

The Trauma Quality Improvement Program of the American College of Surgeons Committee on Trauma

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The Committee on Trauma (COT) of the American College of Surgeons has been dedicated to improving the quality of care provided to the injured for more than eight decades. Its accomplishments include the Advanced Trauma Life Support program, trauma center verification program, trauma systems development, performance improvement, and the National Trauma Data Bank (NTDB). In October 2006, the COT embarked upon the Trauma Quality Improvement Program (TQIP) as the next paradigm in improving the quality of care in trauma. The TQIP group was charged with the mandate to “design and test a trauma quality improvement program that is validated, risk-adjusted, and outcomes based, to measure and improve the quality of trauma care.” In the following sections, we summarize the current status of the program and its future plans for national rollout.

Evolution of performance improvement in trauma

The COT has been on the leading edge of performance improvement since its inception. Trauma was the first medical specialty to develop regionalized systems of care by establishing dedicated trauma centers and to systematically measure health care outcomes at those centers.¹ Recognizing the limitations of traditionally used peer-review forums to improve care quality in the complex field of trauma care, the COT promotes a “systems approach” to improving quality of care. This approach is based on classical principles

of quality improvement described by Donebedian, which define quality in terms of structures, processes of care, and outcomes.² Recently, this approach has been advocated by the Institute of Medicine in a series of landmark reports on errors in medical care.^{3,4} Many of the important recommendations of these reports are already firmly entrenched in the trauma performance improvement culture, including redesigning care processes based on best practices, using information technology to support clinical decision making, improving knowledge and skills management, developing effective teams, coordinating care, and incorporating performance and outcomes measures for quality improvement and accountability.

In 1979, the COT published its first resource document, titled, “Optimal Resources for the Care of the Injured,” in which it emphasized a systems approach to the care of the injured by listing specific structures and processes that an acute care hospital must have in place to provide optimal care to injured patients.⁵ A critical component of the required resources is a multidisciplinary performance improvement (PI) process to monitor care and adverse outcomes and improve compliance with quality of care indicators. The resource document has evolved to include standards and clinical indicators considered important in the management of injured patients.

In 1987, this resource document formed the basis for establishing the trauma center verification review process,⁶ whose objective is to improve the quality of care delivered to injured patients by verifying that the hospitals caring for such patients are able to provide resources that are essential for their optimal care. State (or regional) authorities designate a hospital as a trauma center based either on COT verification or on state-specific requirements that are closely aligned with the COT criteria. The underlying premise of trauma center designation and verification is that standardization of structures and processes of care in trauma centers will lead to high quality care, improve outcomes, and minimize institutional variations in quality of care.

The verification program has identified gaps in trauma center resources and helped those centers to correct their

Disclosure Information: Nothing to disclose.

Based partly on proceedings of a plenary session at the Eastern Association for the Surgery of Trauma 22nd Annual Meeting, January 2009, Orlando, FL.

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Abbreviations and Acronyms

AIS	=	Abbreviated Injury Score
COT	=	Committee on Trauma
NSQIP	=	National Surgical Quality Improvement Program
NTDB	=	National Trauma Data Bank
NTDS	=	National Trauma Data Standard
O/E	=	observed-to-expected ratio
PI	=	performance improvement
TQIP	=	Trauma Quality Improvement Program
VA	=	Department of Veterans Affairs

deficiencies. In the first 5 years of the program, 54 of 124 reviewed hospitals had criteria deficiencies, most commonly related to their PI programs.⁷ Most hospitals corrected their deficiencies, underwent a second review, and were verified as trauma centers. It has been clearly documented that patients treated at designated trauma centers have lower mortality rates than those treated at undesignated hospitals.⁸ Because the quality of the PI program tends to parallel patient outcomes, the COT focuses on improving PI program development in trauma centers. To support these activities, a PI manual was published in 2002 by the COT Performance Improvement and Patient Safety (PIPS) committee.⁹

The COT has also been instrumental in outcomes measurement and benchmarking. In 1982, the COT coordinated the Major Trauma Outcome Study to establish national norms for trauma care which could be used to benchmark trauma centers.¹⁰ The Major Trauma Outcome Study database was used to develop the Trauma Injury Severity Score methodology to predict the probability of survival of individual trauma patients based on indices of physiologic derangement, anatomic injury severity, and age, allowing trauma centers to compare their observed outcomes with those predicted by patients' clinical status. Because of improvements in trauma systems and clinical care since 1982, Trauma Injury Severity Score parameters have become outdated.

In 1989, the COT initiated the NTDB, which aggregates clinical data from individual trauma center registries in a standardized fashion annually.¹¹ Since 2008, participation in the NTDB has been mandatory for hospitals seeking American College of Surgeons COT verification. The NTDB has recently developed annual benchmark reports that are distributed to participating centers. Although these reports compare in-hospital mortality and other patient characteristics, they do not address differences in case-mix across centers, limiting their utility for directing performance improvement efforts. But the NTDB contains clinical data elements that allow for adequate risk adjustment that would increase the value of interfacility comparisons

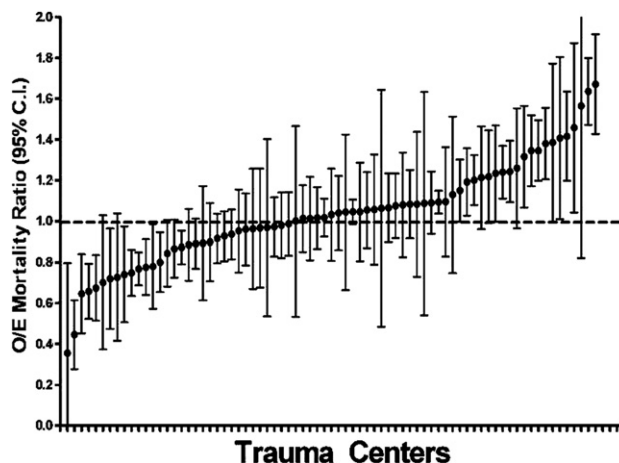


Figure 1. Institutional variations in outcomes of trauma patients from Level I and II trauma centers.³⁷

and make external benchmarking possible. Such an approach has been used successfully by the National Surgical Quality Improvement Program (NSQIP), leading to COT interest in applying NSQIP methodology to the NTDB. Hemmilla and colleagues¹² tested a Trauma Quality Improvement Project (TQIP) in a single trauma center, drawing on the experience of NSQIP to improve the quality of trauma care. In addition, the TQIP group of the COT studied whether variations in outcomes exist among verified trauma centers after appropriate risk adjustment. The study found that trauma centers reporting to the NTDB displayed considerable variation in risk-adjusted mortality, despite being verified as having optimal resources (Fig. 1).¹³

Quality chasm in trauma

Institutional variations in management of several diseases and patient outcomes are well known.¹⁴⁻¹⁷ Conceptually, these variations have two components: one is attributable to differences in patient populations, and the second is attributable to quality of care provided at each institution, which is determined by structures and processes of care. Structural variables, which are based on the setting and attributes of the system in which care is delivered, may include hospital-level variables (eg, hospital volume, ICU staffing, etc.) or attributes of individual providers (eg, surgeon volume, subspecialty training). Structural variables do not affect patient outcomes directly, but exert their effects by influencing processes of care. Important processes of trauma care include initial resuscitation, early identification of injuries and their definitive operative and nonoperative treatment, protocols to minimize complications, and early identification of complications, along with timely and effective interventions to manage them.

From 1991 to 2002, the number of verified and designated trauma centers in the country has increased from 471

to 1,154.¹⁸ Approximately 500 are designated Level I and II trauma centers.¹⁸ As discussed earlier, considerable variability in risk-adjusted mortality rates exists across trauma centers, with some centers achieving significantly better (or worse) outcomes than others.^{13,19,20} Persistence of institutional variations in patient outcomes after robust risk adjustment suggests that variations in patient outcomes are a result of differences in quality of care between hospitals and not from differences in patient characteristics.

National Surgical Quality Improvement Program and its application to trauma

The NSQIP, created in 1994, is the best known effort to improve the quality of surgical care using a systems approach.^{21,22} The NSQIP compares observed mortality and morbidity rates at each hospital with a rate that is expected by its patient mix, ie, risk adjusted for factors such as age, surgical disease and its severity, comorbidities, etc. For each hospital, a ratio of observed-to-expected (O/E) mortality is calculated (with its 90% confidence intervals) and plotted on a chart along with the results from all other VA hospitals. This allows each hospital to easily compare its risk-adjusted performance to those of other participating hospitals. Data are abstracted from patient charts by trained clinical nurses using standard tools and definitions and are submitted to a central repository for validation and analysis. The results are shared with each hospital regularly in the form of comparative, site-specific, and outcomes-based semiannual reports. In addition, best practices are identified by structured site visit comparisons of low outlier status (low mortality) with high outlier (high mortality) institutions, and these practices are disseminated. Since the inception of NSQIP, the 30-day postoperative mortality and morbidity in the Department of Veterans Affairs (VA) system have declined by 27% and 45%, respectively.²³ The initial success of NSQIP in the VA system led to its expansion into non-VA private hospitals under the leadership of the American College of Surgeons.²⁴⁻²⁶

The NSQIP methodology offers advantages over the current benchmark reports to trauma centers by the NTDB. These lessons may be incorporated as COT develops a risk-adjusted benchmarking system for trauma centers in the form of TQIP. First, the NSQIP uses a uniform set of data points and definitions that are standardized for all centers. Second, the NSQIP relies on dedicated surgical clinical nurse reviewers to abstract the data from the patient chart. Third, only one software program is used to collect and aggregate the data, which eliminates errors. Fourth, the data collected are validated through periodic site visits and inter-rater reliability audits. Fifth, an important feature of NSQIP is its online report capability. Participating centers can extract their own data and compare it

with data from a cohort of their choosing. These online reports allow hospitals to explore potential reasons for their O/E mortality ratios by drilling down into detailed raw data.

The Michigan experience

In 1999, the University of Michigan participated as an initial center in the expansion of NSQIP to non-VA hospitals.²⁷ Hemmila and associates^{12,28} applied NSQIP principles to collecting data and assessing outcomes for all adult patients admitted to the trauma service at the University of Michigan starting in August 2004. Inclusion criteria for data collection were: all deaths in the emergency department or hospital, age 18 years or greater, Injury Severity Score greater than 5, and length of stay greater than 24 hours. The NSQIP data elements and definitions were reviewed for trauma relevance and removed or modified as necessary for trauma nuances. A few trauma-specific data points were also added. Data were collected by a physician assistant trained by NSQIP for data abstraction.

Findings showed that trauma patients had fewer comorbid conditions on admission compared with the NSQIP general surgery patients. Although all comorbid conditions used in NSQIP were collected and analyzed, most of these covariates did not improve the risk adjustment model for mortality. Conversely, trauma patients experienced a significantly higher rate of some complications such as pneumonia, urinary tract infection, bleeding requiring transfusions, and deep venous thrombosis. Most importantly, trauma patient data collected using the NSQIP methodology demonstrated markedly higher rates of almost every complication studied when compared with 2004 data for a similar cohort of patients from Level I trauma centers in the NTDB. This suggests that complications may be underreported in NTDB. Another finding of the Michigan study was that significant amounts of admission laboratory data that are commonly collected by NSQIP were not obtained (3% to 40%) because many patients who were either relatively noninjured or very severely injured did not have blood samples drawn. In addition, the data analysis showed that many of these laboratory parameters did not improve the mortality risk adjustment model in trauma patients. So the Michigan study recommended that collection of laboratory parameters for risk adjustment be deemphasized or eliminated in TQIP. These findings highlight the need for TQIP data collection and risk adjustment to be trauma specific. Trauma patients, in general, are young and healthy before injury, so they require fewer data elements for adequate risk adjustment.

Trauma Quality Improvement Program description, challenges, and strategies

TQIP represents a collaborative effort involving input from several groups within the COT. The NTDB subcommittee has experience in data collection and reporting, the Performance Improvement and Patient Safety subcommittee identifies and promulgates best practices, and the Outcomes subcommittee defines relevant outcomes for benchmarking. TQIP may provide an opportunity for the Verification Review Committee to objectively assess the importance of various verification criteria to patient outcomes. So, the TQIP will use the cumulative expertise of the COT membership to accomplish its goals.

Perhaps the single most important impediment to valid external benchmarking and interfacility comparison is the quality of data because of variation in patient inclusion criteria, data collection practices, and data field definitions. Although statistical models can be developed to adjust for differences in case mix across centers, these models must be based on valid and reliable data to ensure that similar populations of patients are compared across trauma centers. The introduction of the National Trauma Data Standard (NTDS) in 2008 assures that chart abstractions across hospitals are based on the same standard data definitions and source hierarchy.²⁹ We also need information about processes of care that is more detailed than ICD-9 procedure codes. This understanding requires development of specific process of care variables, their definitions, source hierarchy, and a data collection module. Finally, indicating to a trauma medical director that his or her center is a poor performer might do little to change practice. To be effective, the TQIP will allow centers to interact and share best practices. These all represent challenges to the development of TQIP. Some possible solutions to overcome these challenges are described in detail below.

Data collection

TQIP data will be collected using the existing trauma registry mechanisms at trauma centers rather than through a parallel data collection infrastructure. Most of the information required for TQIP reporting is included in existing NTDB data fields. Because the majority of institutions use software produced by relatively few vendors, COT will work with the vendors to expand current data collection to include relatively few additional fields proposed for TQIP. The centers will transfer the data to NTDB annually for reporting purposes. TQIP will then extract data from NTDB after they have gone through internal validation and logic checks. In addition, centers will be required to transfer data on a quarterly basis to allow for monitoring of data quality, completeness, and case accrual.

Data standardization

Benchmarking requires standardization of data collection methodologies across all centers. Although data collection for the purposes of maintaining a trauma registry is routine in trauma centers, the ability to interpret data across centers is compromised by two major factors. First, the source documents for data abstraction are not well defined and vary across centers. Second, centers may use definitions inconsistently for comorbidities (critical for risk adjustment) and complications (as one of several outcomes measures). There is no evidence to suggest there is uniformity of capture across centers. In fact, experience from the Michigan study (see above) suggests significant under-reporting of complications in existing trauma registry data.^{12,28}

To improve standardization, TQIP requires the use of the NTDS, which also includes a source hierarchy to guide registrars on approaching conflicting or absent data.²⁹ To assure data standardization, registrars from TQIP participating institutions will be required to attend a training course on the NTDS and source hierarchy, and will be required to participate in quarterly educational activities. The training will include hands-on data abstraction from sample charts. Successful completion of the course and sample abstraction process will be necessary prerequisites for participating in TQIP. After the initial course, data abstractors will be required to participate in quarterly educational activities through a combination of conference calls and Web-based seminars. A listserv for communications, bulletins, and updates will also support the registrars between course updates. These activities will be supplemented with an annual TQIP meeting to allow the participants to share their successes.

Data validation

Internal validation of the collated registry data that comprise the NTDB occurs through range and logic checks and evaluation for improbable values. External validation, however, would provide greater quality assurance. In a previous external validation study, we reabstracted 50 randomly selected charts from 10 centers participating in the National Sample Project (Goble S and colleagues, unpublished data, 2008). Although concordance was excellent for data that were easily attainable (such as dates, gender), several issues with data quality were identified, including missing or incomplete data relating to Glasgow Coma Scale scores and relevant qualifiers (intubation, sedation, paralysis); differences in the first systolic blood pressure and respiratory rate; relevant differences in the lengths of stay (ICU or hospital); and variable recording of complications, comorbidities, and diagnoses. These discrepancies were not always from

Table 1. Trauma Quality Improvement Program Process of Care Measures

Indicator and measures	Cohort
Traumatic brain injury Indicator: ICP monitoring in severe TBI within 8 h of ED arrival Measure: Proportion of cohort with ICP monitoring within 8 hours of arrival	Best GCS within the first 24 h \leq 8 OR Best motor score \leq 3 within the first 24 h AND one of: Abnormal CT brain (hematoma, contusion, swelling, herniation, compression of basal cisterns) OR Normal CT brain AND (Age > 40 y OR SBP <90 mmHg on ED arrival) OR posturing (GCS motor = 2, 3)
Hemorrhage control Indicator: Time to hemorrhage control Measures: Time to hemorrhage control, Proportion of patients within cohort in whom hemorrhage control initiated within 2 h of ED arrival	Lowest SBP in ED < 90 mmHg OR base deficit within 4 h of ED arrival < -6 AND Received 4 units of PRBCs (or >1 L cell saver) within 4 h of ED arrival AND Hemorrhage control required (laparotomy, thoracotomy, sternotomy, angiography \pm embolization, major peripheral vascular procedure)
Fracture management Indicators: Time to operative fixation, Time to irrigation and debridement of long bone fractures (open only) Measures: Time to first definitive fixation, Time to last definitive fixation (if >1 fracture)	AIS \geq 3, fracture long bone (femur, tibia, humerus, radius, ulna) OR pelvis OR spine
Venous thromboembolism prophylaxis Indicator: Pharmacologic VTE prophylaxis on or before day 3 Measure: Proportion of patients within cohort with pharmacologic prophylaxis by calendar day 2 without IVC filter placement	All patients meeting TQIP inclusion criteria (AIS \geq 3 injury)

AIS, Abbreviated Injury Scale; ED, emergency department; GCS, Glasgow Coma Scale; ICP, intracranial pressure; IVC, inferior vena cava; PRBC, packed red blood cells; SBP, systolic blood pressure; TBI, trauma brain injury; TQIP, Trauma Quality Improvement Program; VTE, venous thromboembolism.

registrar error or differences in interpretation, but were sometimes introduced when data were submitted from the facility's registry to NTDB as a result of mapping the center's registry data fields to NTDB data fields.

There are several relatively easy solutions to enhance data quality. Adoption of the NTDS will address errors related to use of different sources of information to find the data (eg, physician versus nursing notes) and mapping errors to the NTDB fields. Registrars from participating centers will be required to undergo training described above. In addition, institutions might be asked to submit a series of test records from the sample charts to identify data mapping errors that should be corrected before data submission. It is noteworthy that there was a very high degree of inter-rater reliability among the trained abstractors in the external validation study, suggesting that with education and the improvements in mapping, data quality should improve.

In addition to these changes, trauma centers participating in TQIP will be required to undergo external validation of their data every 3 years to ensure that all patients eligible for inclusion are included (complete case ascertainment) and that the submitted data accurately represent the data in the medical record.

New data elements for the Trauma Quality Improvement Program

The NTDS allows collection of baseline demographics, injury severity, and selected outcomes. To provide a better understanding of the elements that lead to differential outcomes across centers, TQIP is currently evaluating a series of process measures in collaboration with appropriate subspecialists (such as orthopaedics and neurosurgery) and the Performance Improvement and Patient Safety subcommittee. Examples of some process measures under consideration and the specific cohort of patients to whom they may apply are shown in Table 1. These process measures mandate addition of new data fields in registry software, additional registrar training and data collection to capture the indicators, and where necessary, the reason for a different process when the ideal cannot be achieved. For example, pharmacologic prophylaxis to prevent venous thromboembolism might not be appropriate if hemorrhage control has not been adequately addressed.

Trauma Quality Improvement Program patient inclusion criteria

Inclusion criteria for the NTDB are described in the NTDS and include any patient with at least one injury

Table 2. Trauma Quality Improvement Program Inclusion and Exclusion Criteria

Inclusion criteria (must meet all of the following criteria)	
Age \geq 16 y	
One valid trauma ICD-9 code in the range of 800–959.9, excluding late effects (905–909.9), superficial injuries (910–924.9), and foreign bodies (930–930.9).	
Primary mechanism of injury classified as either blunt or penetrating:	
Blunt is defined as an injury in which the primary E-code is mapped to the following categories: fall, machinery, motor vehicle traffic, pedestrian, cyclist, and struck by or against.	
Penetrating is defined as an injury in which the primary E-code is mapped to the following categories: cut/pierce and firearm.	
Severely injured patients with at least one AIS \geq 3:	
For blunt injuries: At least one injury in any of the following AIS body regions: head, face, neck, thorax, abdomen, spine, or upper and lower extremity.	
For penetrating injuries: At least one AIS \geq 3 injury in any of the following AIS body regions: neck, thorax, and abdomen.	
Calculated Injury Severity Score (ISS)* \geq 9	
ED discharge disposition and hospital discharge disposition must be known.	
Exclusion criteria	
Gunshot wound to the brain defined by E-codes: E922.0–.9 E955.0–.4 E965.0–4, E979.4 E985.0–.4 E970 AND at least one ICD-9 code in the range: 800–801.99, 850–854.1.	
Comorbidity: Preexisting advanced DNR directive to withhold life-sustaining interventions.	
Isolated hip fracture in the elderly defined as an ICD-9 code in the range of 820.0–821.9, AND all other injuries outside the lower extremity with an AIS \leq 2 AND age \geq 65 y.	
Dead on arrival.	

*Estimated using ICD-9 map.

AIS, Abbreviated Injury Scale; DNR, do not resuscitate; E-code, external mechanism of injury ICD code; ED, emergency department; ICD, International Classification of Diseases.

diagnosis code (ICD-9CM 800-959.9) excluding late effects of injury, superficial injuries, and foreign bodies.²⁹ In addition, patients must be admitted (defined by the hospital-specific trauma registry inclusion criteria), transferred from another institution, or have died as a result of their injury. But there is significant variation across hospitals in inclusion criteria such as the duration of admission that mandates registry inclusion, the inclusion of isolated hip fractures in the elderly, and the inclusion of patients dead on arrival.³⁰ These differences would create significant challenges with risk adjustment. Adoption of NTDS will minimize these variations.

To mitigate these concerns, we chose to narrow the population so virtually all patients meeting TQIP inclusion would meet inclusion for each facility's trauma registry. The inclusion and exclusion criteria are listed in Table 2. From this population, only three distinct cohorts of patients will be included in TQIP as follows:

1. Blunt multisystem injury: Blunt trauma with injuries of Abbreviated Injury Score (AIS) \geq 3 in at least two of the following AIS body regions: head, face, neck, thorax, abdomen, spine, or upper and lower extremities.
2. Penetrating truncal injury: Penetrating trauma with injuries of AIS \geq 3 in one of the following AIS body regions: neck, chest, or abdomen.
3. Blunt single system injury: Blunt trauma with injuries of AIS \geq 3 limited to only one AIS body region, with all other body regions having a maximum AIS \leq 2.

The rationale for taking this approach is threefold. First, each cohort challenges different aspects of clinical care, ranging from prompt assessment and surgical intervention to multidisciplinary coordination. Second, because patient populations might be differently represented at different trauma centers, it is important to provide an opportunity for benchmarking that would assure relevance to each participating facility. Last, differential outcomes across the three cohorts for a particular center in relation to other centers would provide a means to better focus performance improvement efforts.

Trauma Quality Improvement Program outcomes

TQIP will focus on in-hospital mortality as the primary outcome. Although death is easy to capture as a marker of trauma center performance,³¹⁻³³ survival to discharge alone is inadequate to evaluate all aspects of care that may be targeted to improve quality of care. Other outcomes may include 30-day or longer mortality, compliance with evidence-based processes of care, complications, longterm functional outcomes, and quality of life.

A complication is defined as any event that deviates from an anticipated uneventful recovery from illness or surgery.⁵

Complications that may be used for measuring quality of care should be important, ie, may increase the risk of death or disability, extend length of stay, or require additional procedures or treatments. In addition, all institutions must adopt uniform definitions and consistent methodology for screening patients for those complications. The top 10 complications identified in the NTDB are pneumonia, urinary tract infection, myocardial infarction, ARDS, coagulopathy, wound infection, skin breakdown, aspiration pneumonia, cardiac arrest, and renal failure.³⁴ The TQIP group is currently working with other subcommittees of the COT to develop uniform, evidence-based definitions of trauma-related complications.

Processes of care refer to how care is delivered to the patients when they are hospitalized. If the appropriate processes of care are in place, complications are reduced and outcomes are improved.³⁵ The Centers for Medicare and Medicaid Services are partnering with physicians and hospitals on a broad array of quality and safety outcomes and processes. One example is the Surgical Care Improvement Project,³⁶ whose goal is to use evidence-based processes to reduce surgical complications by 25% over the next 3 years.³⁶ It is not clear if compliance with Surgical Care Improvement Project measures will improve quality of trauma care. Interestingly, in a study recently performed by Shafi and colleagues,³⁷ there was no relationship between compliance with several Centers for Medicare and Medicaid Services quality indicators and risk-adjusted trauma mortality rates, probably because current Surgical Care Improvement Project measures are not relevant to trauma patient populations. The TQIP group is currently looking to identify evidence-based processes of care that are relevant to common injuries and complications (Table 1).

The most important outcome may be the patient's ability to return to his or her preinjury functional status and quality of life. Several studies have shown that trauma patients suffer from significantly lower quality of life after injury compared with population norms.^{38,39} Although the Outcomes Committee of the COT recommends using SF-36 to assess quality of life post-trauma,⁴⁰⁻⁴² these data are currently not captured by trauma registries. So TQIP will not be able to use functional outcomes or quality of life measures at this time.

Trauma Quality Improvement Program benchmark reports (Appendix 1, online only)

The outcomes of interest for the purposes of TQIP benchmarking will include in-hospital mortality, rates of selected morbidities (complications), and rates of adherence to the process measures listed in Table 1. Statistical modeling for the purposes of risk adjustment will be performed by COT statisticians. Predictive models will be developed to allow

for the assessment of expected rates of outcomes based on institutional case mix. The covariates and relevant coefficients for the risk adjustment models will be reevaluated and published every year to assure transparency.

Annual reports to participating trauma centers will provide information on the centers' O/E mortality ratios, with their 90% confidence intervals. If the O/E ratio with its 90% confidence interval excludes unity, then the institution will be considered an outlier. Centers might be high outliers (O/E ratio > 1, suggesting higher than expected deaths) or low outliers (O/E ratio < 1, suggesting fewer than expected deaths), given their case mix. Centers with O/E ratios with 90% confidence intervals overlapping 1 (suggesting as many deaths as expected) will be considered optimal performers. O/E ratio statistics will be provided in aggregate for all patients and for each of the three cohorts to identify where institutions excel and where opportunities for improvement exist. It is important to emphasize that small number of patients from a trauma center may lead to wide confidence intervals.

Selected complications will also be used for external benchmarking. Complications will be presented to each center along with the average rate across centers to allow for crude interfacility comparisons. Although the NTDS list of complications is relatively comprehensive, it is likely that not all complications are worthy of reporting. Our goal is to focus on those that might increase length of stay or mortality attributable to their occurrence as discussed earlier. One possible outcome may be a morbidity burden for each patient, which is a weighted sum of the complications experienced by the patient. Risk-adjustment models would be developed to predict an expected weighted morbidity burden for each facility, which can then be compared across centers.

The selected outcomes and process measures will be reviewed on an annual basis. New or additional outcomes will be considered if there is evidence that data capture for the outcome of interest is possible and covariates for risk adjustment are available and free of bias.

Trauma Quality Improvement Program pilot study

A pilot study of TQIP including 23 centers was initiated in 2008. Centers submitted calendar year 2007 data to NTDB using the existing mechanisms for data submission. This pilot provided an opportunity to identify specific issues that related to TQIP implementation, such as data quality and mapping (described earlier). The findings were used to develop relevant educational programs for the registrars to improve validity and reliability of the data collected. Because the data used in the TQIP pilot study were collected before the registrars' training, the pilot data provided a baseline measure of data quality that can be moni-

tored for improvement. The pilot study also enabled the participating centers and NTDB to troubleshoot technical issues that had affected NTDB data quality in past years. Finally, the pilot study was used to develop the format of the annual TQIP reports. The first set of TQIP benchmark reports based on admission year 2007 has been sent to all participating centers for feedback to inform the next phase of the study.

Trauma Quality Improvement Program implementation plan

In 2009, we will invite greater participation of Level I and II trauma centers. By 2010, we hope to have approximately 30 centers involved in the program. The program will be gradually expanded over the next few years. Participating centers will be required to train their registrars as described earlier. TQIP benchmark reports based on 2008 data will be sent to pilot centers by the end of 2009. Beginning in 2010, we will also develop and test the TQIP fields that will capture the processes of care described above. It is anticipated that the costs for participation will be relatively low (up to \$10,000 per annum for each center), which should not pose a significant impediment to participation.

Quality improvement through the Trauma Quality Improvement Program (Fig. 2)

TQIP will provide several opportunities for quality improvement to participating facilities. These will include annual reports to individual centers, annual meetings, and site visits. Reports will benchmark the trauma center to other centers using risk-adjusted outcomes while maintaining the anonymity of the other centers. Ability to compare one's performance with that in other trauma centers should provide a strong incentive for improvement to high outliers, as shown by NSQIP. In essence, a trauma center's O/E ratio can be thought of as representing a "dashboard warning light" that will warrant a "look under the hood" to identify opportunities for improvement. Structured site visits will be undertaken on request from individual trauma centers to help them identify structural, procedural, and cultural characteristics that may affect their performance. Site visits to best performing centers may be used to identify their institutional characteristics that help them achieve best outcomes. Annual TQIP meetings will provide a forum for exchange of research findings, training in TQIP procedures, and dissemination of quality improvement programs. Finally, TQIP will provide several opportunities for research to improve quality of care such as improved methodologies for benchmarking, identifying institutional structures and processes of care that affect outcomes, estimating relationships between morbidities and mortality,

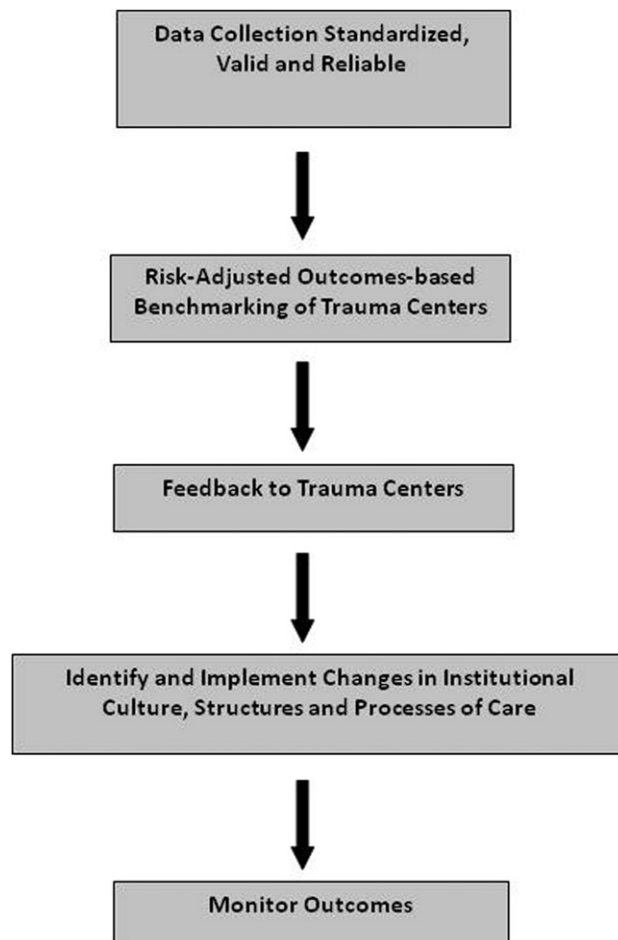


Figure 2. Trauma Quality Improvement Program.

volume-outcomes relationships, and causes of death and complications in high versus low outliers.

Summary of Trauma Quality Improvement Program

The fundamental objective of the TQIP of the COT is to improve quality of trauma care through robust risk-adjusted benchmarking of trauma centers. To accomplish this objective, the COT is undertaking several steps to collect valid and reliable data, provide timely and appropriate feedback to trauma centers, and identify interventions that may improve patient outcomes, as summarized below:

1. All verified or designated Level I and II trauma centers will be eligible for voluntary participation in TQIP.
2. Registrars from participating trauma centers will be required to undergo continuing training to ensure validity, reliability, accuracy, and completeness of data.
3. Data will be collected by the participating trauma centers and sent annually to NTDB through existing mechanisms. Relatively few (10 to 15) additional data

elements will be needed for TQIP that are not currently collected by the NTDB.

4. Data submitted by each trauma center will be validated both internally and externally.
5. Three specific cohorts of patients with AIS ≥ 3 will be eligible for inclusion in TQIP: blunt multisystem injuries, penetrating truncal injuries, and blunt single system injury.
6. Risk-adjusted observed-to-expected in-hospital mortality ratios, rates of selected morbidities (complications), and rates of adherence to the process measures and morbidity ratios will be calculated for each center using robust statistical techniques.
7. Each center will receive an annual confidential TQIP report benchmarking its outcomes to other trauma centers. It is expected that TQIP reports will encourage trauma centers to identify opportunities for improvement in their practices that may improve patient outcomes.
8. Quality improvement will occur through annual TQIP reports to individual trauma centers, annual TQIP meetings, site visits to trauma centers, and through research to identify new and innovative approaches to improve outcomes of trauma patients.

REFERENCES

1. Maier RV. Trauma: the paradigm for medical care in the 21st century. *J Trauma* 2003;54:803–813.
2. Donabedian A. Evaluating the quality of medical care. *Millbank Memorial Fund Quarterly* 1966;44:166–206.
3. Institute of Medicine. *To err is human: building a safer health system*. Washington, DC: Institute of Medicine; 1999.
4. Institute of Medicine. *Crossing the quality chasm: a new health system for the 21st century*. Washington, D.C.: Institute of Medicine; 2001.
5. American College of Surgeons. *Resources for optimal care of the injured patient*. Chicago, IL: American College of Surgeons - Committee on Trauma; 2006.
6. American College of Surgeons. *Trauma consultation and verification*. Available at: <http://www.facs.org/trauma/ntdbacst.html>. Accessed December 7, 2007.
7. Mitchell FL, Thal ER, Wolferth CC. American College of Surgeons Verification/Consultation Program: analysis of unsuccessful verification reviews. *J Trauma* 1994;37:557–562; discussion 562–564.
8. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med* 2006;354:366–378.
9. American College of Surgeons. *Performance improvement and patient safety*. Available at: <http://www.facs.org/trauma/performance/safety.html>. Accessed December 7, 2007.
10. Champion HR, Copes WS, Sacco WJ, et al. The Major Trauma Outcome Study: establishing national norms for trauma care. *J Trauma* 1990;30:1356–1365.
11. American College of Surgeons. *National Trauma Data Bank (NTDB)*. Available at: <http://www.facs.org/trauma/ntdb.html>. Accessed December 7, 2007.
12. Hemmila MR, Jakubus JL, Wahl WL, et al. Detecting the blind spot: complications in the trauma registry and trauma quality improvement. *Surgery* 2007;142:439–448; discussion 448–449.
13. Shafi S, Nathens A, Parks J, et al. Trauma quality improvement using risk adjusted outcomes. *J Trauma* 2008;64:599–606.
14. Birkmeyer JD, Dimick JB, Staiger DO. Operative mortality and procedure volume as predictors of subsequent hospital performance. *Ann Surg* 2006;243:411–417.
15. Chassin MR. Quality improvement nearing the 21st century: prospects and perils. *Am J Med Qual* 1996;11:S4–7.
16. Pronovost PJ, Angus DC, Dorman T, et al. Physician staffing patterns and clinical outcomes in critically ill patients: a systematic review. *JAMA* 2002;288:2151–2162.
17. Render ML, Kim HM, Deddens J, et al. Variation in outcomes in Veterans Affairs intensive care units with a computerized severity measure. *Crit Care Med* 2005;33:930–939.
18. MacKenzie EJ, Hoyt DB, Sacra JC, et al. National inventory of hospital trauma centers. *JAMA* 2003;289:1515–1522.
19. Shafi S, Friese R, Gentilello L. Moving beyond personnel and process: A case for incorporating outcome measures in trauma center designation process. *Arch Surg* 2008;143:115–119.
20. Shafi S, Stewart RM, Nathens AB, et al. Significant variations in mortality occur at similarly designated trauma centers. *Arch Surg* 2009;144:64–68.
21. Khuri SF. The NSQIP: a new frontier in surgery. *Surgery* 2005;138:837–843.
22. Khuri SF, Daley J, Henderson W, et al. Risk adjustment of the postoperative mortality rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. *J Am Coll Surg* 1997;185:315–327.
23. Khuri SF, Daley J, Henderson WG. The comparative assessment and improvement of quality of surgical care in the Department of Veterans Affairs. *Arch Surg* 2002;137:20–27.
24. Khuri SF, Henderson WG, Daley J, et al. The Patient Safety in Surgery Study: background, study design, and patient populations. *J Am Coll Surg* 2007;204:1089–1102.
25. Englesbe MJ, Pelletier SJ, Kheterpal S, et al. A call for a national transplant surgical quality improvement program. *Am J Transplant* 2006;6:666–670.
26. Hua HT, Cambria RP, Chuang SK, et al. Early outcomes of endovascular versus open abdominal aortic aneurysm repair in the National Surgical Quality Improvement Program-Private Sector (NSQIP-PS). *J Vasc Surg* 2005;41:382–389.
27. Fink AS. Evidence-based outcome data after hernia surgery: a possible role for the National Surgical Quality Improvement Program. *Am J Surg* 2004;188:30S–40S.
28. Hemmila MR, Jakubus JL, Maggio PM, et al. Real money: complications and hospital costs in trauma patients. *Surgery* 2008;144:307–316.
29. American College of Surgeons. *National Trauma Data Standard*. Available at: <http://www.ntdsdictionary.org/>. Accessed January 13, 2009.
30. Mann NC, Guice K, Cassidy L, et al. Are statewide trauma registries comparable? Reaching for a national trauma dataset. *Acad Emerg Med* 2006;13:946–953.
31. Fallon WF, Jr, Barnoski AL, Mancuso CL, et al. Benchmarking the quality-monitoring process: a comparison of outcomes analysis by Trauma and Injury Severity Score (TRISS) methodology

- with the peer-review process. *J Trauma* 1997;42:810–815; discussion 815–817.
32. Ivatury RR, Guilford K, Malhotra AK, et al. Patient safety in trauma: maximal impact management errors at a level I trauma center. *J Trauma* 2008;64:265–270; discussion 270–272.
 33. Shanti CM, Tyburski JG, Rishell KB, et al. Correlation of revised trauma score and injury severity score (TRISS) predicted probability of survival with peer-reviewed determination of trauma deaths. *Am Surg* 2003;69:257–260; discussion, 260.
 34. Karadooni S, Haut ER, Chang DC, et al. Hazards of benchmarking complications with the National Trauma Data Bank: numerators in search of denominators. *J Trauma* 2008;64:273–277; discussion 277–279.
 35. Birkmeyer JD, Dimick JB. Potential benefits of the new Leapfrog standards: effect of process and outcomes measures. *Surgery* 2004;135:569–575.
 36. Medicare Quality Improvement Community. SCIP Project Information. Available at: <http://www.medqic.org/dcs/ContentServer?cid=1122904930422&pagename=Medqic%2FContent%2FParentShellTemplate&parentName=Topic&c=MQParents>. Accessed December 15, 2008.
 37. Shafi S, et al. CMS quality indicators do not correlate with risk-adjusted mortality at trauma centers. Paper presented at: 22nd Annual Scientific Assembly of the Eastern Association for the Surgery of Trauma, January 2009, Lake Buena Vista, FL.
 38. Brenneman FD, Katyal D, Boulanger BR, et al. Long-term outcomes in open pelvic fractures. *J Trauma* 1997;42:773–777.
 39. Seto TB, Taira DA, Berezin R, et al. Percutaneous coronary revascularization in elderly patients: impact on functional status and quality of life. *Ann Intern Med* 2000;132:955–958.
 40. Hawker G, Melfi C, Paul J, et al. Comparison of a generic (SF-36) and a disease specific (WOMAC) (Western Ontario and McMaster Universities Osteoarthritis Index) instrument in the measurement of outcomes after knee replacement surgery. *J Rheumatol* 1995;22:1193–1196.
 41. MacKenzie EJ, McCarthy ML, Ditunno JF, et al. Using the SF-36 for characterizing outcome after multiple trauma involving head injury. *J Trauma* 2002;52:527–534.
 42. Stucki G, Liang MH, Phillips C, Katz JN. The Short Form-36 is preferable to the SIP as a generic health status measure in patients undergoing elective total hip arthroplasty. *Arthritis Care Res* 1995;8:174–181.

Appendix 1: Sample Benchmark Report (cover page only)

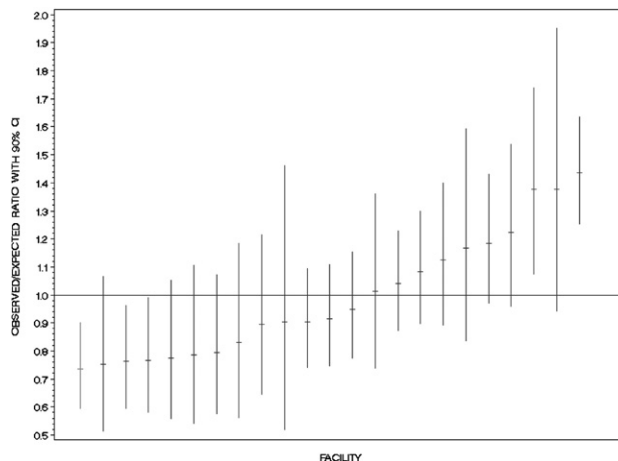
Date xx/xx/xxxx

Facility ID xxxxx

Dear TQIP Pilot Participant:

Thank you for participating in the pilot study of the Trauma Quality Improvement Program (TQIP) of the American College of Surgeons - Committee on Trauma (COT). We have enclosed a report that presents your trauma center's risk-adjusted mortality along with the other 22 participating centers based upon data with hospital arrival year of 2007. The ratio of observed number of deaths to the expected number of deaths (O/E ratio) is used for this analysis. The expected number of deaths was derived from a statistical model that allows us to estimate the number of deaths based upon the characteristics of the patients at your institution. We report the O/E ratio along with the 90% confidence intervals (CI). A 90% CI indicates that we are 90% certain that the true O/E ratio falls within this range. The inclusion criteria, statistical methodology, a guide to the interpretation of findings, and limitations of this analysis are described in detail in the attached document.

In summary, the observed-to-expected mortality ratio of data qualifying into TQIP with admission year 2007 at



your trauma center was less than 1.0 as depicted by the red bar in the diagram. This suggests that the patients treated at your trauma center were at lower risk of dying than expected from their baseline characteristics and injury severity.

Thanks again for your participation in TQIP. Please feel free to contact us with any concerns or questions.

Trauma Quality Improvement Program (TQIP)
ACS Committee on Trauma