury show mixed results with respect to sex disparity.

25. Evidence-Based Care of Geriatric Trauma Patients. Brooks SE, Peetz AB. Surg Clin North Am. 2017 Oct;97(5):1157-1174. doi: 10.1016/j.suc.2017.06.006.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/28958363>

The doubling of the geriatric population over the next 20 years will challenge the existing health care system. Optimal care of geriatric trauma patients will be of paramount importance to the health care discussion in America. These patients warrant special consideration because of altered anatomy, physiology, and the resultant decreased ability to tolerate the stresses imposed by traumatic insult. Despite increased risk for worsened outcomes, nearly half of all geriatric trauma patients will be cared for at nondesignated trauma centers. Effective communication is crucial in determining goals of care and arriving at what patients would consider a meaningful outcome.

26. Trauma surgeon becomes consultant: evaluation of a protocol for management of intermediate-level trauma patients. Fallon SC, et al. J Pediatr Surg. 2014 Jan;49(1):178-82; discussion 182-3. doi: 10.1016/j.jpedsurg.2013.09.052.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/24439605>

PURPOSE:

At our level 1 pediatric trauma center, 9-54 intermediate-level ("level 2") trauma activations are received per month. Previously, the surgery team was required to respond to and assume responsibility for all patients who had "level 2" trauma activations. In 8/2011, we implemented a protocol where the emergency room (ER) physician primarily manages these patients with trauma consultation for surgical evaluation or admission. The purpose of this study was to prospectively evaluate the effects of the new protocol to ensure that patient safety and quality of care were maintained.

METHODS:

We compared outcomes of patients treated PRE-implementation (10/2010-7/2011) and POST-implementation (9/2011-5/2012), including surgeon consultation rate, utilization of imaging and laboratory testing, ER length of stay, admission rate, and missed injuries or readmissions. Statistical analysis included chi-square and Student's t-test.

RESULTS:

We identified 472 patients: 179 in the PRE and 293 in the POST period. The populations had similar baseline clinical characteristics. The surgical consultation rate in the POST period was only 42%, with no missed injuries or readmissions. The ER length of stay did not change. However, in the POST period there were significant decreases in the admission rate (73% to 44%) and the mean number of CT scans (1.4 to 1), radiographs (2.4 to 1.7), and laboratory tests (5.1 to 3.3) ordered in the emergency room (all $p < 0.001$).

CONCLUSION:

Intermediate-level pediatric trauma patients can be efficiently and safely managed by pediatric emergency room physicians, with surgical consultation only as needed. The protocol change improved

resource utilization by decreasing testing and admissions and streamlining resident utilization in an era of reduced duty hours.

27. Impact of telemedicine upon rural trauma care. Duchesne JC, et al. J Trauma. 2008 Jan;64(1):92-7; discussion 97-8. doi: 10.1097/TA.0b013e31815dd4c4.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/18188104>

OBJECTIVES:

Only preliminary reports have evaluated the impact of telemedicine in trauma care. This study will analyze outcomes before (pre-TM) and after (post-TM) implementation of telemedicine in the management of rural trauma patients initially treated at local community hospitals (LCH) before trauma center (TC) transfer.

METHODS:

Seven rural hospital emergency departments in Mississippi were equipped with dual video cameras with remote control capability. All trauma patients initially treated at these LCH with TC consultation were reviewed. Data included patient demographics, Injury Severity Score, institutional volume of patients, mode of transportation, length of stay in LCH, transfer time (TT), mortality, and hospital cost. Patients were grouped in the pre-TM and post-TM periods. Statistical testing was with two-sample Student's t test or chi analysis as appropriate.

RESULTS:

During 5 years, 814 traumatically injured patients (pre-TM, n = 351; post-TM, n = 463) presented to the LCH. In the pre-TM period, 351 patients were transferred directly from the LCH for definitive management to the TC. In the post-TM period, 463 virtual consults were received, of which 51 patients were triaged to the TC. There were no differences in patient age, sex, or mode of transportation. When comparing post-TM with pre-TM era, patients had a higher Injury Severity Score (18 vs. 10, $p < 0.001$); less incidence of blunt trauma 35 (68%) versus 290 (82%), $p < 0.05$; a decrease in length of stay at LCH 1.5 hours versus 47 hours, $p < 0.001$; as well as TT LCH to TC 1.7 hours versus 13 hours, $p < 0.001$. After arrival to TC during the post-TM era patients received more units of packed red blood cells 13 units versus 5 units, $p < 0.001$ but without difference in mortality 4 (7.8%) versus 17 (4.8%), when compared with pre-TM era. Of statistical significance there was a dramatic decrease in hospital cost when comparing post-TM and pre-TM eras (\$1,126,683 vs. \$7,632,624, $p < 0.001$).

CONCLUSION:

Telemedicine significantly improved rural LCH evaluation and management of trauma patients. More severely injured trauma patients were identified and more rapidly transferred to the TC. Total TC hospital costs were significantly decreased without significant changes in TC mortality. Introduction of telemedicine consultation to rural LCH emergency departments expanded LCH trauma capabilities and conserved TC resources, which were directed to more severely injured patients.

MILITARY TRAUMA SYSTEMS

28. Implementing and Preserving the Advances in Combat Casualty Care from Iraq and Afghanistan Throughout the US Military. Butler, Frank, et al. The Journal of Trauma and Acute Care Surgery, August 2015;79(2):321-6.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26218704>

Thirteen years of continuous combat operations have enabled the US Military and its coalition partners to make a number of major advances in casualty care. The coalition nations have developed a superb combat trauma system and achieved unprecedented casualty survival rates. There remains, however, a need to accelerate the translation of new battlefield trauma care information, training, and equipment

to units and individuals deploying in support of combat operations. In addition, the US Military needs to ensure that these advances are sustained during peace intervals and that we continue to build upon our successes as we prepare for future conflicts. This article contains recommendations designed to accomplish those goals. For the proposed actions to benefit all branches of our armed services, the direction will need to come from the Office of the Secretary of Defense in partnership with the Joint Staff. Effective translation of military advances in prehospital trauma care may also increase survival for law enforcement officers wounded in the line of duty and for civilian victims of Active Shooter or terrorist-related mass-casualty incidents.

29. Death on the Battlefield (2001-2011): Implications for the Future of Combat Casualty Care.

Eastridge, Brian, et al. The Journal of Trauma and Acute Care Surgery, December 2010;73(6 Suppl.5):S431-7.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/23192066>

BACKGROUND:

Critical evaluation of all aspects of combat casualty care, including mortality, with a special focus on the incidence and causes of potentially preventable deaths among US combat fatalities, is central to identifying gaps in knowledge, training, equipment, and execution of battlefield trauma care. The impetus to produce this analysis was to develop a comprehensive perspective of battlefield death, concentrating on deaths that occurred in the pre-medical treatment facility (pre-MTF) environment.

METHODS:

The Armed Forces Medical Examiner Service Mortality Surveillance Division was used to identify Operation Iraqi Freedom and Operation Enduring Freedom combat casualties from October 2001 to June 2011 who died from injury in the deployed environment. The autopsy records, perimortem records, photographs on file, and Mortality Trauma Registry of the Armed Forces Medical Examiner Service were used to compile mechanism of injury, cause of injury, medical intervention performed, Abbreviated Injury Scale (AIS) score, and Injury Severity Score (ISS) on all lethal injuries. All data were used by the expert panel for the conduct of the potential for injury survivability assessment of this study.

RESULTS:

For the study interval between October 2001 and June 2011, 4,596 battlefield fatalities were reviewed and analyzed. The stratification of mortality demonstrated that 87.3% of all injury mortality occurred in the pre-MTF environment. Of the pre-MTF deaths, 75.7% (n = 3,040) were classified as nonsurvivable, and 24.3% (n = 976) were deemed potentially survivable (PS). The injury/physiologic focus of PS acute mortality was largely associated with hemorrhage (90.9%). The site of lethal hemorrhage was truncal (67.3%), followed by junctional (19.2%) and peripheral-extremity (13.5%) hemorrhage.

CONCLUSION:

Most battlefield casualties died of their injuries before ever reaching a surgeon. As most pre-MTF deaths are nonsurvivable, mitigation strategies to impact outcomes in this population need to be directed toward injury prevention. To significantly impact the outcome of combat casualties with PS injury, strategies must be developed to mitigate hemorrhage and optimize airway management or reduce the time interval between the battlefield point of injury and surgical intervention.

Understanding battlefield mortality is a vital component of the military trauma system. Emphasis on this analysis should be placed on trauma system optimization, evidence-based improvements in Tactical Combat Casualty Care guidelines, data-driven research, and development to remediate gaps in care and relevant training and equipment enhancements that will increase the survivability of the fighting force.

30. Died of Wounds on the Battlefield: Causation and Implications for Improving Combat Casualty Care. Eastridge, Brian, et al., J Trauma Injury, Infection, and Critical Care, July 2011; 71(Suppl.): S4-8.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/21795876>

BACKGROUND:

Understanding the epidemiology of death after battlefield injury is vital to combat casualty care performance improvement. The current analysis was undertaken to develop a comprehensive perspective of deaths that occurred after casualties reached a medical treatment facility.

METHODS:

Battle injury died of wounds (DOW) deaths that occurred after casualties reached a medical treatment facility from October 2001 to June 2009 were evaluated by reviewing autopsy and other postmortem records at the Office of the Armed Forces Medical Examiners (OAFME). A panel of military trauma experts classified the injuries as nonsurvivable (NS) or potentially survivable (PS), in consultation with an OAFME forensic pathologist. Data including demographics, mechanism of injury, physiologic and laboratory variables, and cause of death were obtained from the Joint Theater Trauma Registry and the OAFME Mortality Trauma Registry.

RESULTS:

DOW casualties (n = 558) accounted for 4.56% of the nonreturn to duty battle injuries over the study period. DOW casualties were classified as NS in 271 (48.6%) cases and PS in 287 (51.4%) cases. Traumatic brain injury was the predominant injury leading to death in 225 of 271 (83%) NS cases, whereas hemorrhage from major trauma was the predominant mechanism of death in 230 of 287 (80%) PS cases. In the hemorrhage mechanism PS cases, the major body region bleeding focus accounting for mortality were torso (48%), extremity (31%), and junctional (neck, axilla, and groin) (21%). Fifty-one percent of DOW casualties presented in extremis with cardiopulmonary resuscitation upon presentation.

CONCLUSIONS:

Hemorrhage is a major mechanism of death in PS combat injuries, underscoring the necessity for initiatives to mitigate bleeding, particularly in the prehospital environment.

31. Impact of Joint Theater Trauma System Initiatives on Battlefield Injury Outcomes. Eastridge, Brian, et al. American Journal of Surgery, December 2009;198(6):852-7.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/19969141>

INTRODUCTION:

The US military forces developed and implemented the Joint Theater Trauma System (JTTS) and Joint Theater Trauma Registry (JTTR) using US civilian trauma system models with the intent of improving outcomes after battlefield injury.

METHODS:

The purpose of this analysis was to elaborate the impact of the JTTS. To quantify these achievements, the JTTR captured mechanism, acute physiology, diagnostic, therapeutic, and outcome data on 23,250 injured patients admitted to deployed US military treatment facilities from July 2003 through July 2008 for analysis. Comparative analysis to civilian trauma systems was done using the National Trauma Data Bank (NTDB).

RESULTS:

In contrast to civilian trauma systems with an 11.1% rate of penetrating injury, 68.3% of battlefield wounds were by penetrating mechanism. In the analyzed cohort, 23.3% of all patients had an Injury Severe Score (ISS) ≥ 16 , which is similar to the civilian rate of 22.4%. In the military injury population, 66% of injuries were combat-related. In addition, in the military injury group, 21.8% had metabolic evidence of shock with a base deficit ≥ 5 , 29.8% of patients required blood transfusion, and 6.4% of the total population of combat casualties required massive transfusion (>10 U red blood cells/24 hours). With this complex and severely injured population of battlefield injuries, the JTTS elements were used to recognize and remedy more than 60 trauma system issues requiring leadership and advocacy, education, research, and alterations in clinical care. Of particular importance to the trauma system was the implementation and tracking of performance improvement indicators and the dissemination of 27 evidence-based clinical practice guidelines (CPGs). In particular, the damage control resuscitation guideline was associated with a decrease in mortality in the massively transfused from 32% pre-CPG to 21% post-CPG. As evidence of the effectiveness of the JTTS, a mortality rate of 5.2% after battlefield hospital admission is comparable to a case fatality rate of 4.3% reported in an age-matched cohort from the NTDB.

CONCLUSIONS:

JTTS initiatives contributed to improved survival after battlefield injury. The JTTS has set the standard of trauma care for the modern battlefield using contemporary systems-based methodologies.

32. Trauma System Development in a Theater of War: Experiences from Operation Iraqi Freedom and Operation Enduring Freedom. Eastridge, Brian, et al. *The Journal of Trauma*, December 2006;61(6):1366-1373.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/17159678>

BACKGROUND:

Medical lessons learned from Vietnam and previous military conflicts led to the development of civilian trauma systems in the United States. Operation Iraqi Freedom represents the first protracted, large-scale, armed conflict since the advent of civilian trauma systems in which to evaluate a similar paradigm on the battlefield.

METHODS:

Collaborative efforts between the joint military forces of the United States initiated development of a theater trauma system in May 2004. Formal implementation of the system occurred in November 2004, the collaborative effort of the three Surgeons General of the U.S. military, the United States Army Institute of Surgical Research, and the American College of Surgeons Committee on Trauma. One trauma surgeon (Trauma System Director) and a team of six trauma nurse coordinators were deployed to theater to evaluate trauma system component issues. Demographic, mechanistic, physiologic, diagnostic, therapeutic, and outcome data were gathered for 4,700 injured patients using the Joint Theater Trauma Registry. Interview and survey methods were utilized to evaluate logistic aspects of the system.

RESULTS:

System implementation identified more than 30 systemic issues requiring policy development, research, education, evaluation of medical resource allocation, and alterations in clinical care. Among the issues were transfer of casualties from point of injury to the most appropriate level of care, trauma clinical practice guidelines, standard forms, prophylactic antibiotic regimens, morbidity/mortality reporting, on-

line medical evacuation regulation, improved data capture for the trauma registry, and implementation of a performance improvement program.

CONCLUSIONS:

The implementation of a theater trauma system demonstrated numerous opportunities to improve the outcome of soldiers wounded on the battlefield.

33. Utilizing a Trauma Systems Approach to Benchmark and Improve Combat Casualty Care. Eastridge, Brian, et al. *The Journal of Trauma*, July 2010;69(Suppl. 1):S5-9.

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/20622620>

BACKGROUND:

Derived from the necessity to improve the outcomes of soldiers injured on the battlefield, the U.S. military forces developed and implemented the Joint Theater Trauma System (JTTS) and the Joint Theater Trauma Registry based on U.S. civilian trauma system models. The purpose of this analysis was to develop battlefield injury outcome benchmark metrics and to evaluate the impact of JTTS-driven performance improvement interventions.

METHODS:

To quantify these achievements, the Joint Theater Trauma Registry captured mechanistic, physiologic, diagnostic, therapeutic, and outcome data on 18,377 injured patients from January 2004 to May 2008 for analysis. Benchmarks were developed and statistically validated by using control chart methodology.

RESULTS:

The majority (66.4%) of battlefield wounds were penetrating mechanism, 23.3% of all patients had an Injury Severity Score of ≥ 16 , 21.8% had a base deficit of ≥ 5 , 30.5% of patients required blood, and 6.8% required massive transfusion (≥ 10 units red blood cell per 24 hours). In this severely injured population from the battlefield, the JTTS developed several pertinent benchmark metrics to assess quality of care associated with postinjury complications and mortality. The implementation of 27 JTTS-developed evidenced-based clinical practice guidelines and an improved information dissemination process was associated with a decrease in aggregate postinjury complications by 54%.

CONCLUSIONS:

Despite the numerous challenges of a global trauma system, the JTTS has set the standard for trauma care on the modern battlefield utilizing evidence-based medicine. The development of injury care benchmarks enhanced the evolution of the combat casualty care performance improvement process within the trauma system.

34. The Effect of a Golden Hour Policy on the Morbidity and Mortality of Combat Casualties. Kowtal, Russ, et al. *JAMA Surgery*, January 2016;151(1):15-24

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/26422778>

IMPORTANCE:

The term golden hour was coined to encourage urgency of trauma care. In 2009, Secretary of Defense Robert M. Gates mandated prehospital helicopter transport of critically injured combat casualties in 60 minutes or less.

OBJECTIVES:

To compare morbidity and mortality outcomes for casualties before vs after the mandate and for those who underwent prehospital helicopter transport in 60 minutes or less vs more than 60 minutes.

DESIGN, SETTING, AND PARTICIPANTS:

A retrospective descriptive analysis of battlefield data examined 21,089 US military casualties that occurred during the Afghanistan conflict from September 11, 2001, to March 31, 2014. Analysis was conducted from September 1, 2014, to January 21, 2015.

MAIN OUTCOMES AND MEASURES:

Data for all casualties were analyzed according to whether they occurred before or after the mandate. Detailed data for those who underwent prehospital helicopter transport were analyzed according to whether they occurred before or after the mandate and whether they occurred in 60 minutes or less vs more than 60 minutes. Casualties with minor wounds were excluded. Mortality and morbidity outcomes and treatment capability-related variables were compared.

RESULTS:

For the total casualty population, the percentage killed in action (16.0% [386 of 2411] vs 9.9% [964 of 9755]; $P < .001$) and the case fatality rate ([CFR] 13.7 [469 of 3429] vs 7.6 [1344 of 17,660]; $P < .001$) were higher before vs after the mandate, while the percentage died of wounds (4.1% [83 of 2025] vs 4.3% [380 of 8791]; $P = .71$) remained unchanged. Decline in CFR after the mandate was associated with an increasing percentage of casualties transported in 60 minutes or less (regression coefficient, -0.141; $P < .001$), with projected vs actual CFR equating to 359 lives saved. Among 4542 casualties (mean injury severity score, 17.3; mortality, 10.1% [457 of 4542]) with detailed data, there was a decrease in median transport time after the mandate (90 min vs 43 min; $P < .001$) and an increase in missions achieving prehospital helicopter transport in 60 minutes or less (24.8% [181 of 731] vs 75.2% [2867 of 3811]; $P < .001$). When adjusted for injury severity score and time period, the percentage killed in action was lower for those critically injured who received a blood transfusion (6.8% [40 of 589] vs 51.0% [249 of 488]; $P < .001$) and were transported in 60 minutes or less (25.7% [205 of 799] vs 30.2% [84 of 278]; $P < .01$), while the percentage died of wounds was lower among those critically injured initially treated by combat support hospitals (9.1% [48 of 530] vs 15.7% [86 of 547]; $P < .01$). Acute morbidity was higher among those critically injured who were transported in 60 minutes or less (36.9% [295 of 799] vs 27.3% [76 of 278]; $P < .01$), those severely and critically injured initially treated at combat support hospitals (severely injured, 51.1% [161 of 315] vs 33.1% [104 of 314]; $P < .001$; and critically injured, 39.8% [211 of 530] vs 29.3% [160 of 547]; $P < .001$), and casualties who received a blood transfusion (50.2% [618 of 1231] vs 3.7% [121 of 3311]; $P < .001$), emphasizing the need for timely advanced treatment.

CONCLUSIONS AND RELEVANCE:

A mandate made in 2009 by Secretary of Defense Gates reduced the time between combat injury and receiving definitive care. Prehospital transport time and treatment capability are important factors for casualty survival on the battlefield.

35. Challenges to Improving Combat Casualty Survival on the Battlefield. Mabry, Robert, et al. Joint Forces Quarterly, 2015;76(1)78-84

PDF: [Read PDF Here](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/24806491>

No abstract

36. The Top 10 Research and Development priorities for battlefield surgical care

Martin, M. et al. 2019 Journal of Trauma and Acute Care Surgery

PDF: [Read PDF HERE](#)

URL: <https://www.ncbi.nlm.nih.gov/pubmed/31246901>

37. Military Trauma Care's Learning Health System: The Importance of Data Driven Decision Making.

Haut ER, Mann NC, Kotwal RS. "Paper commissioned by the National Academies of Sciences, Engineering, and Medicine used to support the report titled "A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths After Injury." 2016. Washington, DC: The National Academies Press.

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URL: <http://nationalacademies.org/hmd/reports/2016/a-national-trauma-care-system-integrating-military-and-civilian-trauma-systems.aspx>