



# Trauma system performance improvement: a review of the literature and recommendations

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**Abstract:** Evaluation of trauma systems has matured over the last few decades. US trauma systems routinely undergo clinical and operational evaluation to ensure optimal care of the injured from the time of injury through reintegration with society. Assessments are carried out with the intent of defining optimal elements and rendering strategic recommendations for the trauma system. The framework for trauma system assessment was adopted from the Trauma Care Systems Planning and Development Act of 1990 which sought to create a consistent process and core functions to ensure a reproducible trauma system from prehospital through rehabilitation. Applying the core function of a public health model to trauma systems provided a process for enhancement of clinical care along the continuum through a framework that accentuates assessment, policy development and assurance while holding to the highest standards in trauma systems performance. A review of contemporary and evidence-based information regarding key strategies and processes related to the evaluation of trauma systems' performance improvement was undertaken. The intent was to identify measurable metrics for trauma systems performance improvement and patient safety. There is a paucity of data related to specific metrics to evaluate the impact of trauma systems on performance and outcomes. The majority of publications focused on quality of trauma registry data, integration of prehospital data, and the core functions of a trauma system but lacked specific quantitative metrics to measure these core functions. The qualitative responses of "met or not met" can be subjective and equivocal. The American College of Surgeons Committee on Trauma (ACS COT) Trauma System Evaluation Committee has also developed qualitative minimal trauma system standards and implemented a comprehensive trauma system evaluation process. Trauma system-wide, risk adjusted, qualitative and quantitative metrics are recommended to address the full spectrum of injury which are essential to the advancement of the care of the injured patient.

**Keywords:** Trauma systems; performance improvement and patient safety; trauma verification; trauma system outcome measures

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## Introduction

Trauma systems have advanced around the world at an exceedingly rapid pace as we experience economic and population growth globally. The Trauma Care Systems

Planning and Development Act of 1990 sought to establish a reliable and reproducible process to ensure a systematic response to natural and manmade disasters from prehospital through rehabilitation (1). This was in response to the

occurrence of traumatic injury around the world but primary in the high-income countries with a rise in the low and middle income countries as of late. Injury in the United States is the number one killer of those aged 45 and younger and the fourth leading cause of death for all ages in the United States (2). As trauma systems evolve, the assessment of the trauma care provided has attempted to keep pace through performance improvement and patient safety efforts. The intent of this article is to review the on-line and print literature for key strategies and processes related to trauma systems performance improvement. This article sought to review the major contributions to the literature regarding a methodical approach to identify measurable metrics for trauma systems performance improvement and patient safety.

Traditional hospital-based trauma performance improvement and patient safety focuses on a trauma centers' evaluation of consistent and contemporary delivery of trauma care from admission through discharge. This evaluation process includes timely identification of events, identification of process aberrations, complications and compliance with clinical practice guidelines. This evaluation process progresses to a data driven analysis of the incidence of the event identified, determination of the contributing factors and classifying its root causes in a peer review process. The outcome must result in the development and implementation of corrective action plans which produce resolution of the event. This all-inclusive process must be supported by ample data from a trauma registry with the ability to construct and visualize the data for presentation and interpretation. The Society of Trauma Nurses' Trauma Outcomes and Performance Improvement Course (TOPIC©) outlines the cycle of trauma performance improvement and patient safety with comprehensive instruction of how to ensure authority in trauma performance improvement, methods to evaluate care, means to identify events and compliance, and implementation of metric driven approaches to evaluate the delivery of trauma care (3). Many trauma centers struggle with implementation of an effective and concurrent trauma performance improvement program which is the number one criterion deficiency for trauma centers that fail their trauma center verification or designation. Most trauma centers struggle with developing and implementing an effective trauma performance improvement program that focuses on identification and resolution of opportunities for improvement. The American College of Surgeons (ACS) How to Manual 2002 cited that most errors are related to a

lack of an effective trauma system (4).

### **Trauma system performance improvement current status**

A trauma system may represent a region, state, province, country or more global military operations. In order to best evaluate trauma system performance improvement, there must be an understanding of how trauma system development has occurred. This is dependent on the socioeconomic development of that region of the world. Trauma systems development in the United States will differ greatly than in countries such as China. The US has benefited from trauma system development since the end of World War II and has evolved to a robust trauma center verification process and a state trauma system evaluation process by the American College of Surgeons Committee on Trauma (ACS COT). Whereas China, with the largest population in the world, did not start to develop their trauma system until the 1970s. They continue to struggle with consistently obtaining valid and reliable data for the vast population. The lack of a formal trauma center verification process has resulted in severely injured patients being taken to the nearest hospital which may not be resourced to provide care to this population (5). China has experienced a growth in population and with that comes an increase in severe injury. China would benefit greatly by developing inclusive trauma centers, training medical professionals, integrate Emergency Medical Service (EMS) and trauma centers and create a model trauma system.

The Model Trauma System Planning and Evaluation 2006 published by the U.S. Department of Health and Human Services defines the essential infrastructure for management of an effective trauma system of care. Using a public health model, they define three core functions and ten essential services which serve as the infrastructure for developing an inclusive trauma system. This includes authority and oversight, strong leadership, information technology to monitor the process and outcome of care and must be supported financially.

There is a paucity of publications related to validated trauma system metrics or benchmarks which accentuates the need for a societal outlay in a public health approach to defining ideal trauma system processes with expected outcomes. This process begins with collection of effective, well defined data and an epidemiologic approach to assess injury patterns, access to qualified trauma centers and preparation for major natural or man-made disaster events. The trauma system performance improvement

process must be integrated both vertically and horizontally to include integration across systems from prevention through reintegration into society. This integration should be evidence based and include performance improvement professionals, healthcare leaders and providers (6). Healthcare systems must standardize trauma performance improvement and patient safety and be in balance with the essentials of the population they serve.

A key element in trauma systems development is the implementation of prehospital response to injury victims which includes evaluation and assessment of care in the moments prior to arrival at a trauma center. Evaluation of civilian deaths that occur prior to arrival at the trauma center has not been well studied. A scarcity of data to evaluate on scene care has slowed the evolution of the trauma system along the continuum (7).

Implementation of an effective trauma performance improvement program has long been a challenging undertaking and is the primary reason that trauma centers fail their trauma center verification. Quality trauma data serves as the foundation of trauma center and trauma system performance improvement. Trauma registry function is multifaceted and built on a foundation of valid and reliable data. Regional and system databases rely on resources to staff the registry, lean work processes and information technology that are well integrated in order to communicate patient information along the continuum of trauma care. Auerbach *et al.* found that trauma registry workgroups within a trauma center and across a network of trauma centers improved trauma registry processes, improved concurrency of data abstraction and reporting, and improved accuracy (8). Classification and measurement of performance improvement data in trauma registries is often unpredictable. O'Reilly *et al.* searched the literature for assessment of the trauma registry role in performance improvement and found it to be very inconsistent, ambiguous and with no standardization. They recommended the data quality must be homogeneous in order to produce useful evaluation of care (9). In 1988 West *et al.* published the findings of the American College of Surgeon Committee on Trauma assessment of regional trauma systems in the US. They identified 8 essential components: authority, formal verification/designation process, trauma registry, prehospital care, performance improvement, research, economic impact and management structure. They found only two states that had all the components, 19 had the majority of the components and that 29 states lacked a trauma center verification or

designation process (10). In follow up to that study Bazzoli *et al.* found that 5 years later there were a total of 5 trauma systems that had all components. There continues to be a lack of EMS triage and bypass criteria as well as an effective inter-hospital transfer process (11).

The ACS COT has developed standards of trauma center care. Subsequent reports have shown that these criterion and verification saves lives. The *New England Journal of Medicine* found in 20,016 that after adjusting for differences in injury severity, patients treated at a verified trauma center had a 25 percent less risk of mortality than in non-trauma center. They stressed the importance of regionalization of trauma care (12). The ACS COT's Trauma Systems Evaluation & Planning Committee has developed a minimum trauma system standard. This list of 11 minimum standards includes trauma standards that address the continuum of trauma care from prevention through return to society. A statutory authority/lead agency should be responsible for compliance; a stakeholders advisory committee should be developed; a trauma systems plan should be implemented; a designation process should be approved; an infrastructure that supports abstraction and validation of data is needed; injury surveillance, EMS and trauma center data should be collected; performance improvement processes and research with a focus on confidentiality should be effected; data acquisition and validation is fundamental to evaluation of care utilizing quality metrics; mass casualty response plans must be multidisciplinary and be verified regularly; integration should exist between civilian and military medical treatment facilities (13).

The National Academies of Science, Engineering and Medicine [formerly the Institute of Medicine (IOM)] convened a panel of subject matter experts to define a "National Trauma Care" system. This system would outline the integration of military and civilian trauma care systems to achieve Zero Preventable Deaths After Injury. The committee's charge was fourfold: to identify key components of a learning health system to optimize care in military and civilian settings; to characterize the Joint Trauma System role as a continuous learning and evidence-based process improvement model; to ensure that advances in trauma care are sustained and built on; and to consider strategies necessary to more effectively translate lessons learned. This requires a continuously learning trauma system with coordinated performance improvement and evidence based best trauma practices. The committee found that the civilian and military collection and integration of trauma data was incomplete and relied on manual

abstraction which was impeded by multiple barriers and lacked transparency. Their recommendation was for all military and civilian trauma systems to participate in trauma performance improvement processes and expand Trauma Quality Improvement Program (TQIP) to point of injury through long term outcomes (14). Yet Eastridge *et al.* found that implementation of a military trauma system, the Joint Theater Trauma System (JTTS) decreased morbidity and mortality in comparison to a civilian cohort. The JTTS was able to successfully improve survival after battlefield injury through military system wide education, tracking morbidity factors, and compliance with 27 military specific clinical practice guidelines such as burn resuscitation, damage control surgery and massive transfusion protocol (15). The goal of improving prehospital trauma care and zero preventable deaths was described successfully by Kotwal *et al.* who examined battle casualties from 8.5 years of wars in Iraq and Afghanistan. They found that a trauma system who trains all personnel in combat casualty care with a continuous feedback system results in a reduction of preventable deaths (16).

There is a lack of trauma system performance improvement metrics at the point of injury. van Rein *et al.* reviewed 33 articles looking at prehospital over and under triage and found the majority of studies were lacking in appropriate methodology. The review found that prehospital trauma triage systems varied with 1% to 68% under-triage. The triage process was found to be ineffective, in that a substantial number of severely injured patients were not transported to the correct level of trauma center (17).

A consensus meeting was held with international subject matter experts with the intent of developing a global set of measurable metrics to evaluate trauma care. Bobrovitz *et al.* described certain themes which focused on evidence-based medicine, training and expertise and patient outcomes which would shape trauma systems performance metrics for the future. The panel of experts used the RAND/UCLA appropriateness method to define quality indicators in trauma care and proposed defining only broadly implemented (18). Claridge *et al.* reviewed regional data from the Northern Ohio Trauma System and found that implementation of a regional trauma system decreased mortality within two years of implementation. Contributing factors were regionalized protocols, collaboration and consolidation (19). Deasy *et al.* concurrently collected data for 8 years which included 1,634 pediatric trauma patients. They identified that the establishment of an integrated inclusive regionalized pediatric trauma system was associated with lower risk adjusted mortality (20).

The World Health Organization (WHO) estimates that 2 million of the 5.8 million people who die from injury each year could have survived if there were advances in trauma care competencies, especially in low-income and middle-income countries. Improvements in trauma care could be achieved by implementing trauma performance improvement programs which resulted in lowering of morbidity and mortality. The WHO has developed guidelines for trauma quality improvement programs. This course was designed as a basic how-to manual to start your trauma center performance improvement program and to address the performance improvement events that occur within their trauma systems (21).

## Recommendations

Regional/state trauma system must incorporate the continuum of this public health issue through public education, targeted injury prevention, prehospital care, acute hospital/trauma center care, rehabilitation, and return to society. The system should address the needs of special populations and injury mechanisms. An effective trauma system that impacts patient outcomes must include a comprehensive and concurrent performance improvement program with well-defined measurable metrics. The following metrics are specific, measurable, achievable, relevant and time-bound and are recommended for developing trauma systems. A compliance threshold must be established for each of the metrics. These metrics must be defined across the continuum of care and tracked with consistent abstraction and data analysis (*Table 1*).

## Conclusions

Trauma centers have long referred to the Resources for Optimal Care of the Injured Patient document for trauma center standards of care (currently the Orange Book) as well as a prescriptive trauma center verification process which includes a risk adjusted TQIP. The ACS COT has also developed trauma system standards of care and implemented a comprehensive trauma system evaluation process. Winchell *et al.* described the work that the Trauma Systems Committee has done in proposing minimum trauma system elements which are qualitative in nature (met/not met) but lack quantitative metric specificity (23). It is now time to develop risk adjusted, measurable outcomes for regional and state trauma systems: a Trauma System Quality Improvement Program (TSQIP). Development of a state or regional trauma system is essential to advance the care of

**Table 1** Trauma system performance improvement metrics

Metrics	Domain
Qualitative metrics	
Multidisciplinary and multiagency stakeholder group review of cases, PI events, regulatory issues, policies, procedures, and standards of care	Lead agency
Documents and measurable trauma systems strategic planning	Lead agency
Effective population-based injury prevention programs	Lead agency and trauma center
Integration of state/region emergency preparedness and statewide trauma system	Lead agency and EMS
Integration of EMS and trauma center information systems	EMS and trauma center
Quantitative metrics	
Prehospital mortality	EMS
Prehospital preventable deaths	EMS
EMS trauma destination compliance	EMS
Prehospital under triage rates (based upon EMS destination protocols)	EMS
Prehospital treatment of recognized hypotension or hypoxia in traumatic brain injury	EMS
Two or more transfers before definitive care	EMS
Timeliness of hemorrhage control in prehospital setting (direct pressure, hemostatic dressing, tourniquet, pelvic binder, junctional tourniquet)	EMS
Timeliness of decision to transfer included in ATLS "disability" assessment (22)	Referring facility
Timeliness of transfer from non-trauma center to trauma center	Referring facility
Timeliness of transfer from lower level trauma center to higher level trauma center	Referring facility
Timeliness of emergent neurosurgical intervention from arrival to intervention: 30 minutes	Trauma center
Timeliness of emergent orthopedic intervention from arrival to intervention: 30 minutes	Trauma center
Timeliness of emergent interventional radiology intervention from arrival to intervention: 30 minutes	Trauma center
Timeliness of correction of the indicators of shock: base deficit, lactate, hypotension and incidence of multiple organ failure	Trauma center
Timeliness of anticoagulant reversal from arrival to administration: 1 hour	EMS, referring facility, trauma center
Timeliness of blood administration across the continuum (defined in each domain)	EMS, Referring facility, trauma center
Timeliness of antibiotics administration across the continuum	EMS, Referring facility, trauma center
Trauma center risk adjusted mortality rate	Trauma center
Trauma center preventable deaths	Trauma center
Trauma center NTDB risk adjusted complications/morbidities	Trauma center
Follow up/discharge outcomes information provided to EMS and referring facilities	Trauma center
Functional status at hospital discharge (documentation)	Trauma center
30-day survival rate	Post discharge
30-day readmission rate	Post discharge
Functional status at rehabilitation discharge	Rehabilitation

PI, performance improvement; EMS, Emergency Medical Service; ATLS, Advanced Trauma Life Support for Doctors; NTDB, National Trauma Data Bank.

injured patients.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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