Centers for Medicare and Medicaid Services Quality Indicators Do Not Correlate With Risk-Adjusted Mortality at Trauma Centers

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Objectives: The Centers for Medicare and Medicaid Services (CMS) publicly reports hospital compliance with evidence-based processes of care as quality indicators. We hypothesized that compliance with CMS quality indicators would correlate with risk-adjusted mortality rates in trauma patients.

Methods: A previously validated risk-adjustment algorithm was used to measure observed-to-expected mortality ratios (O/E with 95% confidence interval) for Level I and II trauma centers using the National Trauma Data Bank data. Adult patients ($\geq$16 years) with at least one severe injury (Abbreviated Injury Score $\geq$3) were included (127,819 patients). Compliance with CMS quality indicators in four domains was obtained from Hospital Compare website: acute myocardial infarction (8 processes), congestive heart failure (4 processes), pneumonia (7 processes), surgical infections (3 processes). For each domain, a single composite score was calculated for each hospital. The relationship between O/E ratios and CMS quality indicators was explored using nonparametric tests.

Results: There was no relationship between compliance with CMS quality indicators and risk-adjusted outcomes of trauma patients.

Conclusions: CMS quality indicators do not correlate with risk-adjusted mortality rates in trauma patients. Hence, there is a need to develop new trauma-specific process of care quality indicators to evaluate and improve quality of care in trauma centers.

Key Words: Quality of care, Trauma systems, TQIP—Trauma Quality Improvement Program: Hospital Compare.

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P ublic reporting of hospital performance has been used increasingly over the last several years.[1–3] The primary purpose of these reports is twofold. First, public reporting

provides an incentive for hospitals to monitor and improve their quality of care. Second, reporting increases the transparency of hospital performance for payers, consumers, and regulatory bodies, all of whom have an interest in the outcomes achieved by the healthcare system. This information is also expected to encourage healthcare providers to improve the quality of care by promoting consistent use of effective therapies and by providing clinicians with relevant feedback.[3–5] More recently, payments for clinical services have also been linked to compliance with specific performance measures.[6] The most commonly used performance measures are mandated by the Centers for Medicare and Medicaid Services (CMS).[7] Hospitals participating in the Medicare program are required to self-report compliance with a list of standardized processes of care called core measures. CMS publicly reports compliance with these core measures on the "Hospital Compare" website as indicators of hospital quality of care.[4] Hospital Compare was created through the efforts of CMS and the Hospital Quality Alliance, a public-private collaboration established to promote reporting on hospital quality of care.[8] Hospital Quality Alliance consists of organizations that represent consumers, hospitals, physicians and nurses, employers, accrediting organizations, and Federal agencies. Hospital Compare provides rates for compliance with specific evidence-based processes of care for adult patients being treated for acute myocardial infarction (AMI), heart attack, heart failure, pneumonia (PNE), or patients undergoing elective surgery. Hospital Compare has become the principal means of measuring performance and quality of care across hospitals.[3,5,9]

It has been shown that compliance with the CMS core quality measures results in decreased mortality for the population targeted.[5,10] However, improved compliance with the core measures explains only a fraction of the observed improvement in outcomes. This suggests that factors other than the measured processes of care may be responsible for improved quality of care.[11] In fact, in one study, the observed impact of compliance with a single quality intervention was 10 times greater than what could be expected from the direct effect of the intervention.[12] These findings suggest that compliance with quality measures may be a marker of an institution that is dedicated to improving quality of care through promoting a "culture of quality." For example, improvement in compliance with prophylaxis against venous thromboembolism requires that hospitals be committed to using

evidence-based protocols, consistent documentation through electronic medical records, monitoring of clinical practices, feed back to noncompliant practitioners, patient safety reporting, pharmacy oversight, and other performance improvement initiatives. All these changes are likely to have an impact above and beyond prophylaxis against venous thromboembolism. In other words, when hospitals adopt changes to improve their measured performance, the same changes also improve their unmeasured performance, which leads to improved patient outcomes.[12] Because trauma centers are predominantly located within full service acute care hospitals, it is plausible that compliance with the CMS core quality measures may also be associated with improved outcomes of trauma patients. If CMS quality indicators correlate with outcomes of trauma patients, it would provide further evidence that quality improvement extends beyond the processes measured. In that case, existing CMS indicators may be used as surrogates for quality of trauma care. On the other hand, a lack of relationship between CMS quality indicators and outcomes of trauma patients would suggest a need to develop new trauma-specific quality indicators.

The purpose of this study was to determine the relationship between publicly reported CMS quality of care indicators and the quality of trauma care at designated trauma centers as measured by their risk-adjusted in-hospital mortality. We hypothesized that compliance with CMS quality indicators at designated trauma centers would correlate with risk-adjusted mortality rates of their trauma patients.

METHODS

Two different sources of data were used in this study: Hospital Compare was used to determine trauma center compliance with CMS quality indicators, and the National Trauma Data Bank (NTDB, version 7.0, 2002–2006) was used to derive risk-adjusted mortality rates at trauma centers.

Trauma Center Selection

There was a total of 4,416 hospitals in the Hospital Compare database at the time of our on-line query.[4] Among these, 981 trauma centers were identified through linking by hospital name and address to trauma centers listed in the inventory of the Trauma Information Exchange Program.[13] Twenty-eight centers were excluded because they did not report any data in the Hospital Compare database. A list of the remaining 953 centers was sent to the American College of Surgeons to identify centers that submitted data to NTDB. The NTDB staff identified 291 centers in their database using a combination of American Hospital Association (AHS) identification numbers, and centers' names and addresses. To preserve the anonymity of trauma centers, the NTDB staff linked the NTDB data to the Hospital Compare data and then removed all hospital identifiers before sending the data to the investigators. Thus, the investigators were blinded to the identity of trauma centers included in this analysis. There were a few facilities with the same NTDB code but different AHA numbers, likely reflecting multiple facilities within a single hospital system. These were treated as single entities for the purposes of this study. This further reduced the number of trauma centers to 255. Of these, there were 114 Level I and II trauma centers

(state designated or ACS verified), which were the focus of our study. Two centers were excluded for incomplete information on patient survival in NTDB. Thus, the final hospital cohort consisted of 61 Level I trauma centers (424,714 patients) and 51 Level II trauma centers (216,066 patients).

Patient Selection

From this cohort, only adult patients (aged 16–99 years) were included in the study. Exclusion criteria consisted of the following:

1. Delayed presentation to trauma centers (time of admission ≥1 day after injury).
2. Primary mechanism burns, poisoning, drowning, hanging, asphyxiation, and submersion.
3. Gunshot wounds to head.
4. Patients deemed dead on arrival and those who died in the emergency department after presenting with a systolic blood pressure of 90 mm Hg or less.
5. Missing information on survival status and Abbreviated Injury Scores (AIS).
6. Missing information on any inclusion/exclusion criteria.

These criteria identified 339,667 patients from 83 trauma centers. From these, we selected three specific cohorts of patients, which comprised 127,819 patients from 82 trauma centers:

Cohort 1—Blunt multisystem injuries, defined as blunt AIS ≥3 injuries to two or more body regions (n = 28,986).
Cohort 2—Penetrating torso injuries, defined as penetrating AIS ≥3 injuries to neck, chest or abdomen (n = 9,785).
Cohort 3—Blunt single system injuries, defined as blunt AIS ≥3 injuries to a single organ system (n = 89,048).

The selection of the blunt multisystem trauma patients (cohort 1) allowed for the assessment of many processes and outcomes related to interdisciplinary management including critical care, neurosurgery, and orthopedic surgery. By contrast, inclusion of the penetrating trauma patients (cohort 2) allowed for evaluation of processes and outcomes related to judgment, timely operative management, effective resuscitation, and surgical skills. Patients with blunt single-system injuries (cohort 3) constitute a majority of trauma patients and inclusion of these patients allowed for evaluation of outcomes in a group of patients with a relatively low risk of adverse outcomes. This cohort had the potential to facilitate the identification of gaps in the quality of care not evident in the most severely injured patients. Seven centers were excluded from this analysis due to incomplete information on critical variables needed for appropriate risk adjustment. Hence, the final study population consisted of 123,492 patients from 75 trauma centers.

Trauma Center Performance Measurement Using CMS Quality Indicators

CMS reports data on several processes of care quality indicators, also called core measures, and on the Hospital Compare website. These data are grouped into four conditions: AMI (containing 8 measures), congestive heart failure (CHF, containing 4 measures), PNE (containing 7 measures),

TABLE 1. Correlation of CMS Quality Indicators With Each Other and With Observed-to-Expected Mortality Ratios (Spearman's Rho)

	AMI	CHF	PNE	SCIP	O/E Ratio
AMI	1.0	—	—	—	—
CHF	0.47 ($p < 0.001$)	1.0	—	—	—
PNE	0.25 ($p = 0.02$)	0.49 ($p < 0.001$)	1.0	—	—
SCIP	0.23 ($p = 0.04$)	0.28 ($p = 0.01$)	0.39 ($p < 0.001$)	1.0	—
O/E ratio	−0.06 ($p = 0.63$)	0.07 ($p = 0.56$)	0.08 ($p = 0.51$)	0.04 ($p = 0.71$)	1.0

and surgical care improvement/surgical infection prevention (SCIP, containing 3 measures). Data for the year 2006 were downloaded from the Hospital Compare website in October 2007. Since then, Hospital Compare has added more core measures to its data; these new measures were not included in this analysis. For each core measure, hospitals report the percentage of eligible patients who received that process of care. Using these data, we calculated a composite score for each of the four conditions for each of the hospitals included in the study. Composite scores were calculated using the previously validated Hospital Core Performance Measurement Project Opportunity model.[14] Conceptually, the model is based on the fact that each patient represents multiple opportunities for interventions that may be measured by performance indicators. Thus, a composite score may be developed for a specific condition by dividing the total number of interventions achieved by the total number of opportunities for those interventions. In this method, the numerators of all individual core measures are summed to determine a composite numerator. The denominators of all individual core measures are also summed to determine a composite denominator. The final composite score is produced by dividing the composite numerator by the composite denominator. For example, in this study, there were eight individual performance measures for AMI. For each hospital, we summed the numerators for all eight measures into a composite numerator, summed the denominators of all eight measures into a composite denominator, then divided the composite numerator by the composite denominator to obtain a composite CMS score for AMI for the hospital.

We examined the internal validity of Hospital Compare data by measuring bivariate correlation among the CMS composite scores for the four conditions using Spearman's rho, which showed statistically significant correlation between the four (Table 1). We also found moderate to strong internal consistency among the CMS composite scores for the four conditions (Cronbach's α 0.68). After ensuring internal validity and consistency of the composite scores, we ranked the trauma centers into three groups within each of the four conditions: high performers (CMS composite score ≥75th percentile), average performers (CMS composite score between 25th and 75th percentile), and low performers (CMS composite score ≤25th percentile).

Trauma Center Performance Measurement Using Risk-Adjusted Mortality Ratios

NTDB (version 7.0, 2002–2006) was used to measure trauma center performance based on risk-adjusted mortality ratios. NTDB is the largest repository of trauma registry data and is maintained by the American College of Surgeons (version 7.0 contained 1,485,098 patients from 712 trauma centers).[15] The outcome of interest was in-hospital mortality. We first calculated observed mortality rates for each trauma center by using the number of patients who died during hospitalization as the numerator and the total number of patients from that center included in the analysis as the denominator. Next, we calculated expected mortality risk for each patient using multivariate logistic regression, adjusted for age, gender, mechanism of injury, transfer status, and injury severity (measured using the injury severity score [ISS], the Glasgow Coma Scale [GCS], and first systolic blood pressure on arrival). Age, ISS, GCS, and blood pressure were entered as linear variables. Interaction terms were explored but were not included because they did not add to the model. The final model demonstrated excellent discrimination (c-index 0.91). The expected mortality rate of patients at each trauma center was calculated by obtaining a mean of expected mortality of all patients in that center. Observed-to-expected mortality ratios (O/E) were calculated for each trauma center, along with 95% confidence intervals (CIs), by using the observed mortality rate as the numerator and the mean expected mortality rate as the denominator. CIs were calculated using methodology described by DeLong (page 2650 in Statistics in Medicine 16:2645-2664:1997). We then classified the trauma centers into one of three groups: average performers (O/E ratio with 95% CI overlapping 1, indicating that the observed mortality rate of patients at the trauma center was the same as that expected from its patient mix), low performers (O/E ratio significantly greater than 1, indicating that the observed mortality rate of patients at the center was higher than expected), and high performers (O/E ratio significantly less than 1, indicating that the observed mortality rate of patients at the trauma center was lower than expected).

Comparison of Performance Rankings by CMS Quality Indicators Versus Risk-Adjusted Mortality Ratios

Nonparametric tests were used for all analyses. To evaluate the relationship between CMS quality indicators and trauma center risk-adjusted mortality ratios, we used three separate approaches. First, we measured bivariate correlations between the composite score for each CMS condition and O/E mortality ratios using Spearman's rho. Next, we compared the mean composite score for each condition across

trauma center performance ranks based on O/E ratios using the Kruskal-Wallis test. Finally, we measured the agreement in performance rankings based on CMS quality indicators to that based on O/E ratios using the kappa coefficient. All statistical analyses were done using commercially available software, with $p < 0.05$ considered significant.

RESULTS

The study population was 47 ± 22 years old, and 65% were men. Patients sustained moderate to severe injuries with an ISS of 17 ± 10, GCS of 13 ± 4, and an overall mortality rate of 6.4%. Injury severity and mortality rates varied between the three cohorts of patients as expected: cohort 1 (blunt multisystem injuries) ISS 29 ± 11, mortality rate 13%; cohort 2 (penetrating torso injuries) ISS 16 ± 10, mortality 7.5%; and cohort 3 (blunt single system injuries) ISS 13 ± 6, mortality 4.3%.

The observed mortality rates at individual trauma centers ranged from 0% to 25%. O/E mortality ratio for the entire study population was 1.03 ± 0.25 and showed significant variation between trauma centers (range 0.35–1.67). CMS composite scores for the entire study population were as follows: AMI 0.91 ± 0.04 (range 0.82–0.99), CHF 0.87 ± 0.08 (range 0.55–1.0), PNE 0.83 ± 0.09 (range 0.52–0.96), and SCIP 0.84 ± 0.08 (range 0.63–0.96).

CMS composite scores in the four conditions (AMI, CHF, PNE, and SCIP) correlated well with each other (Table 1). However, there was no correlation between CMS composite scores and trauma center risk-adjusted mortality ratios (Table 1). Mean CMS composite scores were almost identical for centers ranked low, average, or high performers based on their risk-adjusted mortality ratios (Table 2). There was poor agreement between performance rankings based on CMS scores compared with ones based on risk-adjusted mortality ratios. Similar performance ranking (high, low, and average) was achieved by less than half of the trauma centers in the study (Table 3).

DISCUSSION

The findings of this study demonstrate a complete lack of relationship between publicly reported CMS quality indicators and risk-adjusted mortality in trauma patients. Hence, compliance with the current CMS quality indicators does not reflect quality of care in this patient population.

Compliance with CMS core measures has been associated with a decrease in overall hospital mortality.[3,5,10,11,16] As mentioned earlier, the observed impact of compliance with measured processes of care is generally larger than what could be expected from the direct impact of those interventions.[12] Hence, it seems that compliance with measured quality indicators may simply be a marker for an institution that is dedicated to improving its overall quality of care for all patients. Most trauma centers are located within full service acute care hospitals, and hence, we expected to see a correlation between compliance with CMS core measures

TABLE 2. CMS Composite Score (Mean ± Standard Deviation) by Performance Status Based on Observed-to-Expected Mortality Ratios (*p* Values From Kruskal-Wallis Test)

	Low Performers	Average Performers	High Performers	*p*
AMI composite score	0.91 ± 0.04	0.91 ± 0.04	0.91 ± 0.04	0.79
CHF composite score	0.87 ± 0.1	0.87 ± 0.08	0.87 ± 0.07	0.95
PNE composite score	0.83 ± 0.11	0.83 ± 0.08	0.82 ± 0.09	0.98
SCIP composite score	0.84 ± 0.07	0.84 ± 0.09	0.84 ± 0.06	0.95

TABLE 3. Trauma Center Performance Ranking by CMS Quality Indicators vs. Risk-Adjusted Mortality Ratios

Ranking by CMS Quality Indicators	Ranking by O/E Ratios			% Agreement	Kappa (*p*)
	Low Performer	Average Performer	High Performer		
AMI ranking				41	-0.01 ($p = 0.9$)
Low performer	4	10	2		
Average performer	7	24	8		
High performer	3	14	3		
CHF ranking				39	-0.09 ($p = 0.28$)
Low performer	2	11	3		
Average performer	9	25	8		
High performer	3	12	2		
PNE ranking				45	0.04 ($p = 0.64$)
Low performer	3	9	4		
Average performer	7	28	6		
High performer	4	11	3		
SCIP ranking				33	-0.12 ($p = 0.13$)
Low performer	3	14	2		
Average performer	8	20	9		
High performer	3	14	2		

for these hospitals and outcomes of their trauma patients. Our findings suggest that potential benefits of compliance with CMS quality indicators do not extend to the trauma patient population.

There are several possible explanations for our findings. Trauma patients represent a unique population group within these hospitals. It is known that most trauma patients are young and otherwise healthy with few comorbidities. Hence, they are not necessarily at risk for the diseases and complications that are targeted by CMS. The incidence of coronary artery disease and CHF is very low in trauma patients. Although trauma patients are at risk of developing PNE, it is usually the hospital-acquired, ventilator-associated variety in this patient population. The CMS core measures are targeted toward treatment of community-acquired PNE. Similarly, in the case of surgical site infections, a large number of trauma patients do not require surgical intervention. Even when they do, the emergent nature of operations may not permit administration of prophylactic antibiotics before skin incision, appropriate hair removal, or perioperative use of beta blockers in certain patient populations, all of which are measured as CMS quality indicators for elective surgery. Prophylaxis against venous thromboembolism is another CMS core measure included in SCIP. It is a common complication in trauma patients as well. Hence, compliance with SCIP measures should improve outcomes of trauma patients. Again, we did not find any correlation between SCIP core measures and trauma patient outcomes. It may be due to the fact that there are several clinically valid reasons to withhold pharmacologic prophylaxis using anticoagulants in this patient population, such as ongoing hemorrhage or presence of traumatic brain injury. Finally, it is also possible that CMS core measures currently in use, although based on evidence-based medicine, may not correlate with patient outcomes.[17] These reasons make it plausible that quality indicators or core measures used by CMS may not be applicable to trauma patient population.

A systems approach to quality improvement is based on classical principles described by Donebedian, which define quality in terms of structures, processes of care, and outcomes. The trauma surgical community has long focused on improving structures of care through designating hospitals as trauma centers based on resources available, with very little emphasis on measuring processes of care.[18] Hospitals designated as trauma centers have been shown to improve outcomes of injured patients.[19,20] However, we have previously shown significant variations in risk-adjusted mortality at these centers, suggesting variations in the quality of care.[21–23] Because designated trauma centers are able to provide similar levels of resources, it is likely that observed variations in patient outcomes are related to differences in processes of care. Trauma centers have mandatory performance improvement processes to ensure that the right care is delivered to the right patient at the right time. However, centers are not required to report compliance with specific processes of care that have been shown to improve patient outcomes. For example, Level I and II trauma centers are required to have neurosurgical coverage as an essential criterion for their designation. However, there is no requirement that patients with traumatic brain injury and a Glasgow Coma Scale score of 8 or less receive an intracranial pressure monitor in a timely fashion, as recommended by the Brain Trauma Foundation.[24] Similarly, there are no mechanisms to ensure that patients in hemorrhagic shock receive prompt resuscitation, those at high risk of venous thromboembolism receive appropriate prophylaxis, or those with long bone fractures receive early fixation.

A clear implication of our findings is that there is a need to develop a trauma-specific set of quality measures based on processes of care that ensure optimal care of the injured. These measures should be evidence-based and relevant to common injuries, and should correlate with patient outcomes. In addition, compliance with these quality measures should be integrated into trauma registries for monitoring and reporting purposes. Extensive consultations within the trauma community are needed to select an appropriate set of quality measures, determine patient eligibility for each measure, and describe how compliance will be measured and reported. We think that measuring compliance with specific processes of care is critical in improving quality of trauma care above and beyond the current performance improvement processes. A valid and reliable set of quality indicators for measuring processes of care can then be used to monitor quality of care at trauma centers. Such information will be far more valuable to the public, regulators, and third party payers than the currently used CMS quality indicators. Table 4 lists some examples of quality indicators that may be specific for the trauma patient population. However, before their use in quality measures, all proposed indicators must undergo rigorous testing to ensure their accuracy and validity in measuring quality of care in trauma.

This study has a few limitations that should be acknowledged. The analysis is based on data submitted by individual hospitals and trauma centers. Several data fields in NTDB are not well defined or are the criteria for inclusion of patients in these registries consistent. The quality, accuracy, and consistency of data cannot be ensured. In addition, a large number of patients were excluded due to incomplete information. Risk-adjustment methodology used for measuring patient outcomes at trauma centers may be altered by missing or incomplete data. There is no universally accepted benchmark for measuring the quality of care received by trauma patients, against which other measures can be compared. Finally, given the wide spectrum of injuries encountered in a busy trauma center, it may not be possible to measure quality of care delivered to all patients. However, we think that the three cohorts of patients included in the study are representative of patients most likely to benefit from the resources of designated trauma centers.

In conclusion, the findings of this study demonstrate a lack of relationship between publicly reported CMS quality of care indicators and risk-adjusted outcomes of trauma patients. Therefore, there is a need to develop a set of valid and reliable set of measures based on processes of care that are relevant to the trauma patient population. Such information will provide a meaningful measure of quality of care at trauma

TABLE 4. Possible Trauma Core Measures (Need Validation Before Use)

Area	Trauma Core Measures
Traumatic brain injury	Proportion of patients with severe traumatic brain injury who receive an intracranial pressure monitor within 8 h of arrival
Hemorrhage control	Proportion of patients with major hemorrhage who undergo hemorrhage control surgery or angioembolization within 1 h of arrival
Open fractures	Proportion of patients with open long bone fractures who undergo operative irrigation and debridement within 8 h of arrival
Venous thromboembolism prophylaxis	Proportion of patients at high risk for venous thromboembolism and no contraindication to anticoagulant who receive chemical prophylaxis within 24 h of arrival
Spine fixation	Proportion of patients with unstable spine fractures who undergo operative fixation within 72 h of arrival
Ventilator support	Proportion of patients with acute respiratory distress syndrome (ARDS) who receive low stretch ventilation
Glycemic control	Proportion of patients with high blood sugar who are managed with tight blood sugar control
Blood stream infections	Proportion of central lines that are placed with complete barrier precautions
Alcohol and drug use	Proportion of patients who undergo screening and brief intervention for alcohol and drug use

centers that may be used for continuous quality improvement by the providers, the patients, and the payers. Compliance with trauma core measures may also be incorporated into trauma center designation and verification processes.

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DISCUSSION

Dr. Lorraine Tremblay (Toronto, Ontario): I would like to congratulate Dr. Shafi for his excellent presentation and timely submission of a very well written manuscript addressing an important and contentious issue of how can we accurately assess quality of care in trauma?

In this study, Dr. Shafi and his colleagues find that the CMS indicators for acute myocardial infarction, congestive heart failure, pneumonia, and surgical care improvement do not correlate with risk-adjusted mortality in trauma patients.

I have several questions for the authors. First, why did you choose risk-adjusted mortality in trauma for the comparison? Did you also look at whether the CMS process of care indicators in your cohort actually correlated with risk-adjusted mortality for heart attack, heart failure, and pneumonia. If so, was this correlation better than with trauma-adjusted mortality and if not, do you think a better correlation might have been obtained had you looked at morbidity in trauma survivors, rather than mortality?

Second, this study used data from only seventy-five trauma centers. Do you have any reason to believe that your conclusions might have been different if more or different centers were included? For example, how representative was this sample of U.S. major urban or rural trauma centers?

Third, given your expertise and familiarity with the difficulties investigators have had to date trying to identify valid process indicators that actually correlate with trauma outcomes, what are a couple of the trauma-specific process quality of care indicators that you would propose evaluating

next? I would like to thank the authors for their interesting and important work and the Association for the privilege of discussing this paper.

Dr. Shahid Shafi (Dallas, Texas): Thank you, Dr. Tremblay, for your comments and questions. Your first question was why did we correlate trauma mortality to process of care indicators which are not directly related to trauma and the answer to that question is because we are trauma surgeons. That's our target population and CMS quality of care indicators, there's one study, which I quoted here, which proved that if you look at improvement in mortality associated with compliance with CMS measures for acute MI the impact was ten times higher than what could be expected from the direct effect of the intervention alone, which means that compliance with these few indicators creates a culture of quality that has wide benefit beyond the actual intervention.

We're hoping to see that if that culture of quality directed toward medical patients has crossed over on to the trauma side as well and clearly we found that that was not the case.

With regard to would this have a better relationship with other outcomes, it is entirely possible. The other outcomes may include complications, length of stay, ICU utilization, but we did not look at those parameters.

Your next question was the seventy-five trauma centers which were included in this study, were they representative of all traumas and the answer to that is no, they are not truly statistically representative of all trauma centers in the population, but those were all the centers that we could find which participated in both the Hospital Compare Database as well as NTDB and they were listed as trauma centers in the inventory of trauma centers which is maintained by the American Trauma Society. We were limited by what we had.

The last question was what are some of the trauma-specific quality of care indicators? We listed some of them on the last slide. They may be related to treatment of traumatic brain injury, related to treatment of resuscitation and achieving the endpoint of resuscitation in a timely fashion and they may be related to screening and brief intervention for trauma patients.

The point is that these process of care indicators need to be evidence-based, as much as possible, and they need to be developed by professional societies like EAST and the AAST and the COT and we should be the ones championing it to the payers and CMS to adopt those as trauma quality indicators.

Dr. John Siegel (Newark, New Jersey): I want to congratulate Dr. Shafi on his interesting and enormously interesting research study. However, I suggest that perhaps the reason that there is little correlation among the variables used in his study is that the basic relationship is not between the factors that you have shown here, but rather is more directly related to the degree of physiologic abnormality that the patients have when they come in to the Trauma center.

I am sure that you are familiar with the paper by Rixen and the centers participating in the German Trauma Society study. This group of investigators looked at about 25,000 patients, and found that the degree of physiologic abnormality, based on base deficit as an indicator of degree of shock, plus age, and a couple of other minor factors, were the major determinants of outcome in this large number of trauma patients, all from many centers in one country, where the practice of trauma care is fairly similar.

I doubt whether in the absence of using physiologic parameters that you are going to be able to make this type of determination. This problem may occur because some of the trauma centers in your study may have a higher percentage of more seriously injured patients than the others, and some may fail to correctly or to rapidly enough compensate for the physiologic abnormalities on admission. I suggest that the failure to use a fundamental measure of patho-physiologic abnormality may be a more significant factor in determining the final patient outcome than the other measures which you used. Perhaps you would like to comment on that.

Dr. Shahid Shafi (Dallas, Texas): Dr. Siegel, thank you for your comments and questions. Your question related to the severity of physiologic abnormality in trauma patients and how they relate to patient outcomes and whether correction of those physiologic abnormalities should be used as a quality measure and I'm familiar with your excellent work over your entire career in the last thirty or forty years related to physiologic change in trauma patients. As far as risk-adjustment is concerned, the risk-adjustment model included three specific parameters of injury severity: ISS, GCS, and systolic blood pressure.

We did not include base deficit. As you have shown previously, it's an important predictor of outcome. We didn't include it for two reasons. One is it's missing in a large number of patients in NTDB and two, in a previous study that Dr. Nathens presented at AAST and it was recently published, it showed that ISS, GCS, and blood pressure adequately risk adjust for outcomes of trauma patients.

Correction of physiologic abnormalities, I would agree with you that I think the correction of physiologic abnormalities in a timely fashion does impact patient outcome and so those should be included as appropriate process of care quality indicators. However, we need to just identify which endpoints of resuscitation we are going to use and agree to it and make sure they are evidence-based and then start using them. I think that is what we need to do.