ONLINE FIRST

Weekend and Night Outcomes in a Statewide Trauma System

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Objective: To evaluate whether mortality and clinical outcomes vary for injured patients in a mature trauma system on weeknights and weekends compared with weekdays.

Design: Retrospective cohort study.

Setting: Pennsylvania trauma system.

Patients: A total of 90 461 patients over 5 years.

Intervention: Treatment at a level I, II, or III trauma center.

Main Outcome Measures: In-hospital mortality, time to procedures, and length of stay.

Results: In adjusted analyses, patients presenting on weeknights were no more likely to die than patients presenting during weekdays, and patients presenting on weekends were less likely to die than patients presenting on weekdays (odds ratio = 0.89; 95% confidence interval, 0.81-0.97). Presenting on weeknights was associated with longer intensive care unit stay (incidence rate ratio = 1.06; 95% confidence interval, 1.02-1.10) and longer hospital stay (incidence rate ratio = 1.02; 95% confidence interval, 1.00-1.04). Presenting on weekends was associated with longer intensive care unit stay (incidence rate ratio = 1.04; 95% confidence interval, 1.02-1.10) but not longer hospital stay. Delays to laparotomy or craniotomy were not seen in either group.

Conclusions: We demonstrate comparable mortality among injured patients presenting on weeknights vs weekdays and lower mortality among injured patients on weekends vs weekdays. Systems-based solutions of the trauma model are protective against the weekend effect and inform care for other emergency care–sensitive conditions.

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WEEKEND AND NIGHT presentation has been identified as a risk factor for patients presenting with unplanned critical illness requiring rapid diagnostics and interventions.[1-5] This phenomenon, termed the *weekend effect*, has been observed for time-sensitive conditions including myocardial infarction, cardiac arrest, and ischemic stroke.[6-8] Variability in emergency care outcomes has been attributed to less frequent use of aggressive interventional procedures,[6] less availability of subspecialty care,[8] increased complications,[9] more medical errors,[10] and differential staffing.[7,11,12] The Institute of Medicine recently highlighted the emergency care system's shortcomings, describing the system as "at the breaking point."[13,14]

Emergency care in the United States is provided by independently functioning emergency departments based primarily in private hospitals. Although accredited by The Joint Commission standards, emergency departments are not regionally coordinated and availability of staffing and resources is variable. In contrast, the American College of Surgeons publishes trauma care guidelines[15] that describe resources and staffing required for definitive trauma care as well as the importance of coordinating care between hospitals to create a trauma system. The Institute of Medicine celebrated the trauma system as a model of emergency care because coordination, accountability, and regionalization of care have resulted in improved injury outcomes.

If the design of the trauma system protects against the weekend effect, there are substantial implications for the structures and processes that should be put in place in the further development of the broader emergency care system. We thus sought to determine whether the probability of death or negative clinical outcomes was higher

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among injured patients if they presented at night or on the weekend as compared with the weekday in a mature state trauma system. We hypothesized that outcomes after trauma would be similar for patients presenting at night or on the weekend.

METHODS

STUDY DESIGN

We performed a retrospective cohort study to determine the relative risks of adverse outcomes during weeknights and on weekends compared with weekdays. We included all patients treated at trauma centers in Pennsylvania during a 5-year period.

DATA SOURCE

Data were obtained from the Pennsylvania Trauma Outcome Study (PTOS), a product of the Pennsylvania Trauma Systems Foundation. The Pennsylvania Trauma Systems Foundation is the sole organization responsible for accrediting trauma centers in Pennsylvania and has been reviewing and surveying applicant hospitals since 1986. There are 3 levels of trauma centers in Pennsylvania. Level I trauma centers require trauma research, a surgical residency program, and an annual volume of 600 PTOS patients per year. Level II trauma centers do not require the research and residency components, have several groups of subspecialists, and only require 350 PTOS trauma patients per year. Level III trauma centers are smaller rural centers that do not require a minimum volume of trauma patients or neurosurgical resources, admit mildly injured patients, and focus on stabilization and transport of trauma patients to a higher-level trauma center.[16]

The PTOS includes all records from the 32 accredited trauma centers in Pennsylvania. Data are collected in real time by dedicated trauma registrars within each hospital who have been trained in the PTOS data collection process. All patients presenting to Pennsylvania trauma centers are eligible for inclusion in the standardized hospital registry if they have a diagnosis of injury (*International Classification of Diseases, Ninth Revision, Clinical Modification* codes 800-995), are admitted to the intensive care unit (ICU) or step-down unit, are pronounced dead after arrival, die of injuries in the hospital, are transferred, or remain in the emergency department or hospital longer than 48 hours from the time of emergency department arrival. Available demographic data include race, age, and sex. Collected clinical data include Trauma-Related Injury Severity Score (TRISS), Glasgow Coma Scale score, comorbidities, and procedures performed.[17]

PATIENT POPULATION

We obtained data for all patients in the PTOS registry who were treated from January 1, 2004, to December 31, 2008. We then excluded children (aged <18 years), patients with a primary diagnosis of a burn, and patients transferred from another facility. The study was approved by the institutional review board at the University of Pennsylvania.

MAIN AND SECONDARY OUTCOMES

The primary outcome variable was in-hospital mortality. The ICU length of stay (LOS), hospital LOS, and a delay longer than 2 hours to treatment by laparotomy or craniotomy were considered secondary outcomes.

EXPOSURE VARIABLES OF WEEKNIGHT AND WEEKEND PRESENTATION

Historical definitions for the exposure variables of day and time of presentation are variable.[6,7,18] We chose to create 3 distinct categories representing weekdays (9:00 AM to 5:59 PM Monday through Friday), weeknights (6:00 PM through 8:59 AM Monday through Friday), and weekends (Friday at 6:00 PM through 8:59 AM on Monday). To assess the robustness of the results and enable direct comparison with work conducted previously,[1] the analyses were repeated with historical definitions (weekends defined as between 11:00 PM on Friday and 6:59 AM Monday, and weeknights defined as between 11:00 PM and 6:59 AM on weekdays) and with an alternate 4-category definition (weekday, weeknight, weekend day, weekend night).

POWER ANALYSIS

Power analyses were performed using PS Power and Sample Size Calculator version 2.1.31 (Department of Biostatistics, Vanderbilt University, Nashville, Tennessee). We determined the mortality difference that would be detectable given our sample size, a 2-tailed α of .05, a power of 90%, and baseline mortality differences associated with weeknight and weekend presentation based on pilot data.[18] Separate power analyses were performed for weeknight vs weekday presentation and for weekend vs weekday presentation. We determined that we would be powered to detect a 0.63% difference in mortality for patients presenting on weeknights and a 0.53% difference in mortality for patients presenting on weekends.[19-22] The known mortality variability between level I trauma centers exceeds 1%,[23] so we considered our analysis to be adequately powered. Given the importance of potentially finding no differences between groups, the 95% confidence intervals (CIs) around the effect estimates were our focus in evaluating the outcomes. If the bounds of a 95% CI are between 0.85 and 1.20,[24] we fail to reject the null hypothesis that the likelihood of mortality differs between groups and conclude that the risk of mortality is similar when presenting during weeknights or weekends.

CASE MIX ADJUSTMENT

A modification of the Charlson method was used to adjust for case mix.[25] The Charlson Index is traditionally calculated based on 19 comorbidities. Each comorbid condition is assigned a weight, and the sum of the weighted conditions that are present for a patient is used for predicting the probability of death. The PTOS data do not include information on peripheral vascular disease, any tumor, leukemia, and lymphoma; thus, the Charlson Index that we calculated is based on 15 rather than 19 comorbid conditions.

INJURY SEVERITY ADJUSTMENT

The TRISS method was used to adjust for injury severity. The TRISS incorporates both an anatomical injury scoring system (the Injury Severity Score [ISS]) and a physiological scoring system (the Revised Trauma Score). The TRISS is a standard and comprehensive comparator used to correct for severity in outcome analysis and to predict survival in trauma patients.[26,27] Severe injury was defined as an ISS of 16 or higher.[27]

DESCRIPTIVE STATISTICS AND UNADJUSTED ANALYSES

Unadjusted analyses were performed using Stata version 10 statistical software (StataCorp LP, College Station, Texas). Pearson χ^2 tests, Kruskal-Wallis tests, and *t* tests were used to evaluate characteristics of the patient sample. Logistic regression was used to estimate the unadjusted relative likelihood of death for patients presenting on weekends vs weekdays and for patients presenting on weeknights vs weekdays. Logistic regression was also used in the models that evaluated the secondary outcomes of delayed laparotomy and delayed craniotomy. The secondary outcomes of ICU LOS and hospital LOS were modeled using negative binomial regression. The effect estimates derived through logistic regression are presented as odds ratios (ORs), and the effect estimates derived through negative binomial regression are presented as incidence rate ratios (IRRs). For each of the outcomes, subgroup analyses were performed by stratifying patients according to age group, injury severity, and injury type (blunt or penetrating).

ADJUSTED ANALYSES

Adjusted analyses were performed using Stata version 10 statistical software (StataCorp LP, College Station, Texas). The variables of age, sex, race, TRISS, and comorbid conditions were added to the regression models to estimate the relative likelihood of each outcome while controlling for potential confounding. Variance inflation factors were used to detect multicollinearity and model fit, and outliers were evaluated using conventional methods.[28] In all of the unadjusted and adjusted regression analyses, missing data were managed through the use of multiple imputation by chained equations with 20 imputed data sets.[29,30]

RESULTS

PATIENT CHARACTERISTICS

A total of 90 461 patients were treated during the 5-year period and were included in the study. About a quarter of patients (n=23 841 [26.4%]) presented on weeknights and just more than a third (n=37 349 [41.3%]) presented on the weekend. Compared with patients presenting on weekdays (mean age, 57 years), those presenting on weeknights were younger (mean age, 45 years; $P<.001$), as were those presenting on the weekend (mean age, 45 years; $P<.001$). Also, compared with patients presenting on weekdays (57.6% male), those presenting on weeknights (64.8% male) and weekends (64.2% male) were more likely to be male ($P<.001$ for both). The ISS was not significantly different as a function of when patients presented. Statistical tests rejected the null hypothesis that patients presenting on weeknights or weekends did not differ from patients presenting on weekdays in terms of Glasgow Coma Scale score and TRISS, but the patient groups overall were clinically similar in these variables. Penetrating trauma was more common among patients presenting on weeknights than in those presenting on weekdays (12.8% vs 5.4%, respectively; $P<.001$) and was more common among those presenting on weekends than in those presenting on weekdays (10.6% vs 5.4%, respectively; $P<.001$) (**Table 1**). A total of 38 237 patients (42.3%) had no comorbid conditions, and the number of comorbid conditions ranged from 0 to 16 (median, 0; mean, 2.9). Charlson Index scores ranged from 0 to 13, with a median of 0 and a mean of 0.4. The TRISS was missing for 13.2% of patients. No other variables had more than 5% missing data.

UNADJUSTED ANALYSES

In unadjusted analyses, compared with patients presenting on weekdays, patients presenting on weeknights were more likely to die (6.6% vs 7.5%, respectively; OR=1.15; 95% CI, 1.07-1.22), to have longer than the median ICU LOS (37.0% vs 43.4%, respectively; IRR=1.13; 95% CI, 1.08-1.17), and to have longer than the median hospital LOS (46.8% vs 46.2%, respectively; IRR=1.03; 95% CI, 1.01-1.04). There was no difference in delay to laparotomy or delay to craniotomy for patients presenting at night (**Table 2**).

Patients presenting on the weekend were not more likely to die than patients presenting on weekdays. Weekend presentation compared with weekday presentation was associated with longer than the median ICU LOS (41.1% vs 37.0%, respectively; IRR=1.09; 95% CI, 1.06-1.13) but not longer hospital LOS (42.0% vs 46.8%, respectively; IRR=0.99; 95% CI, 0.97-1.00). There was no significant difference in delay to craniotomy or delay to laparotomy for patients presenting on the weekend (Table 2).

ADJUSTED ANALYSES

In adjusted analyses, patients presenting at night were not differentially likely to die or have a delay to procedure (craniotomy or laparotomy) compared with patients presenting during the day. After adjustment, patients presenting at night continued to have significantly longer ICU LOS (IRR=1.06; 95% CI, 1.02-1.10) and hospital LOS (IRR=1.02; 95% CI, 1.00-1.04) (Table 2).

Patients presenting on the weekend were less likely to die than patients presenting during weekdays (IRR=0.89; 95% CI, 0.81-0.97). No difference was noted in delays to procedures. Weekend presentation compared with weekday admissions was associated with longer ICU LOS (IRR=1.04; 95% CI, 1.02-1.10) but not with longer hospital LOS (IRR=0.99; 95% CI, 0.97-1.00).

SUBGROUP ANALYSES

To examine the relationship between subgroups and outcomes, we performed separate analyses for populations of interest. Results for each outcome after stratifying by age group, injury severity, and injury mechanism are shown in **Table 3** and the **Figure**.

DEATH

No differences were observed in the likelihood of death associated with presenting during weeknights vs weekdays within the subgroups of patients defined by the variables used for stratification. Presenting on weekends vs weekdays was associated with decreased odds of death for patients who sustained blunt trauma (OR=0.89; 95% CI, 0.81-0.97), for patients with lower-severity injuries (ISS <16; OR=0.83; 95% CI, 0.70-0.99) as well as higher-severity injuries (ISS ≥16; OR=0.90; 95% CI, 0.80-0.99), and for younger patients (OR=0.82; 95% CI, 0.71-0.94).

ICU AND HOSPITAL LOS

There were 3 patient subgroups in the stratified analyses among whom presenting on weeknights vs weekdays was

Table 1. Patient Characteristics[a]

Characteristic	Presentation: Weeknight (n=23 841)	Weekend (n=37 349)	Weekday (n=29 271)	Total (N=90 461)
Age, median (IQR), y	45 (28-65)	45 (28-65)	57 (40-77)[b]	48 (31-71)
Male, No. (%)	15 431 (64.8)	23 962 (64.2)	16 856 (57.6)[b]	56 249 (62.2)
GCS score, median (IQR)	15 (14-15)	15 (14-15)	15 (15-15)[b]	15 (15-15)
ISS, median (IQR)	10 (5-18)	10 (5-18)	9 (5-17)	10 (5-17)
TRISS, median (IQR)	0.98 (0.96-0.99)	0.98 (0.98-0.99)	0.98 (0.95-0.99)[b]	0.98 (0.96-0.99)
Race, No. (%)				
White	16 998 (75.0)	27 550 (78.0)	23 636 (84.7)[b]	68 184 (79.3)
Black	4876 (21.5)	6549 (18.5)	3521 (12.6)[c]	14 946 (17.4)
Other	777 (3.4)	1244 (3.5)	858 (3.1)[c]	2879 (3.5)
Penetrating mechanism, No. (%)[d]	3051 (12.8)	3948 (10.6)	1574 (5.4)[b]	8563 (9.5)
Gunshot wound, No. (%)[e]	639 (2.7)	798 (2.2)	285 (1.0)[b]	1722 (1.9)
Charleson Index, median (IQR)[f]	0 (0-0)	0 (0-0)	0 (0-1)[b]	0 (0-0)
Preexisting conditions, median (IQR), No.	1 (0-3)	1 (0-2)	1 (0-5)[b]	1 (0-4)
Conditions, No. (%)				
Cardiac	6088 (25.5)	9668 (25.9)	10 515 (35.9)[b]	26 271 (29.0)
Diabetes	5288 (22.2)	8042 (21.5)	8741 (29.9)[b]	22 071 (24.0)
Gastrointestinal	4606 (19.3)	6947 (18.6)	7514 (25.7)[b]	19 067 (21.1)
Heme	4963 (20.8)	7439 (19.9)	8113 (27.7)[b]	20 515 (22.7)
Psychiatric	4910 (20.6)	7241 (19.4)	7215 (24.7)[b]	19 366 (21.4)
Immunology	4908 (20.6)	7208 (19.3)	7214 (24.7)[b]	19 330 (21.4)
Liver	4836 (20.3)	7123 (19.1)	7124 (24.3)[b]	19 083 (21.1)
Malignant neoplasm	4885 (20.5)	7176 (19.2)	7190 (24.6)[b]	19 251 (21.3)
Musculoskeletal	4781 (20.1)	7069 (18.9)	7068 (24.2)[b]	18 918 (20.9)
Neurological	5571 (23.4)	8206 (22.0)	8103 (27.7)[b]	21 880 (24.2)
Obesity	914 (3.8)	1422 (3.8)	1360 (4.7)[b]	3696 (4.1)
Pulmonary	4839 (20.3)	7092 (19.0)	6337 (21.7)[b]	18 268 (20.2)
Renal	3082 (12.9)	4391 (11.8)	3920 (13.4)[b]	11 393 (12.6)
Substance abuse	4541 (19.1)	6520 (17.5)	4528 (15.5)[b]	15 589 (17.2)
Trauma	444 (1.9)	706 (1.9)	535 (1.8)	1685 (1.9)
Endocrine	1438 (6.0)	2195 (5.9)	2554 (8.7)[b]	6187 (6.8)

Abbreviations: GCS, Glasgow Coma Scale; IQR, interquartile range; ISS, Injury Severity Score; TRISS, Trauma-Related Injury Severity Score.
[a] Differences between groups were tested with *t* tests for normally distributed continuous variables, Kruskal-Wallis tests for nonnormally distributed continuous variables, and χ^2 tests for categorical variables.
[b] $P < .05$ for both weeknight vs weekday and weekend vs weekday.
[c] $P < .05$ for weekend vs weekday but not weeknight vs weekday.
[d] The reference category is blunt mechanism.
[e] The reference category is nongunshot injury.
[f] Modified index as described in the text.

associated with longer ICU LOS. The ICU LOS was longer among patients with lower-severity injuries (ISS <16; IRR=1.13; 95% CI, 1.07-1.19), patients with blunt trauma (IRR=1.04; 95% CI, 1.00-1.09), and younger patients (IRR=1.13; 95% CI, 1.07-1.18). In addition to longer ICU LOS, patients presenting on weeknights with less severe injuries (IRR=1.02; 95% CI, 1.01-1.04) and with blunt injuries (IRR=1.02; 95% CI, 1.00-1.04) were found to have longer hospital LOS than patients who arrived on weekdays. For other subgroups of patients, the likelihood of differential hospital or ICU LOS did not differ as a function of presenting on weeknights vs weekdays.

Three subgroups of patients, including patients with lower-severity injuries (ISS <16; IRR=1.08; 95% CI, 1.03-1.13), patients with penetrating trauma (IRR=1.16; 95% CI, 1.02-1.32), and younger patients (IRR=1.12; 95% CI, 1.07-1.17) had longer ICU LOS if they presented on weekends as compared with weekdays. Overall hospital LOS was shorter on weekends compared with weekdays, however, for patients with less severe injuries (IRR=0.98; 95% CI, 0.96-0.99), patients with blunt trauma (IRR=0.98; 95% CI, 0.97-0.99), and older patients (aged >55 years; IRR=0.97; 95% CI, 0.95-0.99). For other subgroups of patients, the likelihood of differential hospital or ICU LOS did not differ as a function of presenting on weekends vs weekdays.

COMMENT

We examined whether injured patients presenting to a trauma center at night and on the weekend experienced increased mortality or negative clinical outcomes compared with patients presenting during weekdays in a mature state trauma system. In contrast to previous work examining a number of other nontrauma emergency care–sensitive conditions,[6-8] we found no differential adverse outcomes associated with presenting outside traditional working hours. These findings are robust to a number of definitions of weekend and night as described earlier (results not shown). Given the recent attention directed to the shortcomings of the emergency care system in the

Table 2. Outcomes by Time of Presentation

Outcome	Presentation, No. (%)[a]			Weeknight or Weekend vs Weekday, Effect Estimate (95% CI)[b]	
	Weeknight or Weekend	Weekday	Total	Unadjusted	Adjusted
Weeknight vs weekday	(n=23 841)	(n=29 271)	(n=53 112)		
Died	1781 (7.5)	1928 (6.6)	6208 (6.9)	1.15 (1.07-1.22)[c]	0.99 (0.90-1.09)
Delayed laparotomy	270 (16.1)	273 (21.7)	990 (18.6)	1.01 (0.93-1.09)	1.07 (0.99-1.14)
Delayed craniotomy	612 (2.6)	739 (2.5)	2296 (2.5)	1.02 (0.91-1.13)	0.96 (0.86-1.08)
ICU LOS	10 334 (43.4)	10 828 (37.0)	36 501 (40.4)	1.13 (1.08-1.17)[c]	1.06 (1.02-1.10)[c]
Hospital LOS	11 016 (46.2)	13 708 (46.8)	40 405 (44.7)	1.03 (1.01-1.04)[c]	1.02 (1.00-1.04)[c]
Weekend vs weekday	(n=37 349)	(n=29 271)	(n=60 620)		
Died	2499 (6.7)	1928 (6.6)	6208 (6.9)	1.02 (0.96-1.88)	0.89 (0.81-0.97)[c]
Delayed laparotomy	945 (2.5)	273 (21.7)	990 (18.6)	0.99 (0.87-1.12)	1.05 (0.92-1.19)
Delayed craniotomy	1066 (2.5)	739 (2.5)	2296 (2.5)	1.00 (0.91-1.11)	0.96 (0.88-1.07)
ICU LOS	15 339 (41.1)	10 828 (37.0)	36 501 (40.4)	1.09 (1.06-1.13)[c]	1.04 (1.02-1.10)[c]
Hospital LOS	15 681 (42.0)	13 708 (46.8)	40 405 (44.7)	0.99 (0.97-1.00)	0.99 (0.97-1.00)

Abbreviations: CI, confidence interval; ICU, intensive care unit; LOS, length of stay.
[a] For ICU LOS and hospital LOS, the number of patients in each row are those with an LOS longer than the median LOS for all patients (ie, irrespective of time or day of presentation).
[b] The effect estimates for died, delayed laparotomy, and delayed craniotomy are odds ratios calculated with logistic regression; the effect estimates for ICU LOS and hospital LOS are incidence rate ratios calculated with negative binomial regression. Adjusted effect estimates were calculated controlling for sex, age, Trauma-Related Injury Severity Score, comorbidity score, and race. All regressions were completed with multiple imputation.
[c] $P < .05$.

United States,[13] the increased interest in understanding the comparative effectiveness of different models of care,[31] and the federal government's interest in coordinating emergency care in the United States,[32] these findings have significant implications for the staffing and design of the emergency care system.

Although the potential for patients admitted outside traditional working hours to fare worse than patients admitted during the week has been recognized for decades,[1] a weekend effect specific to patients with unplanned critical illness requiring complex or resource-intensive interventions has more recently been described.[3,6-8] Higher mortality rates on weekends for patients with myocardial infarction were attributed to lower rates of invasive cardiac procedures or treatment delays.[6] Similarly, cardiac arrest survival was lower on nights and weekends except in the emergency department and on the trauma service, where staffing is similar independent of time and day.[7] Data examining the effect of weekend admission on stroke outcomes are mixed, and an organized systems-based approach has been suggested as a potential solution to counter the adverse outcomes observed on weekends.[8,33,34] The principal conclusions from our analysis are that the number of deaths does not increase on nights and weekends in a mature state trauma system and that clinical outcomes are also not compromised. A plausible explanation is the particular organizational model of trauma care in the United States.

The American College of Surgeons Committee on Trauma[15] first published guidelines for the organization of trauma care in 1976.[35] Updated frequently, they describe not only the essential components of trauma centers including resources and staffing but also the philosophy of an integrated system of components of care spanning from prehospital care to rehabilitation. Trauma centers are categorized, and an inventory is made publicly available for consumers as well as policy planners (http://www.amtrauma.org/).[36,37] In addition, professional surgical societies have created and endorsed evidence-based practice management guidelines to standardize care across facilities (http://www.east.org/tpg.asp). Severely injured patients treated at trauma centers have had markedly reduced mortality compared with those receiving care at nontrauma centers.[14] The trauma center's systems-based approach has been celebrated by the Institute of Medicine as a model of coordinated, regionalized, and accountable emergency care.[13]

Although the primary conclusion from our analysis is that patients do not have worse outcomes when presenting outside typical working hours, a number of additional findings are notable. We found no variability in overall mortality for patients presenting at night, but we found that weekend presentation is associated with a decreased likelihood of death. This finding is contradictory to most data describing the effect of weekend presentation on outcomes for time-critical conditions, and the immediate availability of resources and personnel that might otherwise be occupied during normal working hours may account for this finding. The explicit requirements of trauma centers to be staffed and prepared to deliver optimal care independent of time of day and day of week may be instructive for other emergency care–sensitive conditions. The financial, practical, and logistical realities associated with developing an emergency care system that is prepared 24 hours a day, 7 days a week, 365 days a year warrant further research and discussion. In subgroup analyses, we identified a few cohorts in which LOS was longer for patients presenting at night compared with patients presenting during the day. We expect that this may be related to either differential use of available ICU beds at night (ie, quicker decision to admit to a higher level of care to facilitate flow) or peculiarities of the hospital process including the practice of awaiting discharges for patients on the floor to facilitate

Table 3. Outcomes by Time of Presentation and Subsets of the Patient Sample

Outcome	Presentation, No./Total No. (%) Weeknight or Weekend	Weekday	Adjusted Effect Estimate (95% CI)[a]
Weeknight vs weekday			
Died			
ISS ≥16	1353/7610 (17.8)	1416/8118 (17.4)	1.03 (0.92-1.16)
ISS <16	403/16 056 (2.9)	484/20 399 (2.3)	0.84 (0.69-1.02)
Penetrating	626/3051 (20.5)	326/1564 (20.8)	1.05 (0.77-1.43)
Blunt	1155/20 766 (5.6)	1602/27 692 (5.8)	0.96 (0.87-1.07)
Aged >55 y	679/8216 (8.3)	1187/15 265 (7.8)	0.98 (0.86-1.12)
Aged ≤55 y	1102/15 625 (7.1)	741/14 006 (5.3)	0.95 (0.82-1.11)
ICU LOS			
ISS ≥16	2893/7610 (38.0)	3156/8115 (38.9)	0.99 (0.94-1.04)
ISS <16	4817/16 055 (30.0)	4991/20 883 (23.9)	1.13 (1.07-1.19)[b]
Penetrating	1445/3050 (47.4)	643/1563 (41.1)	1.11 (0.97-1.27)
Blunt	8881/20 766 (42.8)	10 177/27 690 (36.8)	1.04 (1.00-1.09)[b]
Aged >55 y	3354/8216 (40.8)	5740/15 264 (37.6)	1.02 (0.96-1.09)
Aged ≤55 y	6980/15 624 (44.7)	5088/14 004 (36.3)	1.13 (1.07-1.18)[b]
Hospital LOS			
ISS ≥16	3610/7610 (47.7)	3878/8118 (47.7)	0.99 (0.96-1.02)
ISS <16	6374/16 056 (39.7)	8645/20 883 (41.4)	1.02 (1.01-1.04)[b]
Penetrating	1382/3051 (45.3)	640/1564 (40.9)	0.96 (0.89-1.03)
Blunt	9625/20 766 (46.4)	13 061/27 672 (47.2)	1.02 (1.00-1.04)[b]
Aged >55 y	6248/16 334 (38.3)	15 482/37 858 (40.9)	1.02 (1.00-1.04)
Aged ≤55 y	3652/8216 (44.5)	6466/15 265 (42.4)	1.04 (1.01-1.06)
Weekend vs weekday			
Died			
ISS ≥16	1854/11 550 (16.1)	1416/8118 (17.4)	0.90 (0.80-0.99)[b]
ISS <16	608/25 524 (2.4)	484/20 399 (2.3)	0.83 (0.70-0.99)[b]
Penetrating	787/3948 (19.9)	326/1564 (20.8)	0.87 (0.65-1.17)
Blunt	1709/33 371 (5.1)	1602/27 692 (5.8)	0.89 (0.81-0.97)[b]
Aged >55 y	980/12 721 (7.7)	1187/15 265 (7.8)	0.93 (0.83-1.04)
Aged ≤55 y	1519/24 628 (6.2)	741/14 006 (5.3)	0.82 (0.71-0.94)[b]
ICU LOS			
ISS ≥16	4515/11 547 (39.1)	3156/8115 (38.9)	1.00 (0.96-1.05)
ISS <16	7025/25 521 (27.5)	4991/20 883 (23.9)	1.08 (1.03-1.13)[b]
Penetrating	1767/3947 (44.8)	643/1563 (41.1)	1.16 (1.02-1.32)[b]
Blunt	13 563/33 366 (40.7)	10 177/27 690 (36.8)	1.03 (0.99-1.06)
Aged >55 y	4775/12 719 (37.5)	5740/15 264 (37.6)	0.97 (0.92-1.02)
Aged ≤55 y	10 564/24 624 (42.9)	5088/14 004 (36.3)	1.12 (1.07-1.17)[b]
Hospital LOS			
ISS ≥16	5119/11 550 (44.3)	3878/8118 (47.7)	0.98 (0.95-1.01)
ISS <16	8829/25 524 (34.6)	8645/20 883 (41.4)	0.98 (0.96-0.99)[b]
Penetrating	1626/3948 (41.2)	640/1564 (40.9)	0.99 (0.92-1.06)
Blunt	14 045/33 371 (42.1)	13 061/27 672 (47.2)	0.98 (0.97-0.99)[b]
Aged >55 y	11 574/27 466 (42.1)	15 482/37 858 (40.9)	0.97 (0.95-0.99)[b]
Aged ≤55 y	4657/12 721 (36.6)	6466/15 265 (42.4)	1.00 (0.98-1.02)

Abbreviations: CI, confidence interval; ICU, intensive care unit; ISS, Injury Severity Score; LOS, length of stay.
[a] The effect estimates for died are odds ratios calculated with logistic regression; the effect estimates for ICU LOS and hospital LOS are incidence rate ratios calculated with negative binomial regression. Adjusted effect estimates were calculated controlling for sex, age, Trauma-Related Injury Severity Score, comorbidity score, and race. All regressions were completed with multiple imputation.
[b] $P < .05$.

transfer out of the ICU. More surprising, however, were the findings that patients presenting on the weekend were less likely to die and that several subgroups had shorter hospital LOS than comparable patients presenting on weekdays. Again we speculate that these findings may be associated with the somewhat unique structure of the trauma center, where during the typical workday there is competition for personnel (elective operative schedules and office hours) and resources (blood bank, pharmacy, immediate operating room availability) but where processes of care may be streamlined outside typical business hours given the absence of scheduled patients.

We present a negative study, and although we were appropriately powered to detect a mortality difference of 0.63% for night admissions and 0.53% for weekend admissions, these thresholds may be too low and significant differences may have been missed. In addition, we may have been underpowered for subgroup analyses and analyses of secondary outcomes. We believe, however, that the finding of a general trend toward decreased mortality and secondary outcomes lessens this concern. Although ISS and comorbid conditions were included to adjust for underlying mortality risk and case mix, our models may have insufficiently adjusted for unmea-

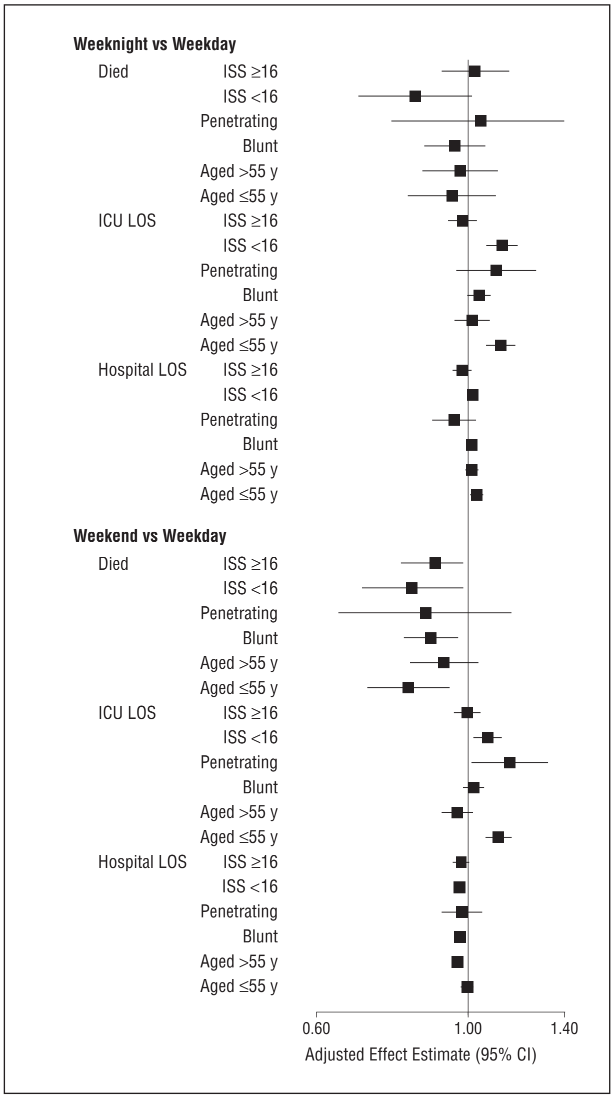

Figure. Adjusted effect estimates for outcomes by time of presentation and by subsets of the patient sample. ISS indicates Injury Severity Score; ICU, intensive care unit; LOS, length of stay; and CI, confidence interval.

sured confounders. Also, we were unable to track transferred patients across hospitals; therefore, such patients were excluded from the analysis. This could have introduced bias if referring facilities transferred only their sickest patients in a manner that varied systematically by time of day or day of week. Finally, we describe trauma care in a single state and recognize that our results may not be generalizable. The Pennsylvania trauma system is a mature trauma system; these protective effects may not exist in developing trauma systems. In addition, the relevance of LOS, examined as secondary outcomes, can be difficult to interpret. In future studies, subgroups including patients requiring subspecialty interventions (craniotomy, pelvic vessel embolization, etc) should be further explored. Standardized risk adjustment strategies such as those used in the trauma quality improvement program would be useful,[38] and internal hospital process measures should be considered.

We demonstrate no difference in adjusted survival for injured patients presenting to the trauma system at night and demonstrate an adjusted survival benefit for injured patients presenting to the trauma system on the weekend. These findings support the use of the trauma model's systems-based approach in the development of care delivery models for time-critical conditions including ischemic stroke,[39,40] acute coronary syndrome,[41,42] critical care,[43] and cardiac arrest[44-46] as well as the emergency care system as a whole.

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