Regional collaborative quality improvement for trauma reduces complications and costs

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BACKGROUND: Although evidence suggests that quality improvement to reduce complications for trauma patients should decrease costs, studies have not addressed this question directly. In Michigan, trauma centers and a private payer have created a regional collaborative quality initiative (CQI). This CQI program began as a pilot in 2008 and expanded to a formal statewide program in 2010. We examined the relationship between outcomes and expenditures for trauma patients treated in collaborative participant and nonparticipant hospitals.

METHODS: Payer claims and collaborative registry data were analyzed for 30-day episode payments and serious complications in patients admitted with trauma diagnoses. Patients were categorized as treated in hospitals that had different CQI status: (1) never participated (Never-CQI); (2) collaborative participant, but patient treated before CQI initiation (Pre-CQI); or (3) active collaborative participant (Post-CQI). DRG International Classification of Diseases—9th Rev. codes were crosswalked to Abbreviated Injury Scale (AIS) 2005 codes. Episode payment data were risk adjusted (age, sex, comorbidities, type/severity of injury, and year of treatment), and price was standardized. Outcome data were risk adjusted. A serious complication consisted of one or more of the following occurrences: acute lung injury/adult respiratory distress syndrome, acute kidney injury, cardiac arrest with cardiopulmonary resuscitation, decubitus ulcer, deep vein thrombosis, enterocutaneous fistula, extremity compartment syndrome, mortality, myocardial infarction, pneumonia, pulmonary embolism, severe sepsis, stroke/cerebral vascular accident, unplanned intubation, or unplanned return to operating room.

RESULTS: The risk-adjusted rate of serious complications declined from 14.9% to 9.1% ($p < 0.001$) in participating hospitals (Post-CQI, n = 26). Average episode payments decreased by $2,720 (from $36,043 to $33,323, $p = 0.08$) among patients treated in Post-CQI centers, whereas patients treated at Never-CQI institutions had a significant year-to-year increase in payments (from $23,547 to $28,446, $p < 0.001$). A savings of $6.5 million in total episode payments from 2010 to 2011 was achieved for payer-covered Post-CQI treated patients.

CONCLUSION: This study confirms our hypothesis that participation in a regional CQI program improves outcomes and reduces costs for trauma patients. Support of a regional CQI for trauma represents an effective investment to achieve health care value. (*J Trauma Acute Care Surg*. 2015;78: 78–87. Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Economic/value-based evaluation, level III.

KEY WORDS: Trauma outcomes; quality improvement; complications; costs.

The American College of Surgeons' *Inspiring Quality* initiative is focused on raising awareness of innovative programs to improve the quality of care for surgical patients.[1] Improving quality of care leads to fewer complications, which translates into better outcomes, greater access for patients, and potentially lowers costs. Value in health care is defined as outcomes relative to costs.[2] Value is an important measure of efficiency in relation to quality since cost reduction without concern for outcomes achieved is detrimental and leads to self-defeating cost savings at the expense of effective clinical care. Concern regarding the relationship between variation in quality and its impact on increasing health care expenditures has led to recent heath care policy initiatives focused on achieving high-quality care with efficient use of scarce health care resources.[3]

Estimated total 1-year treatment costs of major trauma in adult patients is roughly $27 billion annually in the United States.[4] The National Study on Costs and Outcomes of Trauma concluded that care provided at a regional Level 1 trauma center reduces the risk of death by 25% when compared with care of the injured patient at a nontrauma center hospital.[5] This increased survival benefit impacts costs, and treatment at a trauma center versus nontrauma center hospital adds approximately $37,000 in expenditures per quality-adjusted life year gained.[6] The relative cost-effectiveness of care provided in a trauma center is greatest for patients with higher injury severity and in younger patients. These findings support the regionalization of trauma care with triage to the most appropriate level of trauma center to match the injury burden and complexity of each patient.

The American College of Surgeons' Committee on Trauma (ACS COT) is committed to improving all phases of the management of the injured patient and in particular the

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"trauma system."[7] At the heart of an effective trauma system is a multidisciplinary performance improvement (PI) process. The PI process is charged with monitoring patient care, evaluating adverse outcomes, and improving compliance with quality-of-care indicators. To support the PI process and supply risk-adjusted benchmarking to individual trauma programs, the ACS COT created the Trauma Quality Improvement Program (TQIP).[8] In a cohort of similarly verified or designated trauma centers, TQIP discovered significant differences in risk-adjusted mortality outcomes for aggregate, blunt multisystem injury and blunt single system injury.[8,9]

In the state of Michigan, Blue Cross Blue Shield of Michigan (BCBSM), a commercial health care insurance provider, has supported the creation of collaborative quality initiatives (CQIs) on a regional level. The Value Partnership Program of BCBSM is the most ambitious privately sponsored quality improvement program of its type nationwide. Their CQI program, composed of 15 statewide clinical registry-based collaboratives, involving multiple specialties, enrolls 200,000 patients annually and costs more than $25 million annually to administer. To focus on improving the quality of care delivered to trauma patients, BCBSM financially supports the Michigan Trauma Quality Improvement Program (MTQIP).

MTQIP consists of 26 ACS COT Level I and II verified hospitals delivering trauma care in the state of Michigan. The program began in 2008 as a voluntary pilot and was formalized in July 2010 with provision of sustained funding and expansion of enrollment. MTQIP provides comprehensive risk-adjusted benchmark reports to participants in paper form and on a query-enabled Web site. Face-to-face collaborative meetings among all participants are held three times per year. Trauma centers participate in global PI projects (venous thromboembolism prophylaxis, hemorrhage control and blood use, brain injury management). In addition, each center selects its own individual projects with knowledge of baseline data and setting of target values for quality improvement. All MTQIP participant trauma centers are also enrolled in ACS-TQIP and receive full benefits of national participation and benchmarking.

In this study, we used MTQIP data to examine the efficacy of a regional CQI to reduce serious complication rates for trauma patients over time. We also obtained BCBSM claims data and conducted a return-on-investment analysis based on third-party payments for trauma patient diagnoses in MTQIP participant and nonparticipant hospitals.

PATIENTS AND METHODS

Program

MTQIP is composed of all 26 ACS COT–verified Level 1 and 2 trauma centers in Michigan. The program began in 2008 with voluntary participation among seven hospitals. Initial monetary support for the pilot program was obtained from the BCBSM Foundation. MTQIP became a formal BCBSM enterprise–supported CQI on July 1, 2010. Additional interested trauma centers were incorporated on a rolling basis as CQI members between 2009 and 2012. BCBSM provides financing for all of the operating costs of the MTQIP coordinating center. In addition, monetary support is provided by BCBSM to each participant trauma center for enrollment in TQIP, registry license fees, and 30% of a full-time equivalent for data abstraction/entry. Face-to-face collaborative meetings are held three times per year where feedback reports are distributed, data are reviewed, discussion of results occurs, and best practices are shared.

Serious Complications

Serious complications are a composite outcome measure, which include mortality and morbidity (Grade 2 and 3) events that are associated with increased mortality risk or substantial use of hospital resources (Table 1).[10,11] Data for this analysis were abstracted from the MTQIP database for years 2008 to 2013. MTQIP uses a data definitions dictionary, which is published online and updated annually.[12] Each MTQIP center undergoes an annual data validation audit. Written feedback reports detailing audit performance and areas for improvement are provided. Inclusion criteria to form the analysis patient cohort are listed as follows:

- Age of 18 years of older.
- At least one valid trauma DRG International Classification of Diseases—9th Rev.—Clinical Modification (ICD-9-CM) code in the range of 800 to 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 where 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 where the primary E-code is mapped to the following categories: cut/pierce and firearm.
- Calculated Injury Severity Score (ISS) of 5 or greater.
- Emergency department (ED) discharge disposition and hospital discharge disposition must be known.

Patients with no signs of life at initial evaluation (ED systolic blood pressure, 0; pulse, 0; Glasgow Coma Scale [GCS] score, 3) were excluded.[13] All ISS values were derived from registrar abstracted and recorded Abbreviated Injury Scale (AIS) 2005 codes.

The primary outcome of interest was occurrence of a serious complication during hospitalization. Multivariable logistic regression modeling was used to account for differences in baseline characteristics and injury severity, thereby allowing for risk adjustment at the patient level. Potential predictors for the outcome of interest on bivariate analysis were entered into the model. A logit equation was derived based on the significant covariates using forward selection. The order of variable entry was determined by the c-index, which measures the ability of a parameter to discriminate outcome. Expected risks of a serious complication were calculated for each patient using the modeled logit equation. Adjusted rates of serious complications for each hospital or year were calculated by multiplying the rate ratio of observed to expected events by the overall collaborative rate.

In some instances, specific incidents had missing values for potentially important covariates (GCS motor score, systolic

TABLE 1. Complication Grades

Complication	Grade 1	Grade 2	Grade 3	Serious
Catheter-related bloodstream infection	X			
Clostridium difficile colitis	X			
Deep SSI	X			
Drug or alcohol withdrawal syndrome	X			
Graft/prosthesis/flap failure	X			
Organ/space SSI	X			
Osteomyelitis	X			
Superficial SSI	X			
Unplanned Return to ICU	X			
Urinary tract infection	X			
Wound disruption	X			
Decubitus ulcer		X		X
DVT		X		X
Enterocutaneous fistula		X		X
Extremity compartment syndrome		X		X
Pneumonia		X		X
Pulmonary embolism		X		X
Unplanned intubation		X		X
Unplanned return to OR		X		X
Acute lung injury/ARDS			X	X
Acute kidney injury (dialysis)			X	X
Cardiac arrest with CPR			X	X
Mortality			X	X
Myocardial infarction			X	X
Severe sepsis			X	X
Stroke/CVA			X	X

ARDS, adult respiratory distress syndrome; CPR, cardiopulmonary resuscitation; CVA, cerebral vascular accident; DVT, deep vein thrombosis; ICU, intensive care unit; OR, operating room; SSI, surgical site infection.

blood pressure, and pulse rate). To minimize bias, these values were imputed using multiple imputation techniques because missing data were frequently not missing at random. The final model and analysis included all of the incidents that met MTQIP entry criteria for the cohort being examined. To measure how well the model discriminated between prediction of a serious complication, a c-index was calculated. Model fit was checked by constructing a calibration curve. The risk-adjusted serious complication rate was plotted as a function of time by year. In a separate analysis, we determined the serious complication rate as a function of time for the initial seven trauma centers only. *p* values for the change in serious complication or mortality rate over time were calculated using the Cochran-Armitage Trend Test.

Episode Payments

BCBSM claims data from 2008 through 2011 were used as the source of information for calculating trauma patient episode payments. These files contain detailed information about payments made for inpatient, outpatient, emergency care, and professional services. Payment information was also available for covered services related to home health care, rehabilitation, care in skilled nursing facilities, and readmission. In some cases, BCBSM payments were made as the secondary insurance provider for the patient (e.g., Medicare).

Trauma patients were identified by querying the data file for patients with at least one ICD-9-CM code in the range of 800 to 959.9. Patients with codes only in the ranges of late effects (905–909.9), superficial injuries (910–924.9), or foreign bodies (930–930.9) were excluded. Patients with burn injuries only (940.0–949.5) were also excluded. The final cohort consisted of patients with an ISS of 1 or greater who met all inclusion and exclusion criteria. ICD-9-CM diagnosis codes were crosswalked to AIS 2005 codes and ISS values using software services available from Digital Innovation, Inc. (Forest Hill, MD).

We defined a trauma episode as the window of time starting the day of admission and ending 30 days after discharge from the hospital. Within this time frame, we included all hospital and physician payments related to the index hospitalization, as well as all payments for ancillary care occurring following discharge (home health, rehabilitation, skilled nursing facilities, and hospice). In our analyses, costs were assessed in terms of price-standardized payments, which account for regional, provider, and time-specific differences in prices. We first used a commercial claims regrouping program to reassign diagnosis-related groups (DRGs) based on current coding rules for DRG assignment (MS-DRG version 30). We then determined a single "standard" price for each reimbursed service and applied this price to each claim. In our analyses, we

used a standard based on average payments for episode payments for BCBSM patients in 2011. For hospital services, we applied the standardized price to each DRG and adjusted outlier payments for the hospital-specific DRG payment relative to the standard DRG price. For physician services, we applied the standard price based on the Resource Based Relative Value Scale and conversion factor. For carrier file services not included in the physician fee schedule, we used the median payment amount for the specific line item. Finally, for post–acute hospital stays, skilled nursing facility stays, home health care and hospice use, we generally applied an average standard payment amount for each day provided in the specific setting.

Patients were defined as being in one of three groups based on hospital enrollment in MTQIP and the date of incorporation of the hospital into MTQIP: (1) never participated (Never-CQI); (2) collaborative participant, but patient treated before CQI initiation (Pre-CQI); or (3) active collaborative participant (Post-CQI). Coefficients representing a patient's comorbidity profile were calculated based on ICD-9-CM codes using the method of Elixhauser and condensed to a single numeric score.[14,15] Multivariable linear regression was used to assess mean or median episode payments over time in Never-CQI, Pre-CQI, and Post-CQI patients while adjusting for patient characteristics (age, sex, Elixhauser comorbidities), injury (ISS, AIS score > 2 by body region), and interaction effects. This model was used to assess the statistical significance of differences in payments over time between case and control patients. BCBSM hospital-specific median episode payments were linked to the risk-adjusted MTQIP serious complications data to evaluate the relationship between changes in quality and cost at the hospital level.

Statistical Methods

Statistical analyses were performed using Stata 12.0 (StataCorp, College Station, TX) or SAS 9.3 (SAS Institute Inc, Cary, NC) statistical package software. Graphs were produced using GraphPad Prism 5.0 software (GraphPad Software, La Jolla, CA). Results are presented as adjusted mean or median values ± 95% confidence intervals. Statistical significance was defined as a $p < 0.05$.

RESULTS

Serious Complications

Patient characteristic data by year for the MTQIP is listed in Table 2. A logistic regression model containing the following covariates was constructed using forward selection for the outcome measure serious complication: age, sex, race, ISS, abdominal AIS score, chest AIS score, extremity AIS score, motor GCS score, ED systolic blood pressure, ED heart rate, intubation status, mechanism of injury, transfer status, congestive heart failure, chronic obstructive pulmonary disease, myocardial infarction, cirrhosis, cerebral vascular accident with hemiparesis, acquired coagulopathy, routine steroid use, dialysis, metastasis, chronic alcohol abuse, gastric or esophageal varices, and statin medication use. Calculated c-index for this model was 0.87, and the calibration curve is shown (Supplemental Digital Content 1, http://links.lww.com/TA/A502). The MTQIP risk-adjusted serious complication rate declined from 14.9% in 2008 to 9.1% in 2013 (Fig. 1*A*). The mean rate for the entire period was 10.6%. There was a significant decrease in the serious complication rate from 2008 to 2013 ($p < 0.001$, Cochran-Armitage Trend Test). During the study period, the risk-adjusted mortality rate declined from 5.2% to 4.2% ($p < 0.001$, Cochran-Armitage Trend Test). To assure that the decline in serious complications finding was not a result of bias from new centers joining the collaborative during the investigated period, a second analysis was performed using only data from the original seven trauma centers in MTQIP. The same findings were obtained with a significant decrease in serious complications from 2008 to 2013 ($p < 0.001$, Fig. 1*B*).

Episode Payments

The BCBSM claims data contain information on insured patient hospitalizations for traumatic injury across thousands of hospitals. Patient characteristic data by cohort (Never-CQI, Pre-CQI, and Post-CQI) is detailed in Table 3. In constructing the risk adjustment model, we had to accept some limitations. First, no ED physiology or neurologic function data were available. Second, AIS values and ISSs were derived from an ICD-9-CM crosswalk program. No patients had an AIS score greater than 2 in the face or external regions of injury. A linear regression model containing the following covariates was constructed: age, sex, ISS, head AIS score, abdominal AIS score, chest AIS score, extremity AIS score, Elixhauser comorbidity index, and year of admission. Changes in mean 30-day episode payments by year are illustrated in Figure 2. The Never-CQI patients had a consistent year-to-year increase in payments from $23,547 to $28,446 ($p < 0.001$) during the study. Total payment for Pre-CQI patients remained flat over time. Payments among patients treated in Post-CQI centers declined from $36,043 in 2010 to $33,323 in 2011 ($p = 0.08$). Although this decline did not reach statistical significance, it did result in the achievement of an estimated cost savings of $6.5 million in total episode payments from 2010 to 2011 for BCBSM-covered Post-CQI–treated patients (n = 2,384).

In a separate analysis, we investigated the dose response of serious complications on 30-day episode payments for the 26 MTQIP hospitals. Data on risk-adjusted serious complications and 30-day episode payments were summarized at the hospital level. Non-MTQIP hospitals were excluded. A graph of risk-adjusted serious complication rate versus median 30-day episode payment is shown in Figure 3*A*. Construction of a linear regression fitted line describing these data showed a positive and significantly nonzero slope ($p = 0.038$) indicative of escalating payments relative to increases in serious complications. The MTQIP hospitals were divided into quartiles based on risk-adjusted rates of serious complications. The median 30-day payment varied by performance quartile (Fig. 3*B*) but did not reach statistical significance ($p = 0.08$, Kruskal-Wallis test).

DISCUSSION

In this study, we have shown that trauma centers participating in a collaborative quality improvement program produced a 40% decline in the rate of serious complications. Episode payments increased for control patients (Never-CQI, +

TABLE 2. Serious Complications—Patient Characteristics

Characteristic	2008	2009	2010	2011	2012	2013
Trauma centers, n	7	14	22	23	26	26
Patients, n	2,652	7,042	11,561	15,400	16,816	18,613
Age, mean	56.6 ± 22.7	56.7 ± 23.0	56.1 ± 23.1	57.1 ± 23.1	57.1 ± 23.2	58.5 ± 23.5
Age, y, %						
18–25, y	11.5	12.4	12.8	12.3	12.2	12.0
26–45	22.1	21.3	22.1	20.9	21.5	19.4
46–65	27.5	27.7	27.4	27.5	26.3	25.3
66–75	10.4	9.7	10.1	10.3	11.1	11.7
>75	28.5	28.9	27.6	29.0	28.9	31.6
Male sex, %	59.6	59.2	57.2	58.1	58.8	56.6
White race, %	80.0	78.7	73.2	76.4	76.1	76.7
Blunt mechanism, %	92.5	92.8	92.7	92.8	92.7	93.3
Pulse, beats/min, %						
51–120	89.9	91.7	91.9	92.5	92.4	91.7
>120	5.5	5.1	5.4	5.4	5.4	5.0
0–50	1.2	1.1	1.1	1.0	1.1	1.0
Missing	3.5	2.0	1.5	1.1	1.1	2.3
Systolic blood pressure, mm Hg, %						
>90	92.5	94.0	94.9	95.6	95.9	94.7
61–90	2.9	2.9	2.9	2.6	2.4	2.3
≤60	0.8	0.9	0.8	0.6	0.5	0.5
Missing	3.7	2.2	1.5	1.3	1.2	2.5
Motor GCS score, %						
5–6	83.3	83.5	81.4	85.2	86.6	84.8
3–4	3.4	4.3	5.0	5.0	4.9	5.0
1–2	5.8	4.3	4.0	4.3	4.1	3.9
Missing	7.5	8.0	9.6	5.5	4.4	6.3
ISS, %						
5–15	72.0	74.0	76.7	77.1	78.3	79.4
16–24	16.1	15.9	14.2	14.3	13.3	12.9
25–35	8.4	7.9	7.2	6.7	6.8	6.2
>35	3.5	2.2	1.9	1.7	1.6	1.6
Transfer, %	23.4	21.9	17.5	20.8	19.9	16.6

$4,899, $p < 0.001$), remained flat for Pre-CQI patients ($p = 0.6$), and trended downward for Post-CQI patients (−$2,720, $p = 0.08$). There was a significant increase in costs relative to the risk-adjusted rate of serious complications within MTQIP trauma centers. We believe that these changes are attributable to key components of this regional payer-funded quality improvement program. First, risk-adjusted reports of mortality and morbidity outcomes were continuously provided to trauma centers during a 5-year period. Second, face-to-face meetings of the collaborative allowed for discussion of common issues and targeting of global PI initiatives. Third, annual trauma registry data validation audits assured credibility and ongoing reductions in variability of the data.

Discovery of significant variation in patient outcomes has been documented for the specialties of cardiac surgery, general and vascular surgery, bariatric surgery, and trauma.[8,9,16–19] At least one third of patients treated for major trauma receive care at hospitals not designated for trauma care.[20] The premise behind promoting regionalization of trauma care is that concentrating severely injured patients into higher-volume centers will lead to improved outcomes. There exists a strong association of improvements in mortality and decreased hospital length of stay when trauma center volume exceeds 650 cases per year.[21] However, these benefits only occur for patients at highest risk for an adverse outcome. On the basis of these findings, the ACS-TQIP was created to address these differences and to promote best practices for trauma care.[8,9,22]

Serious complications, defined as a complication clinically important enough to increase the length of stay or require substantial additional treatment interventions, can add to risk-adjusted hospital costs for general and vascular surgery patients ($11,000).[23] An occurrence of a postoperative complication can increase the reimbursement paid to the hospital, depending on the payer mix.[24] In the setting of trauma care, development of a complication can paradoxically increase the profit margin to the hospital for an episode of care.[25] Trauma is unique compared with other surgical specialties in that it is not predominantly elective care. The complication rate for a trauma patient can be significantly higher than elective general surgery because of care delivery, patient, and injury factors.[25] Care provided within a trauma center compared with a nontrauma center is associated with a slightly higher risk of complications,

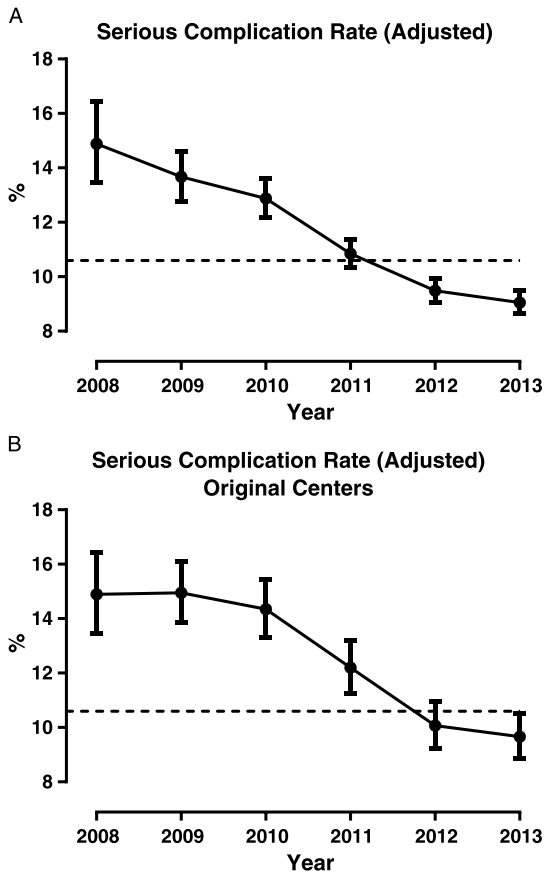

Figure 1. Risk-adjusted serious complication rate trend by year. *A*, All 26 MTQIP trauma centers ($p < 0.001$, Cochran-Armitage Trend Test). *B*, Seven MTQIP trauma centers in pilot study ($p < 0.001$, Cochran-Armitage Trend Test).

despite significant reductions in overall mortality.[5,26] A complication incident occurring in a trauma patient increases hospital costs substantially: $19,000 (minor complication) and $41,000 (major complication).[27] Trauma patients who have a major complication episode result in a $2,100 per day higher mean contribution to hospital margin compared with those patients in whom no complications occur. This risk for increased costs is largely borne by third-party payers based on the current system of claims submission and reimbursement.

Another interesting aspect of trauma care is that there exists a competing risk environment. Since the mortality rate for trauma patients is considerably higher than for general surgery patients (5–6% vs. 1–2%), the most severely injured trauma patient has both a significant risk of dying and/or development of morbidity. Trauma patients who die early in their hospital course have a potential truncation in hospital and payer costs. We accounted for this potential confounding due to death by using a composite outcomes model whereby we included mortality as a serious complication event. In a brief clinical trial of nonpublic reporting of risk-adjusted mortality alone for trauma, provision of one annual feedback report per year did not lead to improved mortality outcomes.[28] However, in our present study, we did observe a small and significant decline in mortality (1% absolute change and 20% relative change). Meaningful differences between MTQIP and the referenced study include a longer intervention period, more robust feedback with three reports provided per year, complications feedback included in addition to mortality, and provision of face-to-face meetings within the CQI.

Delivering results without information on how particular outcomes were achieved or without context regarding interventions to target for outlier centers is analogous to saying "do better" but providing no guidance on what to focus PI efforts. In fact, a dichotomy does exist within trauma care in that there is no correlation between high-performing centers with regard to mortality when carried over to morbidity ranking status.[29] Many strategies have been proposed and implemented within the health care environment to improve quality. These include national PI programs (National Surgical Quality Improvement Program, Society of Thoracic Surgeons National Database, ACS-TQIP), centers of excellence, pay-for-performance, Centers for Medicare and Medicaid Services–defined "never events," selective referral strategies, and bundling of payments.[30] The approach supported by BCBSM within Michigan can be best described as a regional collaboration.

The pay-for-participation regional collaboration model sponsored by BCBSM has the following unifying hallmarks across all CQI programs in Michigan.[3,30,31] The first is rigorous and efficient data collection with standardized data definitions and multitiered data auditing performed for completeness and accuracy. Second, a clinical champion is designated at each site with mandatory participation in collaborative meetings and commitment to PI projects that examine the

TABLE 3. Episode Payment—Patient Characteristics

Characteristic	Never-CQI	Pre-CQI	Post-CQI	*p*
Patients, n	28,680	6,439	3,630	—
Age, mean	68.4 ± 21.3	55.8 ± 26.1	64.3 ± 24.5	<0.001
Age, y, %				
≤25	7.0	19.0	12.5	<0.001
26–45	6.5	12.0	7.6	
46–65	23.9	29.9	23.4	
66–75	13.8	9.5	12.4	
>75	48.8	29.6	44.1	
Male sex, %	40.8	51.1	45.3	<0.001
Elixhauser comorbidity score, mean	1.4 ± 3.9	1.1 ± 3.6	1.9 ± 4.4	<0.001
Elixhauser comorbidity score > 2, %	24.0	20.4	29.7	<0.001
ISS, %				
1–15	93.9	90.3	91.8	<0.001
16–24	3.2	6.6	4.9	
25–35	0.5	1.1	0.9	
>35	2.4	1.9	2.3	
AIS score > 2, %				
Head/neck	8.0	14.6	13.6	<0.001
Chest	5.3	8.7	7.7	<0.001
Abdomen	0.5	1.4	0.7	<0.001
Extremity	30.9	22.3	25.6	<0.001

relationship between outcomes and processes of care required. Third, there is trust that grows within this safe environment. The outcomes data collected are not used to reward or punish participants; rather, they are used to guide collaborative quality improvement efforts. Participants are encouraged to share data and experiences; however, BCBSM has access only to aggregated data to assess the effectiveness of the program at a regionwide level.

Examples of BCBSM regional CQI successes include a decline in risk-adjusted morbidity rates from 13.1% in 2005 to 10.5% in 2009 for general and vascular surgery patients ($p < 0.0001$), a fall in overall complications for bariatric surgery from 8.7% to 6.6% associated with a significant drop in 30-day mortality from 2007 to 2009 ($p = 0.004$).[32] Improvements in quality were achieved in the interventional cardiology collaborative with reductions in contrast-associated nephropathy, stroke, and in-hospital myocardial infarction. Lastly, the cardiac surgery collaborative improved its composite quality score for Michigan participants from average on a national basis to achievement of a three-star rating from the Society of Thoracic Surgeons. This is indicative of aggregate performance that exceeds national norms with a 99% probability and falls within the top 10th percentile of all hospitals.

There are several limitations to this study that merit discussion. We were not able to link payer claims data to outcomes for MTQIP since protected health information is not collected when data are transferred from the trauma registry. Hence, comparisons of serious complications and episode payments can occur only at the hospital level and do not reflect identical groups of patients. Second, the BCBSM claims data used are representative of only a small proportion of a trauma centers' total volume and averages10% to 12% in Michigan trauma centers. The actual total cost savings produced by MTQIP may be substantially greater if the changes demonstrated for BCBSM-covered patients can be extrapolated to the other predominant third-party payers participating in trauma care reimbursement (automobile insurance, commercial health insurance, Medicare, or Medicaid). Third, our claims data demographic findings point to a cohort that is different from a typical trauma center population (e.g., older and more female patients). We accounted for these discrepancies by performing risk adjustment. However, we were limited in the robustness of risk adjustment by not having physiologic or neurologic status data. That the 2010 thirty-day payment point estimate for the Post-CQI patients is higher than for the Pre-CQI or Never-CQI cohorts suggests presence of unmeasured confounder variables. There are also ongoing changes to patient care at MTQIP participating hospitals that MTQIP had no interaction with that could affect patient outcomes. Lastly, each trauma center can experience provider turnover, and there may be a learning curve associated with transition periods as new members become familiar with MTQIP data, reports, and PI processes.

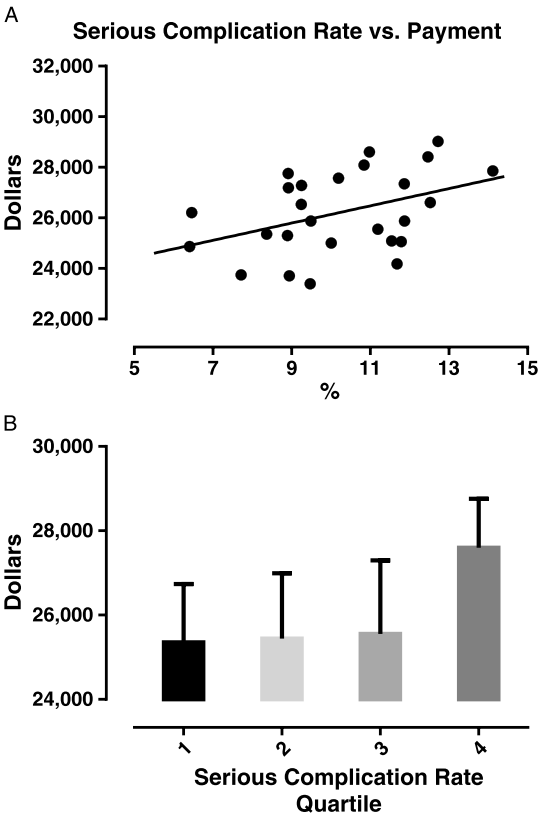

Figure 3. Risk-adjusted serious complication rate vs. 30-day episode payment. *A,* Serious complication rate versus median payment for all 26 MTQIP trauma centers ($p = 0.038$, slope of linear regression fitted line). *B,* Median payment as a function of serious complication rate quartile ($p = 0.08$, Kruskal-Wallis test).

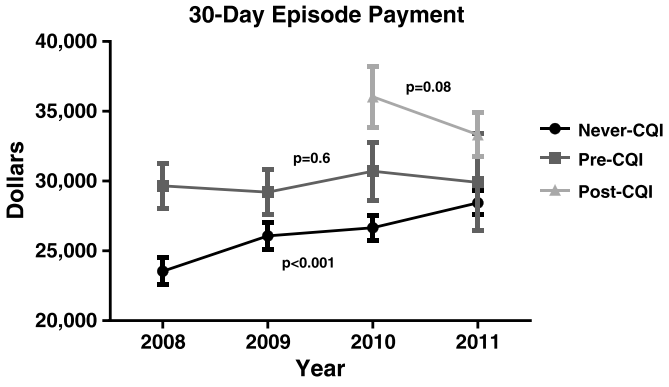

Figure 2. Thirty-day episode payment.

CONCLUSION

This study confirms our hypothesis that participation in a regional collaborative quality improvement program improves outcomes and reduces costs for trauma patients. Support of regional collaborative quality improvement for trauma represents an effective investment to achieve health care value.

AUTHORSHIP

M.R.H., W.L.W., W.E.V.K., J.L.J., and J.N.M. designed this study. M.R.H., W.L.W., W.E.V.K., J.L.J., and J.N.M. collected data. M.R.H. and A.H.C-N. performed data analysis. M.R.H., W.L.W., W.E.V.K., J.L.J., and J.N.M. contributed to data interpretation. M.R.H. wrote the manuscript and prepared figures. A.H.C.-N. prepared tables and figures. All authors participated in critical revision.

DISCLOSURE

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DISCUSSION

Dr. David B. Hoyt (Chicago, Illinois): I'd like to congratulate you, Mark, on an excellent study and an excellent presentation.

With the advent of quality as a focus of health care delivery the study of the process of quality improvement has been very common.

The critical elements for quality improvement have been determined and include the development of standards, the development of infrastructure to support the standards, the development of data tools to measure performance of the standards, and the development of verification programs to assure that the standards are being delivered.

The future of quality improvement is directed towards high reliability and value. Payment will be linked to this in the future.

Collaboratives have been developed to foster quality improvement techniques. They review the positive and negative outliers in performance and foster best practice across systems through collective intelligence and peer motivation that comes from working with others.

With the availability of data bases and the interest in quality improvement dozens of collaboratives have formed within systems of care, amongst geographically-located hospitals, and around specific diseases.

One of the first collaboratives in trauma started in San Diego 30 years ago, almost to the day. It continues to meet monthly and over the last 30 years has reduced complications, reduced costs, developed infrastructure for clinical research, and participated in education and community-based prevention.

The present study shows that hospitals participating in the Michigan Trauma Collaborative have enjoyed reduction in complications, seen their costs reduced, and demonstrated these effects resulted from participation in the collaborative.

Your commitment is admirable. In many regards participating in a collaborative seems to be the secret ingredient that brings quality improvement alive and moves hospitals and physicians toward higher reliability and value. I have several questions:

Is the reduction in specific complications attributable to specific discussion of measured complications during the collaborative, or is it, rather, a general effect on improvement in care? Can you elaborate?

If the latter, how do you explain the reduction of complications such as ARDS, a very complex complication?

Is the cost reduction similarly attributable to specific cost discussions that led to adaptation by participating hospitals?

Where do you see the reduction in costs coming from? Is it from utilization management? Adopting best practice? How do you think that's occurring based on your knowledge of the collaborative?

And finally, why are some hospitals in and others out? You said it's elective but what means should we be using to encourage participation in collaboratives?

Understanding the effects of how these collaboratives achieve the improvements will be critical in getting others to develop collaboratives to sustain continued improvement.

Our societal contract, with patients mandates that we try and achieve optimal care. Sharing our performance with others and remaining open to critique and improvement has always been a unique leadership quality in surgery.

Congratulations to the Michigan group for this important work. We should all be doing this.

Dr. Steven R. Shackford (San Diego, California): Mark, that was really a great paper. And I really appreciate the emphasis on value.

So related to that, did the stipend from Blue Cross/Blue Shield cover all of the costs to the hospitals?

There is a great deal of burden placed upon participating hospitals in all types of collaboratives on gathering process measures and how those process measures might yield more information than what I believe you gleaned from the discharge data set.

Was that the source of the serious complications, the discharge data set? Or did this identification of these serious complications arise from process measures such as DVT prophylaxis, for example?

Dr. Eileen M. Bulger (Seattle, Washington): Mark, excellent presentation and great work. I have just one question and that relates to your cost-savings.

While you saw a decline in the cost per episode in the CQI, post-CQI group, it looks like it still was lower cost overall in the non-CQI hospitals so what's the difference that accounts for that difference in cost?

Is it just that these patients are cared for at academic centers where the costs are generally higher overall so you can see a reduction?

Dr. Ajai K. Malhotra (Richmond, Virginia): Eileen just asked exactly the same question: Why was the absolute cost higher for the institutions that participated versus the non-institutions?

Dr. Walter Biffl (Denver, Colorado): Mark, that's a real important study. In Colorado we've been frustrated by the state's "lip service" to quality. Many people feel that Level I and II centers ought to be participating. Do you think this is strong enough data to get the COT to mandate it as part of a Level I or II designation?

Dr. David Harrington (Providence, Rhode Island): I'm very interested in some of the other questions can you ask of the data. Were these benefits and cost savings particular to low-, medium-, or high-injured patients? The elderly? Or different age groups or different ISSes? So where do they benefit most?

Dr. Mark R. Hemmila (Ann Arbor, Michigan): I'd like to thank Dr. Hoyt and all the members for their comments. Dr. Hoyt asked is the reduction of specific complications attributable to our collaborative discussions of specific complications?

I think right now it's hard to attribute our success to specific discussions. I think our results are more a reflection of creating an awareness among the members of things that they may never have been conscious of before. Most of us had no idea where we stood prior to getting these feedback reports. In my own institution we began to focus on VTE and urinary tract infection and have seen significant reductions in these two complications. The collaborative, as a whole, is currently focused on three areas of global PI projects. They include VTE prophylaxis, blood product ratios, and interventions for head injury.

Is the cost reduction similarly attributable to specific cost reductions that led to adaptation by hospitals participating in it? I would say right now we have not had specific cost discussions. However, we have highlighted differences in care that could contribute to increased costs. One example is the use of IVC filters. There is a large, widespread difference, even when you risk-adjust, for the use of IVC filters between our centers. Why is that? It is hard to figure out. There is no correlation whatsoever with mortality or with any other outcome for these patients having a lot of IVC filters. We are aware of surgeons taking this information back to their institutions and beginning to look into the practice patterns with their colleagues.

Where do you see the cost reductions coming from? The breakout data was messy. But there were some differences in the index DRG. So, in other words, the never group had a much larger rise in the index DRG whereas the post CQI group had a very minimal rise in index DRG payments. There was also some reduction in what is called outlier payments, readmission payments, and transfer-related payments. That might get to some of the questions asked later about the differences in the two, and where they were.

Why are some hospitals in and some are out? All of the Michigan hospitals that are verified ACS centers participate. The main incentive in Michigan was that Blue Cross will fund your participation. It is not, you know, taking over complete funding of your registry but there is additional money that is provided for the capture of these process measures and the added work burden that takes place. The downside if you don't participate is Blue Cross is a payer so the way that they structured the CQI programs in Michigan is if you don't participate you don't quality for added hospital payments because of your being in a CQI program. So there is some money to be left on the table if you don't participate.

Moving on to other questions, Dr. Shackford asked how much of the cost was covered. The entire cost of the coordinating center is covered. The cost of the registrar is sort of prorated at a 30 percent FTE with a very generous salary. The cost of enrolling in TQIP is covered. And the cost of the trauma registry license is covered. We realize that adding the process measures was a tremendous burden in terms of data collection and work. And, therefore, that's why we asked for additional monetary support. As we become more successful we may have more ability to expand the program to ask for additional support from Blue Cross, which will offset the data collection burden.

The source of all complications identified was the complete hospital record for each patient.

Dr. Bulger and Dr. Malhotra, there was definitely a unaccounted for difference between the never-CQI and the post-CQI groups. I think some of this is because we were unable to adjust for measures that you would normally be able to adjust for in this population. We didn't have a full injury profile and we didn't have physiologic data. And, also, there are costs associated with running a trauma center that you are allowed to charge above and beyond what a non-trauma center can that don't really show up particularly well in the balance sheet or specific accounting of the patients but are definitely in there in payments that the provider makes, such as activation fees.

Dr. Biffl, mandate is such a charged word. I am really not a person who would endorse mandating something like this. I feel that there is much more to gain when people don't feel threatened. These programs only work because people can get together in the room and have a considerable amount of trust. We have gotten to the stage in our program where we sit in the room and the results have been completely un-blinded for the last year. Mandating things may make it difficult to have that level of trust.

I think over time there will be more pressure just from society for us to participate in data activities and do data-driven care. I don't think we will necessarily have to mandate it. Thank you.