Staff Commitment to Trauma Care Improves Mortality and Length of Stay at a Level I Trauma Center

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Background: Optimizing human resources at trauma facilities may increase quality of care. The purpose of this study was to assess whether staffing changes within a Level I trauma center improved mortality and shortened length of stay (LOS) for trauma patients.

Methods: Mortality, hospital LOS, and intensive care unit LOS were evaluated during three time periods: trauma service coverage by in-house general surgery residents and attendings ("group 1"), the creation of a core trauma panel with in-house trauma surgeons ("group 2"), and the addition of physician assistants (PAs) to the core trauma panel ("group 3"). Logistic regression and χ^2 tests were used to compare mortalities, and multiple linear regression, *t*-tests, and median tests were used to compare LOS.

Results: There were 15,297 adult patients with trauma included in the analysis. After adjustment for transfers-in, mechanism of injury, injury severity score, age, and head injury, the presence of in-house trauma surgeons (group 2) decreased the following compared with group 1: overall mortality (3.12% vs. 3.82%, $p = 0.05$), mortality in the severely injured (11.41% vs. 14.83%, $p = 0.02$), and median intensive care unit LOS (3.03 days vs. 3.40 days, $p = 0.006$). The introduction of PAs to the core trauma panel (group 3 vs. group 2) decreased overall mortality (2.80% vs. 3.76%, $p = 0.05$), and reduced mean and median hospital LOS (4.32 days vs. 4.69 days, $p = 0.05$; and 3.74 days vs. 3.88 days, $p = 0.02$, respectively).

Conclusion: The presence of in-house core trauma surgeons and PAs improves management and outcome of critically injured trauma patients within a level I trauma center.

Key Words: Physician assistant, Trauma center, Mortality, Length of stay, Staff.

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Improved outcomes for patients treated at designated trauma centers are well established.[1–8] Although outcomes are optimized with field triage to a trauma center, there are no optimal staff models at trauma centers; human resources vary widely and change frequently. Historically, many trauma centers were staffed by year-4 general surgery residents with at-home attending trauma surgeons as back-up. Reduced resident work hours created coverage and continuity of care gaps necessitating changes in staffing models.[9–11] Increased work hours, reduced case loads, and inadequate reimbursement for time and effort spent discourage both current and future surgeons from seeking a trauma career. Many level I trauma centers have used dedicated trauma surgeons, but with a shortage of full-time trauma surgeons in the United States, this practice is not widespread.[11,12] Many centers have chosen to use physician extenders to fill the gaps.[9,10,13–15] Physician extenders, or midlevel providers, include nurse practitioners and physician assistants (PAs). The use of physician extenders is an increasingly preferred alternative after the 80-hour work week mandates for surgical residents were implemented.[13,14,16]

PAs have been shown to play a complementary role in trauma and critical care settings.[10,14,16] A reduction in length of stay (LOS) was demonstrated but without effect on mortality when PAs: (a) replaced surgical residents;[15] (b) were added to an existing surgical residency program;[13] and (c) used in conjunction with trauma surgeons.[9,15] The impact of full-time trauma surgeons versus part-time trauma surgeons or general surgery residents has been mixed; some have reported improved outcomes,[12] whereas others contend there is no change in mortality with full-time trauma surgeons.[11] A commitment to enhance the trauma program through in-house attending coverage, a dedicated trauma admitting unit, regular trauma core curriculum, and multidisciplinary quality assurance meetings, improved patient outcomes.[17]

The purpose of this study was to assess whether staffing changes within the same level I trauma center improved mortality and shortened hospital and intensive care unit (ICU) LOS for patients with trauma. Specifically, we examined the mortality and LOS of the trauma center when staffed primarily by independent general surgery attendings with partial surgical resident coverage, then exclusively by dedicated trauma surgeons (core trauma panel), and lastly, when PAs were added to the core trauma panel.

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PATIENTS AND METHODS

Patient Population

St. Anthony Central Hospital (SAH) is an urban, community-based level I trauma center serving the Denver metropolitan area. The trauma panel has historically covered both trauma and general surgical emergencies. During the initial phase of this study period, fourth year surgery residents provided in-house call with individual private practice surgeons providing call from home. When the surgical resident rotation was phased out, the surgery attendings filled the coverage gaps, and eventually replaced the in-house coverage provided by residents. The surgeons continued the care of their patients individually through the course of the hospitalization. Subsequently, a core trauma panel was developed that cared for patients as a dedicated service with daily sign-out rounds and enhanced multidisciplinary ICU rounds. Finally, 24 hour in-house trauma PAs were incorporated into the service.

This study is a retrospective review of consecutively admitted patients with trauma at SAH between July 1, 1999 and June 30, 2006 who were 18 years of age or older and who were not transferred from SAH emergency department (ED) to another acute care facility. Records of patient with trauma were prospectively collected and entered into the database by dedicated trauma registrars. Before review, this study was approved by the SAH institutional review board.

Statistical Analysis

Analyses were performed comparing three groups:

1. Group 1 (July 1, 1999 through June 30, 2002): the trauma service was staffed by full-time, in-house post-graduate year-4 general surgery residents with attending back up from home, followed by a transition to a trauma service staffed with in-house independent general surgeon attendings.
2. Group 2 (July 1, 2002 through June 30, 2005): the trauma service implemented a core trauma panel consisting of full-time, in-house trauma surgeons, without PAs or residents.
3. Group 3 (July 1, 2005 through June 30, 2006): dedicated trauma service PAs were added to the core trauma panel.

Measured outcomes across the three groups included overall mortality and mortality for patients with Injury Severity Score (ISS) >15; and hospital LOS and ICU LOS, measured in days.

Statistical analyses were performed using SAS software, version 9.1.3 (SAS Institute, Cary, NC). For physiologic vital signs, established clinical definitions were used: hypotension on admission was defined as <90 mm Hg (vs. 90+ mm Hg), and respiratory rate was categorized into normal (10–29), low (<10), and high (>29).[18] Dichotomous variables included mechanism of injury (blunt vs. penetrating), age (≤55 and >55); transfer status (patients transferred into our hospital for a higher level of care); severe head injury (Abbreviated Injury Scale [AIS] score ≥3); and gender. ISS was categorized into minor/moderate injuries (<15), severe injuries (15–24), and very severe injuries (≥25) (Table 1). Head injury was defined continuously using AIS score in the multivariate regression analyses.

In the univariate analyses, χ^2 tests were used to determine whether there were significant differences across groups for demographic and clinical covariates (groups 1 vs. 2 vs. 3), as defined in Table 1. Significance testing for unadjusted outcomes were performed within groups (group 1 vs. 2, 1 vs. 3, and 2 vs. 3) using χ^2 tests for unadjusted mortality, and *t*-tests for unadjusted LOS outcomes. The False Discovery Rate (FDR) method is used to correct for multiple hypothesis testing, and was applied to adjust our collection of three *p* values from the χ^2 tests and the *t*-tests.

Multivariate logistic regression models were used to determine whether staffing changes were an independent predictor of mortality, as well as the effect of staffing changes on mortality of severely injured patients. Covariates that were different across groups (p value <0.15) were adjusted for in the model, in addition to age. Odds ratios (ORs) less than 1.0 represent a reduction in mortality for comparison groups to the referent group. Statistical significance was set at p value <0.05, and p values were corrected using the FDR method. Adjusted percent mortality was calculated using the following formula: $q = (p \times OR)/(1 - p + p \times OR)$, where p equals the adjusted mortality for the referent group, OR is derived from the logistic regression equation, and q equals the adjusted mortality for the comparison group.

Multiple linear regression models were used to determine LOS (hospital and ICU) outcomes. Covariates that were different across groups (p value <0.15) were adjusted for in the model, with continuously defined covariates for age and ISS. *T*-tests (for means) and median tests were used to determine whether adjusted LOS outcomes were statistically different between groups. Brown-mood tests were used to determine whether the distribution of the adjusted LOS outcomes were statistically different across groups. Statistical significance was set at p value <0.05, and p values were corrected using the FDR method.

RESULTS

Population Demographics

A total of 15,297 patients with trauma were admitted between July 1, 1999 and June 30, 2006. There were 6,365 patients (41.6%) admitted and treated by group 1; 6,599 patients (43.14%) admitted and treated by group 2; and 2,333 patients (15.25%) admitted and treated by group 3. Statistically significant differences in patient demographics across the three groups were observed, including ISS, head injury, and transfer status ($p < 0.001$), as seen in Table 1. There was a higher proportion of more severely injured patients in group 3 than group 2 ($p = 0.02$) and group 1 ($p < 0.001$), more patients admitted with a severe head injury during group 3 compared with group 2 ($p = 0.001$) and 1 ($p < 0.001$), and fewer

Table 1 Demographics by Group at St. Anthony Central Hospital (SAH)

	Group 1 % (n)	Group 2 % (n)	Group 3, % (n)	p	Missing (n)
Age				0.78	0
≤55	65.39 (4,162)	65.96 (4,353)	65.50 (1,528)		
>55	34.61 (2,203)	34.04 (2,246)	34.50 (805)		
Mechanism				0.14	53
Blunt	95.48 (6,062)	95.40 (6,265)	94.50 (2,200)		
Penetrating	4.52 (287)	4.60 (302)	5.50 (128)		
Gender				0.25	6
Male	61.28 (3,899)	62.05 (4,093)	63.21 (1,474)		
Female	38.72 (2,464)	37.95 (2,503)	36.79 (858)		
ISS				<0.001	133
<16	79.39 (4,988)	75.02 (4,918)	72.60 (1,688)		
16–24	10.52 (661)	13.13 (861)	14.84 (345)		
>24	10.09 (634)	11.85 (777)	12.56 (292)		
Transfer				<0.001	2
No	69.52 (4,424)	65.43 (4,317)	69.52 (1,622)		
Yes	30.48 (1,940)	34.57 (2,281)	30.48 (711)		
Head injury				<0.001	133
AIS ≥3	16.00 (1,005)	17.66 (1,158)	20.73 (482)		
AIS <3	84.00 (5,278)	82.34 (5,398)	79.27 (1,843)		
Systolic blood pressure				0.82	755
≥90	97.10 (5,751)	97.28 (6,189)	97.16 (2,193)		
<90	2.90 (172)	2.72 (173)	2.84 (64)		
Respirations/min				0.85	1,094
11–29	96.40 (5,600)	96.73 (6,009)	96.70 (2,110)		
<11 or >29	3.60 (209)	3.27 (203)	3.30 (72)		

Group 1: general surgery residents; group 2: core trauma panel; group 3: core panel + physician assistants.
ISS, injury severity score; AIS, abbreviated injury scale; BP, blood pressure; min, minute.

patients transferred into SAH during group 2 than group 1 ($p = 0.003$) and group 3 ($p < 0.001$).

Regression analyses were performed on only complete data; patient records with missing response or explanatory variables were excluded from the analysis, and no attempt was made to substitute missing values for any patient records. Patient records excluded from analyses were as follows: 133 patients without ISS or head AIS; 6 patients with unknown sex; 2 patients without transfer status; and 53 patients with unknown mechanism of injury. Patients with missing ISS included patients with injuries that could not be coded (drowning, hanging, hypothermia, etc.), and patients with trauma who died in the ED without autopsy information. Mortality rates for excluded patient records were not statistically different when compared with included patient records ($p = 0.16$). Multivariate logistic regression analyses included 98.8% of the patient records among the total population, and 99.8% of patient records among severely injured patients (ISS, 16–75).

Overall Mortality

Between July 1, 1999 and June 30, 2006, the overall crude mortality rate was 3.69%, with 565 deaths of 15,297 patients. Chi-square tests were computed for overall unadjusted mortality by group and no statistically significant decreases were observed for any comparison using FDR-corrected p values (Table 2). A multivariate logistic regression was performed to examine the independent effect of staffing changes on mortality, adjusting for age, ISS, mechanism of injury, severe head injury, and transfers into SAH. The adjusted mortalities and the adjusted OR (with 95% confidence intervals [CIs]) are presented in Table 3.

Table 2 Unadjusted Mortality and Length of Stay Outcomes by Group

	Overall	FDR, p Value* (Group)	ISS 16–75	FDR, p Value* (Group)
Unadjusted % mortality (n)				
Group 1	3.82 (243)	0.86 (1 vs. 2)	14.83 (192)	0.04 (1 vs. 2)
Group 2	3.76 (248)	0.30 (1 vs. 3)	12.21 (200)	0.006 (1 vs. 3)
Group 3	3.18 (74)	0.30 (2 vs. 3)	9.73 (62)	0.02 (2 vs. 3)
	Hospital LOS	FDR, p Value* (Group)	ICU LOS	FDR, p Value* (Group)
Unadjusted length of stay (d)				
Group 1	4.46	0.003 (1 vs. 2)	4.97	0.58 (1 vs. 2)
Group 2	5.28	0.02 (1 vs. 3)	5.12	0.29 (1 vs. 3)
Group 3	5.10	0.36 (2 vs. 3)	5.61	0.29 (2 vs. 3)

* The FDR p value, correcting for multiple comparisons.

After adjustment, there was a statistically significant overall decrease in mortality for all group comparisons after correcting for multiple hypothesis testing. Overall mortality was decreased for group 2 compared with group 1 (3.12% to 3.82%; adjusted [OR], 0.81; [95% CI], 0.66 − 0.999; $p = 0.05$), and group 3 compared with group 1 (2.32% vs. 3.82%, adjusted [OR], 0.60; [95% CI], 0.45 − 0.81; $p = 0.003$). Adjusted mortality also decreased significantly for group 3

Table 3 Adjusted Mortality Outcomes by Group

Overall Adjusted Mortality*				
% Mortality (Group)	% Mortality (Group)	OR	95% CI	FDR, p Value†
3.82 (1)	3.12 (2)	0.81	0.66–0.99	0.05
3.82 (1)	2.32 (3)	0.6	0.45–0.81	0.003
3.76 (2)	2.80 (3)	0.74	0.55–0.99	0.05
Adjusted Mortality, ISS 16–75*				
% Mortality (Group)	% Mortality (Group)	OR	95% CI	FDR, p Value†
14.83 (1)	11.41 (2)	0.74	0.58–0.94	0.02
14.83 (1)	9.03 (3)	0.57	0.41–0.80	0.003
12.21 (2)	9.67 (3)	0.77	0.55–1.08	0.13

* Adjusted for: Injury severity score, age, mechanism of injury, head injury and transfer status.
† The FDR p value, correcting for multiple comparisons.

Table 4 Adjusted Length of Stay Outcomes by Group

	Mean LOS	FDR p Value† (Group)	Median LOS	FDR p Value† (Group)
Adjusted hospital LOS (d)*				
Group 1	4.62	0.59 (1 vs. 2)	3.94	0.11 (1 vs. 2)
Group 2	4.69	0.05 (1 vs. 3)	3.88	0.003 (1 vs. 3)
Group 3	4.32	0.05 (2 vs. 3)	3.74	0.02 (2 vs. 3)
	Mean LOS	FDR p Value† (group)	Median LOS	FDR p Value† (group)
Adjusted ICU LOS (d)*				
Group 1	4.41	0.87 (1 vs. 2)	3.40	0.006 (1 vs. 2)
Group 2	4.23	0.87 (1 vs. 3)	3.03	0.003 (1 vs. 3)
Group 3	4.36	0.87 (2 vs. 3)	2.84	0.17 (2 vs. 3)

* Adjusted for: Injury severity score, age, mechanism of injury, head injury, and transfer status.
† The FDR p value, correcting for multiple comparisons.

compared with group 2 (2.80% vs. 3.76%; adjusted [OR], 0.74; [95% CI], 0.55 − 0.99; $p = 0.05$).

Mortality (ISS >15)

There were 3,570 patients (23.34%) with an ISS >15 (n = 1,295 for group 1, n = 1,638 for group 2, and n = 637 for group 3). There was a statistically significant decrease in the unadjusted mortalities of severely injured patients for all group comparisons, after correcting for multiple hypothesis testing (Table 2). Compared with group 1, unadjusted mortality was significantly reduced during group 2 (12.21% vs. 14.83%, $p = 0.04$) and during group 3 (9.73% vs. 14.83%, $p = 0.006$). Mortality was also significantly reduced for group 3 compared with group 2 (9.73% vs. 12.21%, $p = 0.02$).

Adjusted mortalities are presented in Table 3. The mortality was significantly reduced for group 2 compared with group 1 (11.41% vs. 14.83%; adjusted [OR], 0.74; [95% CI], 0.58 − 0.94; $p = 0.02$) and group 3 compared with group 1 (9.03% vs. 14.83%; adjusted [OR], 0.57; [95% CI], 0.41 − 0.80; $p = 0.003$). However, the presence of PAs did not independently reduce mortality of severely injured trauma patients (adjusted [OR], 0.77; [95% CI], 0.55 − 1.08; $p = 0.13$).

Hospital length of stay

There were 14,568 patients with a hospital LOS of one or more days. Patients included in the trauma registry who were not admitted to the hospital include patients who were discharged from the ED, died in the ED, and were transferred to another acute care facility. Patients transferred to other acute care facilities include children and patients with severe burns. The mean unadjusted LOS in the hospital (days) was significantly longer during group 2 and group 3 compared with group 1 (group 2, 5.28 days vs. 4.66 days; $p = 0.003$; and group 3, 5.10 days vs. 4.66 days; $p = 0.02$) (Table 2).

After adjustment, the mean and median hospital LOS was not significantly different for group 2 compared with group 1 (Table 4). However, the mean hospital LOS was reduced for group 3 compared with group 2 (4.32 days vs. 4.69 days, $p = 0.05$) and group 1 (4.32 days vs. 4.62 days, $p = 0.05$). Likewise, the median adjusted hospital LOS was significantly shorter during group 3 compared with group 2 (3.74 days vs. 3.88 days, $p = 0.02$) and group 1 (3.74 vs. 3.94 days, $p = 0.003$).

Intensive Care Unit length of stay

ICU LOS was calculated for all patients with an ICU LOS of one or more days (n = 3260). The mean unadjusted ICU LOS was not significantly different between groups after correcting for multiple hypothesis testing (Table 2). After adjustment, there was no significant change, by group, in the mean ICU LOS (Table 4). However, median ICU LOS was significantly shorter for group 2 and group 3 compared with group 1 (2 vs. 1: $p = 0.006$; 3 vs. 1: $p = 0.003$). Median ICU LOS for group 3 versus group 2 did not reach significance ($p = 0.17$).

DISCUSSION

This study compares three time periods with varying levels of trauma faculty and human resource involvement within the same hospital. To our knowledge, it is the first study to compare several forms of staff commitment to trauma care, including the transition from private general surgeons with and without residents to an in-house core trauma panel without residents and eventually adding dedicated in-house trauma PAs. Previously published studies reported the effects of adding midlevel providers (including PAs) to a trauma service staffed by surgical residents. Miller et al.[9] first reported the addition of PAs to a trauma service staffed with trauma surgeons as opposed to surgical residents. The presence of PAs decreased LOS and transfer times compared with the preceding period (trauma surgeons only), but their presence had no effect on mortality. Oswanski et al.[15] reported the effects of substituting surgical residents for PAs at a level I trauma center with in-house trauma surgeons.

Their findings suggest no marked improvement in mortality with PAs; however, LOS (from ED to floor) was reduced.

Contrary to the earlier studies, we found that the addition of PAs significantly reduced overall mortality as well as mean and median LOS in the hospital. The addition of PAs to the trauma panel reduced overall mortality by 25.5%. The significant percent reduction in mean and median hospital LOS with addition of PAs to the trauma service was 7.9% and 3.6%, respectively. The presence of PAs did not significantly reduce ICU LOS (mean or median), or mortality for the most severely injured patients. However, the primary responsibilities of PAs do not include provision of care for severely injured patients and patients in the ICU, so these results were expected.

Adjusted overall mortality and mortality for the most severely injured trauma patients were both significantly reduced with a trauma service staffed with an in-house core trauma panel (18.3% overall and 23.1% among patients with ISS >15). The median ICU LOS decreased significantly (10.9%) when trauma surgeons were present in-house.

The mean ICU LOS was not significantly reduced for groups 2 and 3 compared with group 1, but there was a significant reduction in median ICU LOS, reflecting a shift in the distribution of ICU LOS. A larger proportion of patients are (a) being discharged from the hospital and the ICU earlier; and (b) staying in the ICU longer. We hypothesize that these results may reflect an improvement in patient care because a subset of patients who may have died are living and extending their ICU LOS.

During the group 1 period, all patients with trauma were cared for by a group of 10 to 12 general surgeons, none of which were certified in critical care. During this time, the hospital staff transitioned from being on-call to in-house. During the group-2 period, the dedicated trauma surgeons were available in-house 24 hours per day, with second-call and third-call trauma attending backup available. No additional staffing changes were made during this time. The dedicated trauma surgeons provided complete care to all patients admitted with a traumatic injury, regardless of ICU disposition or ISS. The core group of dedicated trauma surgeons includes four primary surgeons (two have critical care certification) that take six to seven calls per month and work 24-hour shifts, in addition to two trauma surgeons that take fewer calls and then sign out patients to the core group. The addition of a dedicated core trauma panel resulted in reduced mortality and ICU LOS. We believe that improved consistency, coordination, and continuity of care contributed significantly to these outcomes.

During the group-3 period, dedicated trauma service PAs were added to the existing core trauma panel. The PAs are nationally certified, have audited the advanced trauma life support course, adhere to continuing medical education, and attend weekly morbidity and mortality conferences. The PAs attend to less severely injured trauma patients under the supervision of the trauma surgeon, and work in conjunction with the trauma surgeon to attend to severely injured patients (ISS >15); the dedicated trauma surgeons cared for all patients who were admitted to the ICU. At our institution, there are five PAs who share call; they work in 12-hour shifts (24 hours a day) and work one week on either the day or night shift, followed by 1 week off. There is very little turnover, most likely because of the shift work schedule and the high level of job satisfaction. The role of the PA is both complementary and wide ranging; they: (1) provide continuity of care and a "familiar face" to the patient with trauma; (2) round with the trauma surgeons and provide additional knowledge on the patient's total course of stay; (3) perform tasks that require follow up, including patient discharge and writing prescriptions; (4) allow the trauma surgeons to concentrate on the more severely injured patients; and (5) provide improved communication between trauma service nursing and ancillary services. The addition of PAs to the trauma service also resulted in standardization of progress notes and admission orders. Each of these factors speaks to an improvement in the efficiency of the trauma service.

There are three limitations of the study that should be considered. First, because of the retrospective nature of the analysis, the database was predetermined, and not all of the covariates which could be significantly associated with outcomes were collected. For instance, changes in care that were made during the study period were not all accounted for in the statistical analyses, including improved technology and new evidence-based protocols. However, the results that were observed after addition of the PAs to the trauma service (group 3 vs. group 2) should not significantly be confounded by time and general improvements in technology or critical care medicine, because this period was only one calendar year. Second, the improvements in LOS and mortality that were observed during group 2 compared with group 1 may be confounded by patient volume; there were fewer surgeons during group 2 compared with group 1, and the surgeons in group 2 saw a higher volume of severely injured patients and performed a higher volume of operations than the surgeons in the group 1 period. Third, the group 1 period was characterized by a transition from on-call attending surgeons to in-house surgeons, and the outcomes may not be homogenous across the study period.

In conclusion, expanding commitment to trauma by modifying the human resources available to patients with trauma improved management and outcome of critically injured trauma patients within our level I trauma center. Additional studies are needed to determine what, if any, the optimal staff commitments to trauma care may be, particularly at level I centers.

REFERENCES

1. Cooper DJ, McDermott FT, Cordner SM, Tremayne AB. Quality assessment of the management of road traffic fatalities at a level I trauma center compared with other hospitals in Victoria, Australia.

Consultative Committee on Road Traffic Fatalities in Victoria. *J Trauma.* 1998;45:772–779.
2. Demetriades D, Martin M, Salim A, Rhee P, Brown C, Chan L. The effect of trauma center designation and trauma volume on outcome in specific severe injuries. *Ann Surg.* 2005;242:512–517.
3. Demetriades D, Martin M, Salim A, et al. Relationship between American College of Surgeons trauma center designation and mortality in patients with severe trauma (injury severity score >15). *J Am Coll Surg.* 2006;202:212–215.
4. Kreis DJ Jr, Plasencia G, Augenstein D, et al. Preventable trauma deaths: Dade County, Florida. *J Trauma.* 1986;26:649–654.
5. 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.
6. Nirula R, Brasel K. Do trauma centers improve functional outcomes: a national trauma databank analysis? *J Trauma.* 2006;61:268–271.
7. Smith JS Jr, Martin LF, Young WW, Macioce DP. Do trauma centers improve outcome over non-trauma centers: the evaluation of regional trauma care using discharge abstract data and patient management categories. *J Trauma.* 1990;30:1533–1538.
8. Scarborough K, Slone DS, Uribe P, Craun M, Bar-Or R, Bar-Or D. Reduced mortality at a community hospital trauma center: the impact of changing trauma designation from II to I. *Arch Surg.* 2008; 143:22–27.
9. Miller W, Riehl E, Napier M, Barber K, Dabideen H. Use of physician assistants as surgery/trauma house staff at an American College of Surgeons-verified Level II trauma center. *J Trauma.* 1998;44:372–376.
10. Nyberg SM, Waswick W, Wynn T, Keuter K. Midlevel providers in a Level I trauma service: experience at Wesley Medical Center. *J Trauma.* 2007;63:128–134.
11. Offner PJ, Hawkes A, Madayag R, Seale F, Maines C. General surgery residents improve efficiency but not outcome of trauma care. *J Trauma.* 2003;55:14–19.
12. Haut ER, Chang DC, Efron DT, Cornwell EE III. Injured patients have lower mortality when treated by "full-time" trauma surgeons vs. surgeons who cover trauma "part-time." *J Trauma.* 2006; 61:272–278.
13. Christmas AB, Reynolds J, Hodges S, et al. Physician extenders impact trauma systems. *J Trauma.* 2005;58:917–920.
14. Mathur M, Rampersad A, Howard K, Goldman GM. Physician assistants as physician extenders in the pediatric intensive care unit setting. A 5-year experience. *Pediatr Crit Care Med.* 2005;6:14–19.
15. Oswanski MF, Sharma OP, Raj SS. Comparative review of use of physician assistants in a level I trauma center. *Am Surg.* 2004; 70:272–279.
16. Goldstein MJ, Kim E, Widmann WD, Hardy MA. A 360 degrees evaluation of a night-float system for general surgery: a response to mandated work-hours reduction. *Curr Surg.* 2004;61:445–451.
17. Cornwell EE III, Chang DC, Phillips J, Campbell KA. Enhanced trauma program commitment at a level I trauma center: effect on the process and outcome of care. *Arch Surg.* 2003;138:838–843.
18. American College of Surgeons Committee on Trauma. Resources for Optimal Care of the Injured Patient. Chicago, IL: American College of Surgeons Committee on Trauma; 2006:17, 22.