Trauma Surge Index: Advancing the Measurement of Trauma Surges and Their Influence on Mortality

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BACKGROUND: Increases in trauma patient volume and acuity, such as during mass casualty events, can overwhelm hospitals, potentially worsening patient outcomes. Due to methodological limitations, the effect of trauma surges on clinical outcomes remains unclear, so hospitals have not prepared for such events in an evidence-based manner. The objective of this study was to develop a new measure of hospital capacity strain corresponding to trauma admissions and to examine the relationship between trauma surges and inpatient mortality.

STUDY DESIGN: Using trauma registry data from hospitals across the United States and Canada (2010 to 2011), we developed the Trauma Surge Index (TSI), a measure of capacity strain that controls for variation in hospital admission volume and patient acuity. Using the TSI and an established definition of mass casualty events, we quantified hospital surges and entered each measure as an exposure variable in separate risk-adjusted mortality models.

RESULTS: Using the TSI method, we observed that patients admitted during high-surge periods display significantly increased mortality compared with patients admitted during low-surge periods (odds ratio [OR] = 2.05; 95% CI, 1.36−3.10), and patients with firearms injuries were particularly at risk (OR = 7.29; 95% CI, 2.13−24.91). Using mass casualty event criteria, we found no difference between the mortality of patients admitted during trauma surges and nonsurge periods (OR = 0.94; 95% CI, 0.88−1.01).

CONCLUSIONS: We demonstrate the TSI, which is a novel method that identified periods of high-capacity strain in hospitals associated with increased trauma patient mortality. Our newly developed TSI method can be implemented by hospitals and trauma systems to examine periods of high-capacity strain retrospectively, identify specific resources that might have been needed, and better direct future investments in an evidence-based manner. (J Am Coll Surg 2015; 221:729−738. © 2015 by the American College of Surgeons)

Traumatic injury is among the largest contributors to morbidity and mortality worldwide.[1] Although considerable advances have occurred in the treatment of traumatic injury, the potential impact of hospital conditions on its delivery remains poorly understood. Previous studies suggest that trauma surges lead to poor clinical outcomes when

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Abbreviations and Acronyms
ISS = Injury Severity Score
MCE = mass casualty event
OR = odds ratio
ROC = receiver operating characteristic
TQIP = Trauma Quality Improvement Program
TSI = Trauma Surge Index
TSL = Trauma Surge Load

characterized by rapid increases in trauma patient volume and acuity.[2-6] During these surges, the health care needs of patients exceed available resources, thereby disrupting hospital operations and causing them to falter.[7] As projected shortages in the health care workforce constrain the health care system and the projected incidence of traumatic injury increases, overwhelming events are likely to become increasingly prevalent in the United States.[8-14] For health care systems outside of the United States, the threat of becoming overwhelmed by unexpected events is even greater due to the limited available resources.

To date, efforts to prepare for unexpected trauma surges have relied primarily on expert opinion rather than objective data.[7,15,16] For example, policy directives that address surge capacity have focused on isolated hospital factors, such as bed availability, despite the fact that not all hospitals suffer from a shortage of hospital beds. Meanwhile, individual hospitals remain poorly equipped to identify historic periods of high-capacity strain and assess the specific resources needed during those periods.[17] In addition, the needs of individual hospitals have not been well-differentiated from the specific needs of trauma systems. Understanding these factors is essential to distribute patients and resources effectively among multiple hospitals when faced with capacity strain. These knowledge gaps largely exist due to historic methods used to identify and measure hospital capacity strain.

The most extensively studied form of trauma surge is mass casualty events (MCEs), and those events have been identified using a minimum surge threshold, such as 10 trauma patient admissions in a 24-hour period.[3,6,18] However, this definition produces only a crude estimate of capacity strain, without accounting for patient injury severity or variation in hospital capacity, principle determinants of health care resource demand. Therefore, MCE does not specifically address whether low-volume and high-volume trauma centers display differences in their thresholds that define when these centers become overwhelmed.

In this study, we demonstrate a new measure of trauma surge that accounts for patient injury severity based on data from the Trauma Quality Improvement Program of the American College of Surgeons. Our approach is applicable to a broad range of hospitals by controlling for the annual volume and acuity of trauma patients treated in each specific hospital. To compare our measure and the established MCE surge measure, we further examined the relationship between trauma surges and inpatient trauma mortality in a broad range of hospitals across the United States and Canada. Notably, we observe differences in the ability of each respective measure to detect clinically relevant trauma capacity strain.

METHODS

Study design

We conducted a retrospective cohort study of trauma patients treated at hospitals participating in the Trauma Quality Improvement Program (TQIP). Primary exposure variables included two different measures of trauma patient capacity strain—Mass Casualty Event criteria and the Trauma Surge Index—and the primary outcome of interest was inpatient trauma mortality.

Data source

The cohort consisted of patients meeting inclusion criteria for the American College of Surgeons TQIP.[19] The TQIP is a consortium of trauma centers across the United States and Canada that collects clinical trauma registry data using standardized definitions and provides risk-adjusted performance improvement reports to its participants. Trained trauma registry personnel collect prehospital, emergency department, operative, intensive care, and hospital data for all adult trauma patients with an Abbreviated Injury Scale Score of $\geq$3 in at least one body region resulting in an Injury Severity Score (ISS) $\geq$9. Regular audits ensure data validity for the program's clinical registry. In addition to standard clinical information, the dataset for this study included date and time of hospital admission as well as discharge. These data were provided in an encrypted fashion through collaboration with the American College of Surgeons to ensure compliance with the Health Insurance Portability and Accountability Act. The TQIP analytic methods have been described in detail previously.[19]

Study population

We included patients discharged from a TQIP participating center between January 2010 and December 2011. We excluded patients who lacked records for date and time of admission to the emergency department. We also excluded patients who presented to emergency departments without signs of life, defined as an initial systolic blood pressure of 0 mmHg, heart rate of 0 beats/min, and Glasgow Coma Scale motor score of 1.[20]