Real money: Complications and hospital costs in trauma patients

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Background. *Major postoperative complications are associated with a substantial increase in hospital costs. Trauma patients are known to have a higher rate of complications than the general surgery population. We used the National Surgical Quality Improvement Program (NSQIP) methodology to evaluate hospital costs, duration of stay, and payment associated with complications in trauma patients.*
Methods. *Using NSQIP principles, patient data were collected for 512 adult patients admitted to the trauma service for > 24 hours at a Level 1 trauma center (2004–2005). Patients were placed in 1 of 3 groups: no complications (none), ≥ 1 minor complication (minor, eg, urinary tract infection), or ≥ 1 major complication (major, eg, pneumonia). Total hospital charges, costs, payment, and duration of stay associated with each complication group were determined from a cost-accounting database. Multiple regression was used to determine the costs of each type of complication after adjusting for differences in age, sex, new injury severity score, Glasgow coma scale score, maximum head abbreviated injury scale, and first emergency department systolic blood pressure.*
Results. *A total of 330 (64%) patients had no complications, 53 (10%) had ≥ 1 minor complication, and 129 (25%) had ≥ 1 major complication. Median hospital charges increased from $33,833 (none) to $81,936 (minor) and $150,885 (major). The mean contribution to margin per day was similar for the no complication and minor complication groups ($994 vs $1,115, P = .7). Despite higher costs, the patients in the major complication group generated a higher mean contribution to margin per day compared to the no complication group ($2,168, P < .001). The attributable increase in median total hospital costs when adjusted for confounding variables was $19,915 for the minor complication group (P < .001), and $40,555 for the major complication group (P < .001).*
Conclusion. *Understanding the costs associated with traumatic injury provides a window for assessing the potential cost reductions associated with improved quality care. To optimize system benefits, payers and providers should develop integrated reimbursement methodologies that align incentives to provide quality care. (Surgery 2008;144:307-16.)*

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WIDE VARIATIONS IN THE QUALITY OF HOSPITAL CARE are motivating changes in how hospitals and physicians are paid. A recent initiative from the Center for Medicare and Medicaid Services (CMS) has resulted in a new pay-for-performance fee structure for physicians.[1] The Physician Quality Reporting Initiative, which began July 1, 2007, links reporting of performance data to physician payment for Medicare claims. Although this program is voluntary, it represents an important first step in linking quality measurement to reimbursement. Most recently, CMS announced a policy change whereby Medicare will no longer pay the extra costs of treating preventable errors, injuries, and infections that occur in hospitals. Although this new policy is targeted specifically at Medicare not paying for "serious preventable events," it may have far-reaching implications.[2]

Trauma patients often require expensive hospital-based healthcare and are at significant risk for morbid events during their convalescence.[3,4] Most mature trauma systems have active quality improvement programs in place to monitor performance improvement and patient safety.[5] One difficulty is the inability to distinguish between the degree of risk for a morbid event that the burden of a patient's traumatic injuries or comorbid conditions creates versus the relationship of the complication to potential provider lapses in quality patient care. Clinically, this situation manifests itself as the polytrauma patient who sustains a femur fracture, multiple rib fractures, and a closed head injury who consequently develops pneumonia. Is this complication the result of nonadherence to an intensive care unit ventilator–associated pneumonia prevention protocol or did the pneumonia develop because of unavoidable microaspiration at a time of biologic/immune risk due to the systemic inflammatory response syndrome triggered by the patient's traumatic injuries?

Collection of prospective data for healthcare quality performance measurement and improvement is expensive[6,7]; it should be noted, however, that quality assurance is a real line-item cost present in the production of manufactured goods and services in every other industry. Whereas few in healthcare debate the utility of the return associated with ensuring quality care, it remains unclear which stakeholder—payer or provider—should monetarily support quality initiatives. A previous study from the University of Michigan demonstrated that both hospitals and payers suffer financial consequences for patients who experience morbid events after an operation[8]; the larger financial burden, however, tended to fall on the healthcare payer.

Because our previous work showed that trauma patients suffer morbid events at a much greater rate than general surgery patients,[4] it is likely that trauma patients represent a population that could benefit clinically and economically from quality improvement initiatives aimed at reducing the incidence of costly complications. To make a business case for a Trauma Quality Improvement Program,[9] it is necessary to examine the costs associated with complications in trauma patients and analyze the financial consequences borne by each stakeholder. To accomplish this, we used the data collection methodology of the National Surgical Quality Improvement Program (NSQIP) and applied it to trauma patients at our institution (the University of Michigan Health System) by coupling clinical data to financial data from the hospital's cost accounting system. We judged the impact on the hospital by determining how costs and clinical margin change when complications occur. To establish the impact on healthcare payers, the costs, payment, and duration of stay associated with presence or absence of complication events were determined.

MATERIAL AND METHODS

Patient data. From August 1, 2004, to July 31, 2005, a total of 525 adult trauma patients 18 years of age or older with an injury severity score (ISS) $\geq$ 5 were admitted to the University of Michigan Trauma Service. Patients admitted directly to other services such as orthopedics, neurosurgery, or internal medicine were excluded. Patients admitted for less than 24 hours or with only burn injuries were also excluded. Data were collected on each patient using the NSQIP methodology and the data definitions published for general surgery patients. The individual who collected our data is a trauma service physician assistant who underwent NSQIP training at the West Roxbury Department of Veterans Affairs NSQIP training center in Boston. Trauma registry data were abstracted from the National Trauma Registry System (NTRACS version 3.4, American College of Surgeons) for ISS, new ISS (nISS), Glasgow coma scale score (GCS), maximum head abbreviated injury scale (hAIS), and mechanism of injury.

Hospital cost data. Cost accounting data were obtained from the University of Michigan Health System Data Warehouse (HSDW). The cost accounting data from each patient encounter was entered into the HSDW using a detailed cost-accounting system (Transition Systems Inc [TSI], Tucson, AZ). The system tracks the use of all resources and assigns estimates of costs; these estimates are based on direct acquisition costs for supplies and time-and-motion studies for labor costs.[10] Financial data obtained included hospital charges, net payment, direct costs, indirect costs, and total margin for the inpatient trauma encounter. We also obtained the primary payer data and placed them into appropriate categories for analysis.

Complications. The primary outcomes of interest were the hospital costs and margins associated with and without complications. All complications for the patients in the study were recorded into a Trauma Quality Improvement Program database using standard definitions from NSQIP. Additional definitions were created for trauma-specific, non–NSQIP-defined complications such as unplanned extubation, reintubation, tension pneumothorax, new onset arrhythmia, decline in GCS, diffuse intravascular coagulation, and shock > 12 hours. Patients were grouped according to complications. The first group of patients had no complications. The second group had one or more minor complications. The third group had one or more major complications. The severity of a complication determined whether it was categorized as major or minor.[6] Major complications were those considered clinically important enough to result in increases to the duration of stay or a need for substantial additional treatment interventions. A listing of the complications classification system is shown in Table I.

Complication subgroups were created for different complications within a similar organ system. The complication subgroups included infectious or incisional, cardiovascular, neurologic, renal, respiratory, and thromboembolic or bleeding. Data were obtained as to which third-party insurance provider was the primary payer for each patient. These payers were placed into categories of commercial or automobile, Blue Cross, Medicare, Medicaid, and a health maintenance organization sponsored by the University of Michigan Health Systems (M-Care HMO).

Statistical analysis. Data were compared using univariate and multivariate statistical measures. Patients who died in the emergency room or in the operating room prior to inpatient admission were excluded from the analysis. Continuous variables were analyzed using an unpaired 2-tailed Student *t* test for data with a normal distribution. Continuous data exhibiting a skewed distribution, such as duration of stay, were analyzed using the Wilcoxon rank sum test. Discrete variables were compared using a chi-square analysis. Multivariate analysis of costs was performed using multiple linear regression and adjusting for age, sex, nISS, total GCS, hAIS, and first emergency department or hospital systolic blood pressure (ED SBP). Prior to multivariate analysis, continuous right-skewed data were natural log-transformed. The regression analysis was then conducted, and the coefficient from the regression model was exponentiated to determine the percent increase in costs or duration of stay associated with each variable. Database management and querying were performed using Microsoft Access software (Microsoft Corp, Redmond, Wash). All statistical analysis was performed using STATA SE 9.2 software (Stata Corp, College Station, Tex). Results are presented as mean values unless otherwise noted. Statistical significance was defined as a *P* value <.05. Approval for this study was obtained from the University of Michigan Health System Institutional Review Board.

Table I. Aggregation of specific complications into minor and major complication groups.

Complication
Minor complication
Superficial incisional SSI
Unplanned extubation
Reintubation
Tension pneumothorax
Progressive renal
Insufficiency
Urinary tract infection
Peripheral nerve injury
New onset arrhythmia
DVT/Thrombophlebitis
Decubitus ulcer
Major complication
Deep incisional SSI
Organ space SSI
Incisional dehiscence
Pneumonia
Unplanned intubation
Pulmonary embolism
Empyema
Acute renal failure
CVA/Stroke
Decline in GCS
Cardiac arrest requiring CPR
Myocardial infarction
Bleeding > 4 u PRBC's
Diffuse intravascular
Coagulation
Sepsis
Shock > 12 hours

SSI, surgical site infection; *DVT*, deep vein thrombosis; *CVA*, cerebral vascular accident; *GCS*, Glasgow coma scale score; *CPR*, cardiopulmonary resuscitation; *PRBC's*, packed red blood cells.

RESULTS

Patient demographics. A total of 525 adult trauma patients were studied during the 1-year data collection period. Of these patients, 13 were excluded because they died in the emergency room or operating room prior to formal admission to a hospital bed; 512 patients were thus available for cost analysis. Patient characteristic data stratified by complication group (none, ≥ 1 minor, and ≥ 1 major) are listed in Table II. The change in proportion of males to females in the ≥ 1 minor complication group can be attributed to a disproportionate amount of urinary tract infections occurring in females (21 females and 15 males with a urinary tract infection in the minor complication group). Table III demonstrates the rates of complications when ranked by different categories of nISS, GCS, and hAIS. Patients who experienced a major or minor complication were older and had

Table II. Patient demographics.

Patient characteristic	No complications	≥ 1 Minor complication	p-value	≥ 1 Major complication	p-value
N (%)	330 (64)	53 (10)	–	129 (25)	–
Mean age, y	40	48	0.002	47	< 0.001
Gender					
Male	70%	47%	< 0.001	74%	0.5
Female	30%	53%		26%	
Blunt mechanism of injury	92%	94%	0.5	95%	0.2
Penetrating mechanism of injury	8%	6%		5%	
Mean nISS	22	27	0.01	35	< 0.001
Mean GCS					
Motor	5.5	5.2	0.2	4.2	< 0.001
Verbal	4.4	4.0	0.07	3.1	< 0.001
Eye	3.7	3.4	0.08	2.7	< 0.001
Total	13.5	12.6	0.1	10.0	< 0.001
Mean head AIS	1.8	2.0	0.5	2.5	<0.001
Mean ED SBP, mm Hg	135	132	0.4	123	<0.001

nISS, new injury severity score; *GCS*, Glasgow coma scale score; *AIS*, abbreviated injury scale; *ED SBP*, emergency room department systolic blood pressure.

Table III. Injury severity score, Glasgow coma scale score, and Head AIS categories.

New injury severity score	nISS 1-15		nISS 16-25		nISS 26-35		nISS >35	
	N	%	N	%	N	%	N	%
No complications	83	25.2%	107	32.4%	120	36.4%	20	6.1%
≥ 1 Minor complication	8	15.1%	15	28.3%	22	41.5%	8	15.1%
≥ 1 Major complication	7	5.4%	20	15.5%	51	39.5%	51	39.5%

Glasgow coma scale score	GCS 14-15		GCS 9-13		GCS 3-8	
	N	%	N	%	N	%
No complications	280	84.8%	14	4.2%	36	10.9%
≥ 1 Minor complication	39	73.6%	4	7.5%	10	18.9%
≥ 1 Major complication	65	50.4%	10	7.8%	54	41.9%

Maximum head AIS	Head AIS < 3		Head AIS ≥ 3	
	N	%	N	%
No complications	210	63.6%	120	36.4%
≥ 1 Minor complication	33	62.3%	20	37.7%
≥ 1 Major complication	64	49.6%	65	50.4%

nISS, new injury severity score; *GCS*, Glasgow coma scale score; *AIS*, abbreviated injury scale.

a greater injury burden based on nISS and GCS data compared to the no complication group in univariate analysis.

Clinical and economic outcomes. The total number of patients who experienced each complication and the percent prevalence for the complication are listed in Table IV. Complications that occurred in greater than 4% of patients included pneumonia (15%), urinary tract infection (13%), deep venous thrombosis/thrombophlebitis (7%), sepsis (5%), and bleeding/transfusions (5%). Mortality was 3.6% in the no complication group, 0% in the ≥1 minor complication group, and 14.7% in the ≥1 major complication group. Patients with a minor or major complication experienced a significant increase in their median hospital and intensive care unit duration of stay (Table V).

The presence of a minor complication increased hospital charges, net payment, and hospital costs compared to patients with no complications. A minor complication did not significantly increase the total margin or contribution to margin per day. Patients who experienced a major complication had a substantial increase in hospital charges, net payment, hospital costs, total margin, and contribution to margin per day compared to the no complication group. For a major complication, the median total hospital costs

Table IV. Complications.

Type of complication	Events N	Events %
Infectious or incisional complications		
Superficial incisional SSI	10	2.0
Deep incisional SSI	9	1.8
Organ/Space SSI	10	2.0
Sepsis	25	4.9
Incisional dehiscence	3	0.6
Decubitus ulcer	6	1.2
Cardiovascular complications		
Myocardial infarction	3	0.6
Cardiac arrest requiring CPR	3	0.6
New onset major arrhythmia	10	2.0
Neurologic complications		
Peripheral nerve injury	8	1.6
Decline in GCS	6	1.2
Stroke/CVA	5	1.0
Renal complications		
Urinary tract infection	66	12.9
Progressive renal insufficiency	3	0.6
Acute renal failure	5	1.0
Respiratory complications		
Unplanned extubation	2	0.4
Unplanned intubation	14	2.7
Reintubation	6	1.2
Tension pneumothorax	1	0.2
Pneumonia	74	14.5
Empyema	3	0.6
Thromboembolic or bleeding complications		
DVT/Thrombophlebitis	34	6.6
Pulmonary Embolism	5	1.0
Bleeding/Transfusions	24	4.7
Diffuse intravascular coagulation	1	0.2
Shock > 12 hours	8	1.6

SSI, surgical site infection; *CPR*, cardiopulmonary resuscitation; *CVA*, cerebral vascular accident; *GCS*, Glasgow coma scale score; *DVT*, deep vein thrombosis.

increased from $17,618 to $71,658 ($P < .001$), and the mean total margin increased from $5,073 to $32,884 ($P < .001$). Because patients with complications have a longer hospital duration of stay, the total margin was divided by the hospital duration of stay to generate a mean contribution to margin per day value that offered a normalized margin for comparison between patient groups. Patients with a major complication had an increase in their mean contribution to margin per day from $994 to $2,168 ($P < .001$) compared to patients who did not experience a complication.

To examine other variables that may contribute to costs in addition to complications, a multivariate analysis was performed. Financial and duration of stay data were adjusted for differences in age, sex, nISS, GCS, hAIS, and ED SBP between the complication groups using multiple linear regression. Table VI lists the attributable increase in financial measures and duration of stay due to a minor or major complication when unadjusted or adjusted for differences in patient characteristics. When adjusted for confounding variables, the presence of a minor complication increased the median duration of stay by 3.5 days ($P < .001$), and a major complication resulted in an increase of 8.7 days ($P < .001$) to the median hospital duration of stay. Patients with a minor complication had an increase in mean contribution to margin per day of $170 attributable to the presence of the minor complication compared to the group of patients with no complications. Whereas the unadjusted analysis attributed an increase of $1,173 ($P < .001$) to the mean contribution to margin per day for a major complication, the adjusted analysis showed that this attributable increase due to a major complication was only $625 ($P = .1$), which was not significant.

Clinical and economic outcomes by complication subgroup and payer type. When specific complication subgroup analysis was performed, the hospital charges, costs, and durations of stay increased markedly for patients with a complication in each of the subgroup categories compared to patients who did not experience a complication (Table VII). Respiratory complications resulted in the largest median increase in hospital duration of stay, increasing from 5 days for patients without to 20 days for patients with a respiratory complication ($P < .001$). The greatest increase in hospital charges was for presence of a thromboembolic or bleeding complication ($140,701) followed by respiratory ($122,149) and infectious or incisional complications ($120,196). Total hospital costs increased by $38,628 to $64,508 for patients with a complication in the organ system subgroups. The largest increase in cost was for an infectious or incisional complication ($64,508). Respiratory complications also increased hospital costs by a similar amount ($62,890). Only a thromboembolic/bleeding ($2,598 vs $1,122, $P < .001$) or neurologic ($2,811 vs $1252, $P < .001$) complication, however, resulted in a statistically significant increase in the mean contribution to margin per day compared to patients with no complications.

The state of Michigan operates under no-fault automobile insurance rules. Therefore, patients who are injured while traveling in an insured automobile have medical coverage regardless of their third-party health insurance status. For analysis purposes, commercial medical insurance providers (eg, Aetna) were lumped with automobile insurance providers (eg, American Automobile

Table V. Outcomes and financials by complication group.

Parameter	No complications	≥ 1 Minor complication	p-value	≥ 1 Major complication	p-value
N	330	53	–	129	–
Mortality, %	3.6%	0	0.2	14.7%	< 0.001
Median length of stay, d (IQR)	5 (3-8)	9 (6-13)	< 0.001	17 (9-26)	< 0.001
Median ICU length of stay, d (IQR)	2 (3-8)	4 (6-13)	0.001	10 (9-26)	< 0.001
Median hospital charges, $ (IQR)	$33,833 (20,793-60,582)	$81,936 (62,383-126,093)	< 0.001	$150,885 (85,760-248,567)	< 0.001
Median net payment, $ (IQR)	$20,034 (11,089-37,837)	$51,359 (32,798-82,026)	< 0.001	$88,941 (50,444-176,774)	< 0.001
Median direct costs, $ (IQR)	$11,900 (7,354-20,158)	$28,444 (21,817-40,758)	< 0.001	$47,524 (29,760-82,055)	< 0.001
Median indirect costs, $ (IQR)	$5,705 (3,359-10,023)	$14,169 (10,729-20,441)	< 0.001	$24,133 (14,120-42,682)	< 0.001
Mean total margin, $ (95% CI)	$5,073 (3,331-6,816)	$7,505 (1,015-13,994)	0.3	$32,884 (22,502-43,265)	< 0.001
Mean contribution to margin per day, $ (95% CI)	$994 (650-1,339)	$1,155 (420-1,890)	0.7	$2,168 (1,541-2,794)	< 0.001

IQR, interquartile range; *ICU*, intensive care unit; *CI*, confidence interval.

Table VI. Relationship of complications to unadjusted and adjusted financial measures and length of stay.

Parameter	Attributable increase with ≥ 1 Minor complication*			
	Unadjusted	p-value	Adjusted	p-value
Median hospital charges, $ (95% CI)	$43,341 (28,701-61,407)	< 0.001	36,063 (23,167-51,875)	< 0.001
Median net payment, $ (95% CI)	$29,484 (18,209-44,082)	< 0.001	24,063 (14,239-36,703)	< 0.001
Median direct costs, $ (95% CI)	$16,011 (10,333-23,139)	< 0.001	13,343 (8,376-19,528)	< 0.001
Median indirect costs, $ (95% CI)	$8,015 (5,354-11,317)	< 0.001	6,593 (4,278-9,444)	< 0.001
Mean total margin, $ (95% CI)	$2,431 (-2,602-7,464)	0.3	2,240 (-2,883-7,363)	0.4
Mean contribution to margin per day, $ (95% CI)	$161 (-746-1,067)	0.7	170 (-752-1,093)	0.7
Median length of stay, d (95% CI)	4.0 (2.3-6.0)	< 0.001	3.5 (1.9-5.4)	< 0.001
	Attributable increase with ≥ 1 Major complication*			
	Unadjusted	p-value	Adjusted	p-value
Median hospital charges, $ (95% CI)	$106,525 (86,833-129,431)	< 0.001	$79,852 (62,450-100,400)	< 0.001
Median net payment, $ (95% CI)	$67,239 (52,097-85,560)	< 0.001	$47,128 (34,302-62,981)	< 0.001
Median direct costs, $ (95% CI)	$37,217 (29,920-45,788)	< 0.001	$27,077 (20,792-34,569)	< 0.001
Median indirect costs, $ (95% CI)	$18,069 (14,627-22,093)	< 0.001	$13,519 (10,487-17,120)	< 0.001
Mean total margin, $ (95% CI)	$27,810 (20,798-34,823)	< 0.001	$23,274 (15,165-31,383)	< 0.001
Mean contribtution to margin per day, $ (95% CI)	$1,173 (499-1,847)	0.001	$625 (-142-1,392)	0.1
Median length of stay, d (95% CI)	9.1 (7.1-11.4)	< 0.001	8.7 (6.5-11.3)	< 0.001

CI, confidence interval.
*Analysis performed using multivariate linear regression. Adjusted for age, gender, *nISS*, *GCS*, *hAIS*, and *ED SBP*.

Association) in the commercial or automobile category. Table VIII lists the distribution of insurance payers who provided the primary coverage for medical care received at the University of Michigan for the trauma patients in this study.

The total margin and mean contribution to margin per day were positive for the commercial/automobile and Blue Cross–insured patients whether they experienced a complication or not (Table IX). Medicare and Medicaid generated a negative total margin and mean contribution to margin per day if the patient did not develop a complication. Medicare patients who developed a complication had a positive total margin of

Table VII. Outcomes and financials by complication sub-group.

Complication sub-group	*Complication present*	*Complication absent*	p-*value*
Median hospital charges, $ (IQR)			
Infectious or incisional complications	$171,376 (83,980-310,104)	$50,980 (26,398-94,631)	< 0.001
Cardiovascular complications	$154,638 (87,355-292,093)	$52,218 (26,943-100,699)	< 0.001
Neurologic complications	$163,388 (92,517-325,750)	$52,218 (26,942-100,121)	< 0.001
Renal complications	$142,501 (71,396-270,089)	$47,555 (24,813-87,397)	< 0.001
Respiratory complications	$166,144 (100,663-253,990)	$43,995 (24,210-78,712)	< 0.001
Thromboembolic and bleeding complications	$188,270 (78,558-249,281)	$47,569 (24,549-87,721)	< 0.001
Median total costs, $ (IQR)			
Infectious or incisional complications	$90,153 (40,534-170,687)	$25,645 (12,711-49,900)	< 0.001
Cardiovascular complications	$73,999 (44,714-129,723)	$26,588 (12,992-52,689)	< 0.001
Neurologic complications	$80,877 (37,440-171,126)	$26,638 (12,992-51,861)	< 0.001
Renal complications	$67,502 (35,963-139,846)	$23,899 (12,392-44,714)	< 0.001
Respiratory complications	$85,544 (49,926-128,041)	$22,654 (12,278-40,397)	< 0.001
Thromboembolic and bleeding complications	$62,981 (40,494-123,425)	$24,353 (12,389-45,331)	< 0.001
Mean contribtution to margin per day, $ (95% CI)			
Infectious or incisional complications	$1,476 (575-2,376)	$1,295 (996-1,593)	0.4
Cardiovascular complications	$2,567 (514-4,620)	$1,271 (984-1,558)	0.07
Neurologic complications	$2,811 (1,750-3,873)	$1,252 (960-1,543)	0.02
Renal complications	$1,181 (562-1,800)	$1,326 (1,010-1,642)	0.6
Respiratory complications	$1,789 (1,190-2,388)	$1,211 (892-1,531)	0.07
Thromboembolic or bleeding complications	$2,598 (1,444-3,752)	$1,122 (843-1,400)	< 0.001
Median length of stay, d (IQR)			
Infectious or incisional complications	19 (9-36)	6 (4-12)	< 0.001
Cardiovascular complications	20 (10-27)	6 (4-13)	< 0.001
Neurologic complications	20 (8-33)	6 (4-13)	< 0.001
Renal complications	17 (7-27)	6 (3-12)	< 0.001
Respiratory complications	20 (13.5-25.5)	5 (3-10.5)	< 0.001
Thromboembolic and bleeding complications	16.5 (5-24)	6 (4-12)	< 0.001

IQR, interquartile range; *CI*, confidence interval.

$1,879 per patient, which was not statistically significant compared to those patients who did not have a complication.

DISCUSSION

In this study, we sought to determine the impact of complications on hospital costs, reimbursement, and duration of stay for trauma patients. Although some complications may have an iatrogenic component, it is also true that the biology of a patient responding to acute injury often sets the stage for many of the morbid events that occur in trauma patients. This concept is known as the two-event construct of postinjury multiple organ failure. It is based on the premise that injury primes the host's innate immune system in such a way that a second insult during this vulnerable period provokes a severe systemic inflammatory response. The result is end-organ dysfunction.[11] Of the top 5 complications present in this study, 4 are potentially influenced by the status of the systemic inflammatory system after injury (pneumonia, urinary tract infection, deep venous thrombosis, and sepsis). Likewise, those patients who were older and had a greater injury burden, as evidenced by nISS and GCS data, were at increased risk for minor or major complications. This observation is in contrast to the private-sector NSQIP data in which patients who had a minor or major complication had a similar mean age when compared to the no complications group.[6]

Table VIII. Payers

Insurance provider	*N*	*%*
Commercial or automobile	299	58
Blue cross	121	24
Medicare	36	7
Medicaid	35	7
M HMO	21	4
Total	512	100

M HMO, M-Care health maintenance organization.

Development of a minor or major complication in trauma patients increased hospital payments borne by third-party payers and duration of stay in univariate and multivariate analyses. A minor complication increased payment by $24,063 when adjusted for case mix, and a major complication

Table IX. Financials by payer.

Parameter	*No complications*	*≥ 1 complication*	p-*value*
Commercial or automobile			
Median hospital charges, $ (IQR)	$33,468 (21,237-60,431)	$112,972 (76,250-215,947)	<0.001
Median net payment, $ (IQR)	$24,007 (15,141-44,724)	$88,229 (52,803-169,275)	<0.001
Median total costs, $ (IQR)	$17,359 (10,317-29,438)	$57,546 (36,253-111,284)	<0.001
Mean total margin, $ (95% CI)	$10,368 (8,604-12,132)	$44,387 (35,093-53,682)	<0.001
Mean contribtution to margin per day, $ (95% CI)	$1,893 (1,549-2,237)	$3,165 (2,564-3,766)	<0.001
Blue cross			
Median hospital charges, $ (IQR)	$36,259 (19,971-67,356)	$154,235 (82,734-213,795)	<0.001
Median net payment, $ (IQR)	$16,590 (7,443-33,996)	$66,818 (36,643-138,881)	<0.001
Median total costs, $ (IQR)	$18,281 (9,922-33,991)	$73,232 (42,310-110,176)	<0.001
Mean total margin, $ (95% CI)	$471 (-4,293-5,235)	$3,916 (-9,428-17,261)	0.6
Mean contribtution to margin per day, $ (95% CI)	$338 (-564-1,240)	$127 (-786-1,040)	0.8
Medicare			
Median hospital charges, $ (IQR)	$36,914 (20,005-50,980)	$136,700 (57,172-169,276)	<0.001
Median net payment, $ (IQR)	$17,068 (11,191-31,943)	$53,234 (15,167-102,351)	0.01
Median total costs, $ (IQR)	$19,187 (13,716-24,798)	$66,005 (28,289-90,992)	<0.001
Mean total margin, $ (95% CI)	-$502 (-5,037-4,034)	$1,879 (-14,819-18,576)	0.7
Mean contribtution to margin per day, $ (95% CI)	-$360 (-1,414-694)	-$84 (-925-756)	0.7
Medicaid			
Median hospital charges, $ (IQR)	$32,023 (27,903-56,871)	$100,699 (61,598-218,904)	<0.001
Median net payment, $ (IQR)	$13,009 (8,187-22,721)	$32,798 (27,375-42,086)	0.01
Median total costs, $ (IQR)	$19,888 (13,799-32,722)	$58,845 (37,162-116,373)	<0.001
Mean total margin, $ (95% CI)	-$8,137 (-12,516–3,757)	-$34,566 (-84,418-15,287)	0.05
Mean contribtution to margin per day, $ (95% CI)	-$1,055 (-1,975–135)	-$403 (-2,491-1,684)	0.5
M HMO			
Median hospital charges, $ (IQR)	$29,321 (19,334-75,255)	$102,561 (101,019-143,640)	0.003
Median net payment, $ (IQR)	$9,493 (7,298-18,700)	$38,725 (34,642-41,300)	0.02
Median total costs, $ (IQR)	$13,299 (8,229-37,074)	$49,766 (45,889-69,091)	0.02
Mean total margin, $ (95% CI)	-$6,190 (-14,881-2,500)	-$26,083 (-61,058-8,892)	0.06
Mean contribtution to margin per day, $ (95% CI)	-$1,274 (-3,971-1,424)	-$1,621 (-3,027–216)	0.9

IQR, interquartile range; *ICU*, intensive care unit; *CI*, confidence interval.

increased payment by $47,128. Surprisingly, the increase in duration of stay was not detrimental financially to the hospital, as the mean contribution to margin per day did not decrease or increase in multivariate analysis when adjustments were made for confounding variables. Therefore, provided that hospital bed utilization is not at maximum capacity the bottom line did not change for the hospital if a patient stayed longer because of a complication.

The lifeblood of a healthcare system is provision of high quality care with maintenance of a reasonable profit margin. Institutions must continually invest in quality initiatives to maintain their brand presence while recruiting and retaining the best physicians and nurses within the region. Maintaining a market position related to optimal quality of care provides for enhanced physician referrals, increased patient satisfaction, and enhanced provider desirability with employers/payers. Conversely, the provision of low quality care will lead to poor patient outcomes, patient dissatisfaction, loss of future patient referrals, and potential medical liability. Providers have a very direct and tangible incentive to deliver quality care to patients and report outcomes of quality initiatives to the public. Therefore, both hospitals and healthcare payers have strong incentives to work toward reducing complications through quality improvement initiatives.

One should not assume that the financial data from our institution is transferable universally to all institutions or healthcare systems. Our study is limited by the fact that we treat a high proportion of trauma patients who have a blunt mechanism of injury and very few who suffer penetrating injuries. Also, we are a suburban rather than urban trauma center, and our economics may not be applicable to higher volume intercity trauma centers. Morbid events have an increased prevalence in trauma patients who are older and have a greater burden of injury. This finding is evident from the data in our study. It should not be surmised that all or even a majority of these complications are preventable; however, even a small reduction in these complications could potentially result in a large hospital cost savings, which was the basis for conducting our study. Finally, the state of Michigan operates under no-fault automobile insurance rules, and a patient who is injured in a motor vehicle accident and who has automobile insurance has unlimited medical benefits.

To better appreciate why it is difficult to demonstrate directly the financial returns related to enhanced quality inpatient care, one must first understand the cost structure of a typical hospital. A hospital by its very nature is a high fixed-cost business. A hospital requires huge ongoing investments in its physical plant, new technologies, skills training, and recruitment. As a result, the bulk of a hospital's costs are fixed. Financially, this means that the institution bears the majority of its costs regardless of the patient volume. By some reports, a hospital's overhead approximates 60%–85% of the cost structure of the organization.[12] Although there is some accounting nuance to these numbers, the key to understanding is appreciating that the main part of the institutional costs are determined prior to any patient arrival.

Conversely, the variable costs associated with the delivery of care reflect only 15%–40% of the total cost. It is in this variable cost allocation where the additional personnel whose focus is on quality initiatives rests. As a result of this variable cost allocation and the diffuse nature of quality work itself, a performance improvement initiative has a potentially limited opportunity for substantive cost reduction.[13] This factor makes it difficult to ascertain precisely the direct financial beneficiary of the incremental cost associated with quality improvement personnel. Current CMS quality measures, such as influenza vaccines, counseling for smoking cessation, and beta-blocker and aspirin therapy, mainly improve patients' outcomes after discharge from the hospital. Medicare realizes a financial savings from the patient's improved long-term health, but the hospital bears the expense of implementing and conducting continuously these programs with no obvious cost benefit.[13]

Is there really a low opportunity cost to the hospital in having a patient's duration of stay increased by a complication? A look at other high fixed-cost companies suggests that this may not be the case. Southwest Airlines is one example. Airplanes do not generate revenue when they are not in flight. Southwest boards its customers in groups without assigned seating and turns around its planes in 20 minutes, twice as fast as its competitors. If its turnaround times were 10 minutes longer, the airline would need 40 additional new aircraft to handle its current capacity at a cost of millions of dollars.[13,14] Conceptualize an airplane as a 20-bed intensive care unit, and the reason for placing an emphasis on increased throughput begins to make sense as a way to improve quality. In its simplest terms, the hospital's incentive for quality improvement may be to focus on asset and capacity management (cash flow) to improve throughput by optimizing the utilization of fixed-cost investments. This approach is in contrast to the traditional healthcare strategy of performance improvement through cost reduction initiatives.

Investment in quality improvement initiatives with the intent to reduce complications should lead to a decrease in trauma patient duration of stay. This reduction in duration of stay could decrease cost/case as the substantial fixed costs are dispersed over a larger patient population, which manifests by increased bed utilization. The end result is increased cash flow with incremental contribution to the margin. A reduction in complication events among trauma patients has the possibility to translate into substantial savings for payers who have an adjusted increase of 120% in payment for a minor complication and 235% for a major complication. Third-party payer partnering with healthcare systems to pay for continuous quality improvement initiatives for trauma patients is a potential win-win situation. This will become imperative as third-party payers reduce or eliminate reimbursement for complications.

CONCLUSIONS

Development of a minor or major complication results in increased hospital charges, hospital costs, and net payment in trauma patients. Because the current third-party payer system provides incremental reimbursement for complications, there is modest financial incentive for institutions to invest in proactive quality initiatives. To achieve long-term success, hospitals and payers should partner to develop continuous quality improvement initiatives targeted at reducing the complications noted in this study.

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