Health Care Reform at Trauma Centers—Mortality, Complications, and Length of Stay

Shahid Shafi, MD, MPH, Sunni Barnes, PhD, David Nicewander, PhD, David Ballard, MD, PhD, MSPH, Avery B. Nathens, MD, PhD, Angela M. Ingraham, MD, Mark Hemmila, MD, Sandra Goble, MS, Melanie Neal, MS, Michael Pasquale, MD, John J. Fildes, MD, and Larry M. Gentilello, MD

Objective: The Trauma Quality Improvement Program has demonstrated existence of significant variations in risk-adjusted mortality across trauma centers. However, it is unknown whether centers with lower mortality rates also have reduced length of stay (LOS), with associated cost savings. We hypothesized that LOS is not primarily determined by unmodifiable factors, such as age and injury severity, but is primarily dependent on the development of potentially preventable complications.

Methods: The National Trauma Data Bank (2002–2006) was used to include patients (older than 16 years) with at least one severe injury (Abbreviated Injury Scale score ≥ 3) from Level I and II trauma centers (217,610 patients, 151 centers). A previously validated risk-adjustment algorithm was used to calculate observed-to-expected mortality ratios for each center. Poisson regression was used to determine the relationship between LOS, observed-to-expected mortality ratios, and complications while controlling for confounding factors, such as age, gender, mechanism, insurance status, comorbidities, and injuries and their severity.

Results: Large variations in LOS (median, 4–8 days) were observed across trauma centers. There was no relationship between mortality and LOS. The most important predictor of LOS was complications, which were associated with a 62% increase. Injury severity score, shock, gunshot wounds, brain injuries, intensive care unit admission, and comorbidities were less important predictors of LOS.

Conclusion: Quality improvement programs focusing on mortality alone may not be associated with reduced LOS. Hence, the Trauma Quality Improvement Program should also focus on processes of care that reduce complications, thereby shortening LOS, which may lead to significant cost savings at trauma centers.

Key Words: Trauma quality improvement; Trauma core measures; Health care reform

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From the Institute for Health Care Research and Improvement (S.S., S.B., D.N., D.B.), Baylor Health Care System, Dallas, Texas; Trauma Quality Improvement Group (A.B.N., A.M.I., M.H., S.G., M.N., M.P., J.J.F.), American College of Surgeons, Chicago, Illinois; University of Toronto (A.B.N.), Toronto, Ontario, Canada; American College of Surgeons (A.M.I., S.G., M.N.), Chicago, Illinois; University of Michigan (M.H.), Ann Arbor, Michigan; Lehigh Valley Hospital (M.P.), Allentown, Pennsylvania; University of Nevada (J.J.F.), Las Vegas, Nevada; and University of Texas Southwestern (L.M.G.), Dallas, Texas.
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Address for Reprints: Shahid Shafi, MD, MPH, Institute for Health Care Research and Improvement, Baylor Health Care System, 1600 West College Street, Suite LL 10, Grapevine, TX 76051; email: shahid.shafi@baylorhealth.edu.

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Health care costs in the United States are the highest in the world and are projected to consume almost 20% of the Gross National Product in the near future.[1] However, this massive spending has not been associated with improvements in patient outcomes when compared with other developed countries. According to the Dartmouth Institute, higher health care spending is associated with worse outcomes for certain diseases.[2]

Performance improvement efforts in trauma have typically focused on reducing in-hospital mortality. Over the past three decades, mortality rates associated with trauma have been reduced to $<5\%$.[3] However, we have recently demonstrated that there are significant variations in risk-adjusted mortality rates at designated trauma centers.[4,5] The Trauma Quality Improvement Program (TQIP) of the American College of Surgeons primarily focuses on reducing mortality rates across centers.[6] This approach has been used successfully by the National Surgical Quality Improvement Program to reduce surgical mortality rates.[7] However, it is not known whether improvements in mortality rates are associated with reduced costs of care.

Length of stay (LOS) has been used as a marker for quality of care, costs, and resource utilization.[8] Diagnosis-related group-based prospective payment systems reward hospitals with shorter LOS for management of several diseases.[9] However, the relationship between risk-adjusted mortality rates and LOS at trauma centers has not been elucidated. A common perception in the trauma community is that patients with the shortest LOS are the ones who die early. In other words, the LOS of seriously injured patients is likely to be much longer if they are salvaged by aggressive resuscitation and timely interventions. Thus, LOS at trauma centers that have lower mortality rates may actually be higher than at centers with higher mortality rates. If this is true, TQIP efforts to reduce mortality rates at trauma centers will lead to longer LOS and higher costs.

On the other hand, it is also possible that trauma centers with low mortality rates also have shorter LOS as a result of institution-wide commitments to quality and efficiency with streamlined processes of care. Or, LOS may primarily be determined by intrinsic patient characteristics and injury severity factors that are not subject to quality improvements. The primary study hypothesis was that LOS is not primarily determined by unmodifiable factors, such as age and the magnitude of injury, but by the development of complications that

are potentially avoidable. A secondary hypothesis was that better performing trauma centers with lower risk-adjusted mortality rates would have a shorter LOS.

METHODS

The National Trauma Data Bank (NTDB; 2002–2006, version 7.2) was used to identify adult patients (older than 16 years) with at least one moderate to severe injury (Abbreviated Injury Scale score ≥3) who were admitted to a Level I or II trauma center. All patients who met these criteria and were injured by a blunt mechanism were included. Those injured by a penetrating mechanism were included if the injury was to the neck, thorax, or abdomen. Patients injured by the following mechanisms were excluded: burns, poisoning, drowning, hanging, submersion, asphyxiation, gunshot wounds to the head, those deemed dead on arrival in the emergency department (ED), and those who arrived to the ED ≥1 day after injury. Centers with <50 patients meeting the inclusion criteria were excluded as the sample size would be too small to obtain precise estimates. The final study population consisted of 217,610 patients from 151 centers.

Mean and median LOS were calculated for each center. Observed-to-expected (O/E) mortality ratios for each center with 95% confidence intervals were calculated using a previously validated risk-adjustment algorithm used by TQIP.[6] We explored the relationship between LOS and O/E mortality ratios at the facility level using two different approaches: Pearson correlation coefficient and univariate Poisson regression with LOS as the dependent variable and O/E ratio as the predictor. Next, to identify independent predictors of LOS, patient-level data were used, clustered by facility. Multivariate Poisson regression using the GENMOD procedure in SAS was used, with LOS as the dependent variable, and demographic and clinical factors that may influence LOS explored as predictors. These included age; gender; mechanism of injury; insurance status; transfer status; presence of injuries to the head, chest, or abdomen; injury severity using the injury severity score (ISS); Glasgow Coma Scale (GCS) motor component; systolic blood pressure on arrival to the ED; intensive care unit stay; in-hospital mortality; presence of comorbidities; and occurrence of complications.

Systolic blood pressure was categorized into three groups: 0 versus 1–90 versus >90. ISS was categorized into two groups: ≤24 versus >24. GCS motor score was categorized into three groups: 1 versus 2–5 versus 6. The final model was used to calculate expected LOS for each center. As trauma registries participating in the NTDB are known to underreport complications, International Classification of Diseases—9th Revision diagnosis codes for specific complications as defined by the National Trauma Data Standards[10] were also used to enhance capture. To estimate the potential impact of specific complications on LOS after adjusting for other patient and injury characteristics, complications were inserted in the final model one at a time.

All analyses were conducted using SAS version 9.2 (SAS Institute, Cary, NC). Test statistics with an associated p value of ≤0.05 were considered statistically significant. Measured characteristics were summarized by calculating means, medians, and standard deviations for continuous variables and proportions for categorical variables.

RESULTS

Significant variations in risk-adjusted mortality rates were noted across the centers as demonstrated in our previous studies (Fig. 1). Forty-one centers had lower than expected mortality, 23 centers had higher than expected mortality, and mortality at the remaining 87 centers was as expected. Large variations in LOS were also noted, with the median ranging from 4 days to 8 days (Fig. 2). The median observed and expected LOS at high, low, and average mortality centers was similar (Table 1).

There was a very low correlation between O/E mortality ratios and observed LOS (Pearson $r = 0.14$; $p = 0.09$), as well as expected LOS ($r = 0.05$; $p = 0.6$). In univariate models, there was no association between O/E ratios mortality ratios and observed LOS ($p = 0.09$), or expected LOS ($p = 0.6$). There

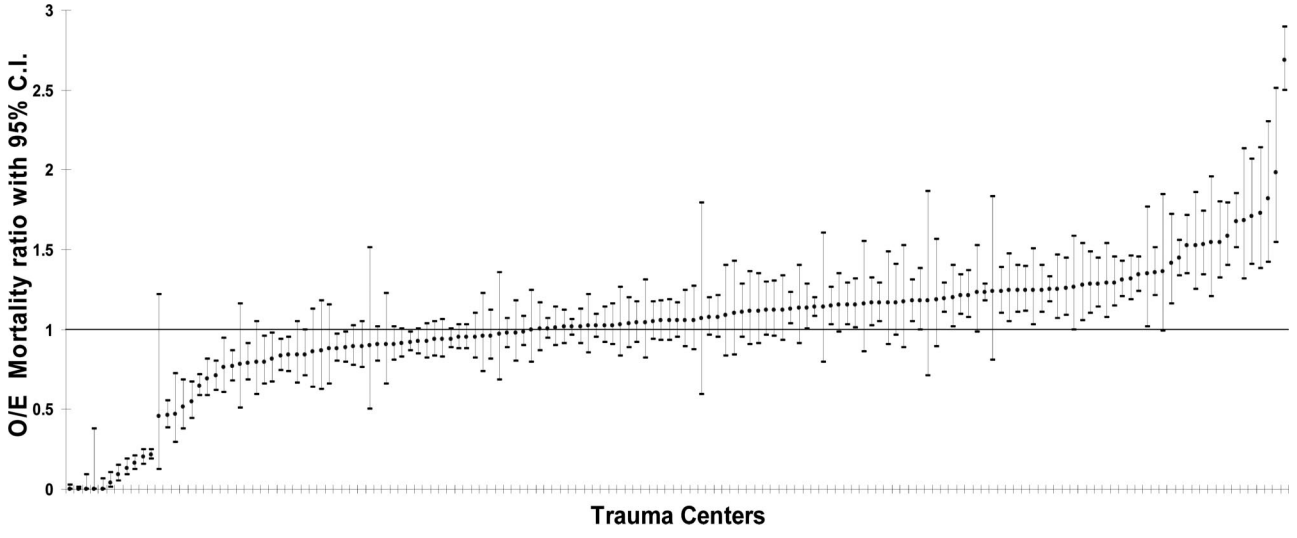

Figure 1. O/E mortality ratios.

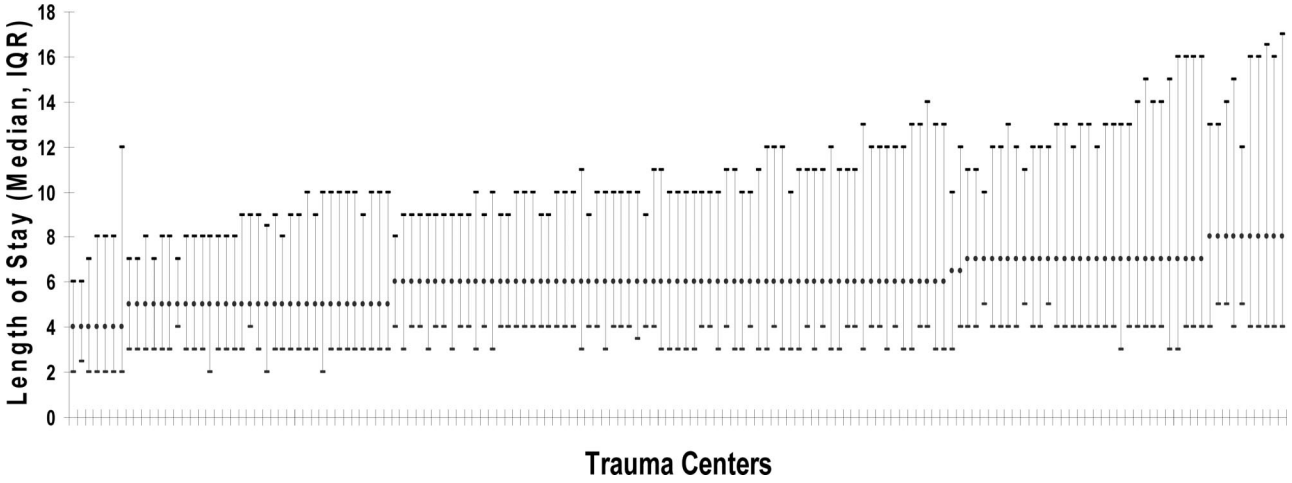

Figure 2. LOS (median, interquartile range [IQR]).

TABLE 1. Length of Stay at High, Average, and Low Mortality Centers

		Length of Stay		
	N	Mean, observed (d)	Median	Mean, Expected (d)
High mortality centers	23	9.6	9.2	9.8
Average mortality centers	87	8.9	8.7	9.5
Low mortality centers	41	10.5	10.0	9.9

was no association between observed LOS and O/E mortality ratio in multivariate analysis ($p = 0.9$). The same was true for a subgroup of patients who survived >24 hours.

Independent predictors of prolonged LOS included gunshot wound mechanism, ISS, admission to the intensive care unit, preinjury comorbidities, and the occurrence of complications (Fig. 3). There was no statistically significant association between LOS and age, gender, transfer status or insurance status. Patients presenting without a blood pressure and those without head injuries (normal GCS motor score) had a significantly shorter LOS (Fig. 3). Overall, the most potent predictor of LOS was the development of complications, which was associated with a 62% increase. Among the complications, infections, pulmonary embolism, cardiovascular, and respiratory complications were the most important determinants of LOS (Fig. 4). Although there may be an interaction between injury severity and occurrence of complications, the analysis showed that injury severity and complications were independently associated with prolonging LOS.

DISCUSSION

The purpose of this study was to determine the relationship between risk adjusted mortality rates and LOS at

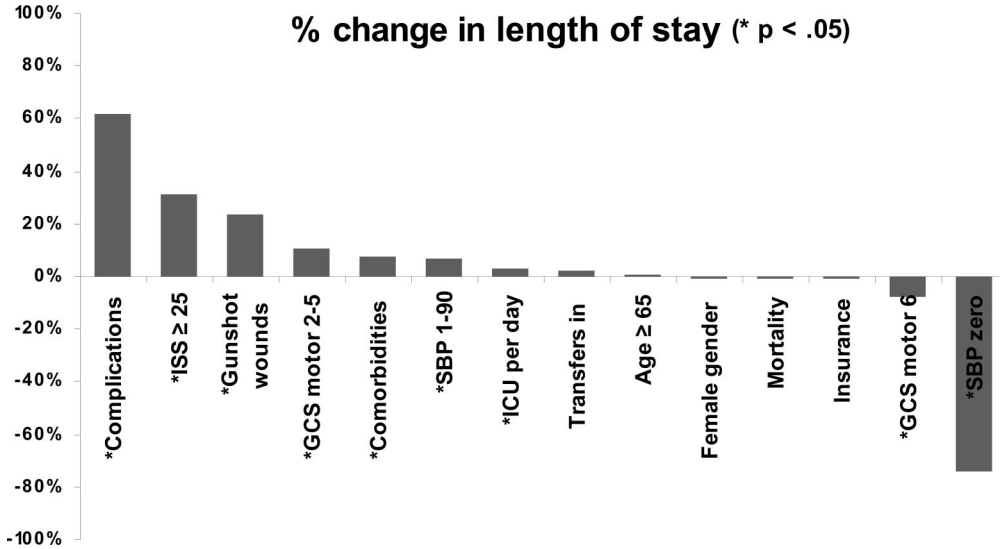

Figure 3. Predictors of length of stay. SBP, systolic blood pressure; ISS, Injury Severity Score; GCS, Glasgow Coma Scale; ICU, intensive care unit.

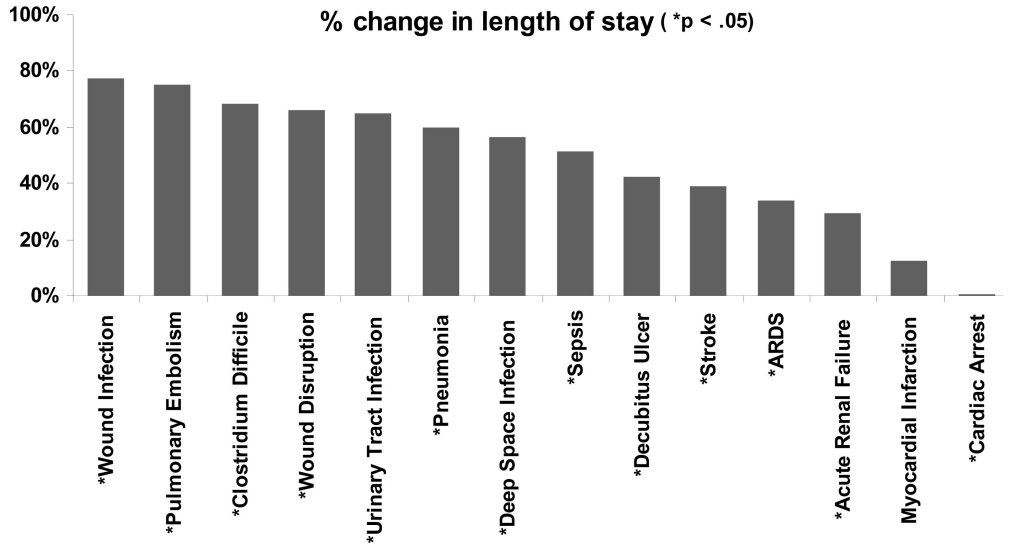

Figure 4. Relative impact of specific complications on LOS. ARDS, acute respiratory distress syndrome.

trauma centers and to identify independent predictors of LOS. Our findings suggest that there is no relationship between risk-adjusted mortality and LOS. Thus, trauma centers that over perform and save more patients do not generate increased costs. The most important determinants of LOS were potentially avoidable complications. These findings provide important information that can be used not only to guide efforts to improve the quality of trauma care but also to reduce LOS and resulting high costs.

The lack of relationship between mortality and LOS in the trauma patient population is plausible. Of course, patients with the most severe injuries who presented without a measurable blood pressure had a shorter LOS as they died very early. Recent studies have shown that >95% of trauma deaths occur in the first 24 hours, with a flattening of the late peak in the classical trimodal distribution of trauma deaths (Gunst and Shafi, unpublished data).[11] Hence, patients who survive beyond the first 24 hours are likely to survive. Hence, except for patients who die in <24 hours, there is no relationship between mortality and LOS.

These findings have several important implications. Better resuscitation and enhanced hemorrhage control techniques that reduced mortality may reduce the costs of care by reducing complications. On the other hand, improved salvage of severely injured patients may lead to prolonged hospitalization and increased costs. Perhaps the most important implication is that quality improvement efforts in trauma need to be multipronged. Until recently, the trauma community has primarily focused on reducing mortality. Recent studies have shown a gradual reduction in mortality rates to around 5%, with some suggestion that further reductions in mortality are unlikely to result from improvements in clinical care.[3,12] Hence, it is important to identify other outcomes that can be used for benchmarking and quality improvement, such as LOS.

As a marker of quality of care, LOS fulfills several criteria. It is ascertained easily and can be measured reliably and consistently. It is already included in trauma registries, and its reporting does not require any additional resources. An important limitation of using LOS as a quality measure is that it may be affected by nonclinical factors such as insurance status, family support, preinjury functional status, and resources available for postdischarge care. Our findings suggest that insurance status is not a significant predictor of LOS. However, the other factors listed above may hinder a center's ability to discharge the patient even after their clinical needs have been met. In addition, when using LOS as a marker of quality of care at trauma centers, it will be necessary to account for patient case mix. Our analysis shows that high ISS and gunshot wounds were important independent predictors of LOS. Hence, trauma centers should not be penalized for caring for severely injured patients.

Our findings suggest that the single most important determinant of LOS is occurrence of complications. Complications are also the only potentially modifiable predictor of LOS. The Centers for Medicare and Medicaid Services have also recently started using "present on admission" reporting to refuse payments for expenses attributable to hospital-acquired complications.[13] Recent studies have shown that significant increases in costs are associated with the occurrence of complications in general surgical and trauma patients.[14,15]

An important component of TQIP is reporting of complication rates.[16] However, these rates are currently not adjusted for patient characteristics, and the primary focus of TQIP is adjusted mortality rate. In contrast, the National Surgical Quality Improvement Program uses risk-adjusted complications rates, which have been associated with a nearly 50% reduction in morbidity in Veterans Affairs hospitals.[17] It is likely that incorporating risk-adjusted complication rates into TQIP reporting would have similar impact and cost savings.

The current study and another recent study by our group have identified infectious, respiratory, and wound com-

plications as being significantly associated with LOS.[18] Preventing these complications requires early identification of high risk patients and implementation of evidence-based processes of care that reduce the complications' occurrence. "Bundles" for prevention of ventilator associated pneumonia, catheter-related infections, surgical site infections, and venous thromboembolism already exist and have been broadly disseminated but have not been widely implemented.[19,20] Currently, there are no mechanisms in place to ensure compliance with these guidelines in trauma centers. Centers for Medicare and Medicaid Services has required reporting of compliance with evidence-based treatments for acute myocardial infarction and congestive heart failure.[21] Development of similar processes of care that are relevant to the trauma patient population may help to reduce complications and improve LOS.

This study has a few limitations. It is a retrospective analysis of a large voluntary national database with all its inherent shortcomings related to data quality, consistency, and validity. NTDB relies on individual centers to provide registry data. Until the recent introduction of the National Trauma Data Standards, data definitions and registry inclusion criteria varied from center to center.[10] Despite these shortcomings, the NTDB remains the largest multiinstitutional repository of trauma patient information and has been used extensively for clinical research and quality improvement reports. An important limitation of NTDB is potential underreporting of complications.[22,23] In this study, we attempted to minimize this by using International Classification of Diseases—9th Revision codes to supplement complication information provided by NTDB.

Reduction in complications has been associated with significant cost savings.[15,16] However, perhaps the most important limitation of this study is the assumption that many complications are potentially preventable. Complication rates at trauma centers are generally higher than in other clinical settings, even after adjusting for case mix.[24]

In conclusion, quality improvement programs focusing on mortality alone may not be associated with a reduction in LOS and cost savings in trauma centers.[25] Hence, in addition to mortality, incorporation of risk-adjusted complication rates into TQIP reporting might enhance adoption of best practices to reduce complications, thereby shortening LOS, which may lead to significant cost savings.

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