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CLINICAL RESEARCH STUDY

Complication Rates on Weekends and Weekdays in US Hospitals

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ABSTRACT

PURPOSE: Recent studies and anecdotal evidence suggest that patient safety may be compromised on weekends. Our objective was to determine whether rates of complications in hospitals are higher on weekends than on weekdays.

METHODS: We examined records from 4,967,114 admissions to acute care hospitals in 3 states and analyzed complication rates using the Patient Safety Indicators. We selected 8 indicators that could be assigned to a single day: complications of anesthesia, retained foreign bodies, postoperative hemorrhage, accidental cuts and lacerations during procedures, birth trauma, obstetric trauma during vaginal deliveries with and without instrumentation, and obstetric trauma during cesarean delivery. Odds ratios (ORs) comparing weekends versus weekdays were adjusted for demographics, type of admission, and admission route. In a subgroup analysis of surgical complications, we restricted the population to patients who underwent cardiac or vascular procedures.

RESULTS: Four of the 8 complications occurred more frequently on weekends: postoperative hemorrhage (OR 1.07, 95% confidence interval [CI], 1.01-1.14), newborn trauma (OR 1.06, 95% CI, 1.03-1.10), vaginal deliveries without instrumentation (OR 1.03, 95% CI, 1.02-1.04), and obstetric trauma during cesarean sections (OR 1.36, 95% CI, 1.29-1.44). Complications related to anesthesia occurred less frequently on weekends (OR 0.86). Among patients undergoing vascular procedures, surgical complications occurred more frequently on weekends (OR 1.46, 95% CI, 1.16-1.85).

CONCLUSIONS: Rates of complications are marginally higher on weekends than on weekdays for some surgical and newborn complications, but more significantly for obstetric trauma and for surgical complications involving patients undergoing vascular procedures. Hospitals should work toward increasing the robustness of safeguards on weekends. © 2007 Elsevier Inc. All rights reserved.

KEYWORDS: Complications; Weekends; Working conditions; Logistic modeling; Quality of health care; Agency for Healthcare Research and Quality

It is commonly suspected that weekends and holidays are dangerous times to get sick. During weekends, a higher proportion of patients are admitted to hospitals through the emergency department,¹ fewer patients are discharged,² and many hospital services are unavailable.³ However, the incidence of many medical problems and the need for medical

care in hospitalized patients have no preference for the day of the week, and although hospitals attempt to maintain a capacity for preserving life and handling emergencies over weekends, the robustness of hospital safety systems and the redundancy of safeguards may be challenged.

Prior studies have measured differences in outcomes of hospital care between weekdays and weekends, with mixed results. Barnett and colleagues⁴ and Ensminger and colleagues⁵ found modestly increased rates of mortality in patients admitted to the intensive care unit on weekends,

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whereas Bell and Redelmeier¹ and Cram and colleagues⁶ found an increase in mortality of patients admitted through the emergency departments on weekends for conditions that require immediate care. Staffing levels and working conditions, commonly thought to influence patient safety, also vary between weekends and weekdays. Fewer nurses, senior physicians, and a higher average patient acuity all tax safety mechanisms over weekends and during holidays, and several studies suggest a relationship between staffing and safety.⁷⁻¹¹ Other published data do not support the presence of a weekend effect. Gould et al¹² showed insignificant differences in rates of neonatal mortality on weekends (although only after adjusting for birth weight). Arias et al¹³ found increased odds of death in children admitted to the intensive care unit during evenings, but no difference between days of the week, and a study looking at measures of quality in a Spanish emergency department found improved care on weekends.¹⁴

Previous studies that examined mortality of patients admitted on weekends are limited by the difficulty of attributing the outcome to a day of the week. However, certain complications, such as those related to surgical procedures, can be linked to specific events and dates. Nevertheless, in the past it has been difficult to study these phenomena because of the absence of validated measures, and because the scarcity of inpatient complications requires large databases to identify sufficient numbers of cases. Our study was conducted using all admissions to inpatient facilities in 3 states over 3 years and used a new tool developed for identifying complication rates. We hypothesized that rates of complications during weekends would be higher, after controlling for differences between weekend and weekday admissions.

METHODS

Data Sources

We collected state administrative inpatient data from 1999 to 2001 for New York and Massachusetts, and from 2000 to 2001 for North Carolina. The data were obtained from the Healthcare Utilization Project's State Inpatient Databases, which are a compilation of data from participating states containing the universe of those states' nonfederal hospital discharge abstracts.¹⁵ These databases have been used extensively in health services and outcomes research.¹⁵⁻¹⁸ They contain standardized data on hospital admissions, including data on diagnoses and procedures that are obtained directly from providers. Although the data quality has lim-

itations, according to some measures they are considered more reliable than household surveys.¹⁷

We chose the 3 states for their geographic diversity and the availability of procedure dates in the inpatient database needed for identification of weekend and weekday complications. Every patient admitted to a nonfederal acute care facility during that period was identified, regardless of whether the patient was discharged, transferred to another institution, or deceased. We obtained patient information that included demographics, admission type, admission route, discharge status, *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) codes for all available diagnoses and procedures, and dates of all procedures, deliveries, cesarean sections, and births. The data were purchased from the Healthcare Cost and Utilization Project, and the study was approved by the institutional review board at Massachusetts General Hospital.

CLINICAL SIGNIFICANCE

- Rates of complications are higher on weekends than on weekdays for some surgical and newborn complications.
- The main surgical complication that occurred more frequently on weekends was postoperative hemorrhage.
- There was a significant increase in the weekend complications (odds ratio 1.46) in patients undergoing vascular procedures.
- Obstetric trauma with cesarean sections occurred 36% more frequently on weekends ($P < .01$).

Identifying Complications on Weekdays and Weekends

We used the Agency for Healthcare Research and Quality Patient Safety Indicators to identify patients who had complications or were exposed to a risk of complication on weekends and weekdays. The Patient Safety Indicators program, developed by the Agency for Healthcare Research and Quality and Stanford-University of California at San Francisco Evidence-Based Practice Center, classifies more than 20 medical, surgical, newborn, and obstetric complications using administrative data. For each complication, the Patient Safety Indicators algorithm determines a unique population at risk for the complication (denominator) and then identifies those that experienced the complication of interest (numerator).¹⁹ Thus, it identifies *rates* of complications, where each complication has its own numerator and denominator. Each Patient Safety Indicator was selected after a literature search for relevance and was validated and used in numerous peer-reviewed publications.¹⁹⁻²¹ Although the Patient Safety Indicators may lack sensitivity, their specificity is high, especially for surgical complications.²⁰ The Patient Safety Indicators were constructed to indicate trends of complications, to be used as screens and research tools to highlight possible safety problems. It is in this spirit that we applied them to the study of weekend complication rates.

After consultation with staff physicians and senior coders, we focused on 8 types of complications for which we could determine a *singular* date of exposure and complication. An example of a Patient Safety Indicator included in our study is

birth trauma. The Patient Safety Indicators identify “birth trauma” as documented hypoxic injury, nerve injuries, and several other types of injuries in low-risk births. We posited that the complication occurred on the date of birth, and we could therefore determine whether the complication occurred on a weekend or a weekday. Another complication is “retained foreign bodies.” Here we posited that the foreign body was retained during the principal surgery of the patient’s admission, whose date we could determine. Complications for which we could not identify a singular date, for example, nosocomial infections, were not analyzed. Table 1 lists the 8 complications selected for study, the relevant population at risk, and how the date of complication was determined.

Statistical Analysis and Control for Confounding

Weekends were defined as any Saturday or Sunday (the period from midnight between Friday and Saturday until midnight between Sunday and Monday). In a separate analysis, we included all major federal holidays as “weekends,” but that analysis did not alter the results.

The data from all states were combined for the analysis to allow sufficient power to detect changes in rates of relatively rare events. We identified populations at risk for each of the 8 types of complication and then calculated rates of complications for each.

Control for confounding is critical to the attribution of effects when using administrative data. We controlled for the relative heterogeneity in the risk pools with all measurable admission characteristics, as well as comorbidities. We followed the methods established by Cram et al⁶ and Bell

and Redelmeier,¹ who found that controlling for route and type of admission minimized the differences between patients admitted on weekends and weekdays. Admission route refers to whether the patient was admitted through the emergency department, and admission type indicates whether the admission was an urgent admission. Comorbidity was measured using the Elixhauser comorbidity method, which accounts for the influence of selected comorbidities on patient outcomes.^{22,23} Individual comorbidities were used as independent adjusters in the logistic regressions.

Our principal analytic approach used logistic regression to estimate odds ratios adjusted for demographic characteristics, comorbidities, and admission characteristics (route and type).²⁴ We used direct standardization to the demographic and comorbidity characteristics of the full study cohort and accounted for clustering of patients within hospitals.^{25,26} To test the stability of our findings, we used propensity scores as an alternative method to control for confounders. This technique analyzes treatment effects in observational studies where randomization is not possible.²⁶⁻²⁹ The technique uses measured characteristics to construct a propensity score, which predicts group membership rather than the dependent variable and then generates a control group that matches the case group on key characteristics. We calculated a propensity score using the same adjusters and then used the scores as predictors.^{26,30} Because the results of both methods were similar, we only present the numeric results of the logistic regression.

In a subgroup analysis, we hypothesized that patients undergoing procedures that require specialized surgeons or involve a high level of complexity would be more adversely

Table 1 Description of Patient Safety Indicators Used in Study

Complication Group (PSI)	Exposed Populations	Rule for Assigning Date of Complication
1 Complications of anesthesia (S)	Inc: surgical patients Exc: anesthetic poisoning AND active drug dependence, active nondependent abuse of drugs, or self-inflicted injury	Date of principal process or intubation
2 Retained foreign body (S)	Inc: surgical patients	Date of principal procedure
3 Postoperative hemorrhage (S)	Inc: surgical patients Exc: obstetric patients	Date of principal procedure
4 Accidental laceration during a procedure (S)	Inc: surgical patients Exc: obstetric patients	Date of principal procedure
5 Birth trauma (N)	Inc: liveborn infants Exc: infants w/subdural or cerebral hemorrhage, preterm infants, injury to skeleton, osteogenesis imperfecta	Date of birth
6 Obstetric trauma During vaginal delivery with instrumentation (O)	Inc: instrument-assisted vaginal deliveries	Date of delivery
7 Obstetric trauma during vaginal delivery without instrumentation (O)	Inc: vaginal deliveries Exc: instrument-assisted deliveries	Date of delivery
8 Obstetric trauma during cesarean delivery (O)	Inc: cesarean section deliveries	Date of delivery

S = surgical complication; N = newborn complication; O = obstetric complication.

Source: Patient Safety Indicators Ver 2.1 Rev 1.

affected by weekend working conditions. That is, if rates of complications depend on the demands of patient care and the supply of resources and staffing, then the weekend effect might be most pronounced when the demands are high and the supply is short. Patients undergoing vascular and cardiac procedures were selected for analysis because these are sensitive to staffing levels, have a relatively high degree of complexity, and are common. By using ICD-9 codes, we selected the most frequent vascular surgical procedures (ICD-9 codes 38.7 [inferior vena cava filter placement], 39.49 [thrombectomy], 38.12 [carotid endarterectomy], 39.29 [femoropopliteal bypass], 39.27, and 39.42 [new hemodialysis shunt placement]) and most frequent cardiac procedures (ICD-9 codes 36.13, 36.14, 36.15, 36.12 [various coronary artery bypass graftings], 36.01, 36.05, and 36.02 [percutaneous coronary interventions], 37.83 [pacemaker or implantable cardioverter defibrillator device placement],

and 37.72 [temporary pacing wires]), and restricted our cohort to those who underwent these procedures. We then performed a logistic regression on these subgroups. To allow for sufficient power, and because the surgical risk pools have similar denominators, we combined the rates for all 4 surgical Patient Safety Indicators. We then calculated differences in rates as the odds ratio of having a complication, with significance at the 95% level.

RESULTS

Characteristics of the Population

We collected data on 4,967,114 admissions of patients at risk for at least 1 of the 8 study complications during our study period. The baseline characteristics of patients who were at risk for a complication on weekends compared with weekdays are shown in Table 2. Patients admitted on week-

Table 2 Characteristics of Patients at Risk for Selected Study Complications: New York, North Carolina, and Massachusetts, 1999 to 2001

	Weekend	Weekday	Total
Surgical admissions			
No.	256,084	2,678,118	2,934,202
Average age of risk group	47.7	54.2	53.6
% Male	36.7%	41.3%	40.8%
% White	60.4%	65.1%	64.7%
% Black	12.3%	10.2%	10.4%
% Hispanic	6.6%	4.9%	5.1%
Average No. of comorbidities	0.45	0.40	0.41
Urgent ED admissions‡	24.1%	53.5%	26.7%
Newborns			
No.	267,395	908,103	1,175,498
% Male	51.3%	51.2%	51.3%
% White	48.0%	51.6%	50.8%
% Black	14.5%	13.2%	13.5%
% Hispanic	10.2%	9.2%	9.5%
Vaginal deliveries			
No.	211,342	655,865	867,207
Average age of risk group	27.7	28.0	27.9
% White	48.1%	50.9%	50.3%
% Black	13.9%	13.0%	13.3%
% Hispanic	10.0%	9.3%	9.5%
Urgent ED admissions‡	12.6%	11.0%	11.4%
Average No. of comorbidities	0.09	0.09	0.09
Cesarean sections*			
No.	50,423	241,528	291,951
Average age of risk group	29.3	30.0	29.9
% White	47.6%	52.4%	51.6%
% Black	16.2%	14.0%	14.4%
% Hispanic	10.3%	9.3%	9.5%
Average No. of comorbidities	0.17	0.15	0.16
Urgent ED admissions‡	11.1%	7.8%	8.4%
Total No. of admissions†	733,375	4,233,739	4,967,114

ED = emergency department.

Source: Healthcare Cost and Utilization Project SID data for New York (1999-2001), Massachusetts (1999-2001), and North Carolina (2000-2001), and Patient Safety Indicators Ver 2.1 Rev 1.

*Admissions with cesarean sections were analyzed for surgical complications and complications specific to cesarean sections.

†The total number of admissions is less than the sum of the risk pools, because some patients were at multiple risk pools.

‡Unscheduled admissions through the emergency department.

Table 3 Total Number, Percent, and Rate per 100,000 of Selected Complications by Study State and Aggregate

Complication	New York			North Carolina			Massachusetts			All States		
	No.	Percent	Rate	No.	Percent	Rate	No.	Percent	Rate	No.	Percent	Rate
1 Anesthesia	875	1.5%	49	384	1.3%	72	538	2.0%	87	1797	1.6%	61
2 Foreign bodies	422	0.7%	24	178	0.6%	33	141	0.5%	23	741	0.6%	25
3 Postoperative hemorrhage	3284	5.6%	210	928	3.2%	199	1277	4.9%	229	5489	4.8%	212
4 Cuts and lacerations	11,878	20.1%	761	6556	22.8%	1406	5634	21.4%	1010	24,068	21.1%	931
5 Birth trauma	3095	5.2%	429	1669	5.8%	782	1737	6.6%	722	6501	5.7%	553
6 OB trauma, vaginal delivery with instrumentation	6446	10.9%	22,572	3636	12.7%	26,935	2737	10.4%	24,446	12,819	11.2%	24,072
7 OB trauma, vaginal delivery without instrumentation	32,197	54.5%	6535	14,934	52.0%	9867	13,667	52.0%	8017	60,798	53.3%	7479
8 OB trauma, cesarean section	916	1.5%	504	419	1.5%	781	542	2.1%	959	1877	1.6%	643
Total	59,113	100.0%		28,704	100.0%		26,273	100.0%		114,090	100.0%	

OB = obstetric.

ends constituted 14.8% of the total number of admissions and, on average, were younger and less likely to be white. Table 3 shows the distribution of complications by type and state. We detected 114,090 complications within the population (2.3% of admissions), of which 28.3% were surgical complications, 5.7% were newborn complications, and 66% were related to obstetric trauma. New York was the largest state in the study, with 61% of admissions and 52% of complications.

Surgical Complications

Adjusted rates of each type of complication, by weekends and weekdays, are displayed in Table 4. Only 1 of the 4 surgical complications, postoperative hemorrhages, occurred more frequently on weekends (227 vs 212 per 100,000). We found no significant differences in the rates of retained foreign bodies or accidental lacerations. Only com-

plications related to administration of anesthesia occurred less frequently on weekends compared with weekdays.

For patients undergoing vascular procedures, we found a significant increase in the weekend rates of complications (OR 1.46). That increase was stable whether we used the logistic regression model or the propensity score model of analysis. There was a trend but no significant difference in the rates of complications in patients with cardiac procedures (OR 1.12).

Newborn and Obstetric Complications

Complication rates for birth trauma and 2 of the 3 obstetric trauma indicators were significantly greater on weekends than on weekdays. Complications related to newborn trauma and vaginal deliveries without instrumentation occurred more frequently on weekends ($P < .05$). The largest

Table 4 Adjusted* Complication Rates per 100,000 Admissions, by Weekend Versus Weekday Occurrence

Complication	Adjusted Weekend Rate	Adjusted Weekday Rate	Odds Ratio (95% CI)
1 Anesthesia	54	63	0.86† (0.78-0.95)
2 Foreign bodies	25	26	0.96 (0.82-1.11)
3 Postoperative hemorrhage	227	212	1.07† (1.01-1.14)
4 Cuts and lacerations	934	947	0.99 (0.95-1.02)
5 Birth trauma	600	565	1.06† (1.03-1.10)
6 Vaginal delivery with instrumentation	24,359	24,355	1.00 (0.98-1.02)
7 Vaginal delivery without instrumentation	7840	7650	1.03† (1.02-1.04)
8 Cesarean section	852	626	1.36† (1.29-1.44)
Total No. of complications	21,480	92,610	114,090

CI = confidence interval.

*Odds of complication rates were adjusted by logistic regression for age, sex, race, comorbidities, and mode of arrival to the hospital, except complication 5 for sex and race only, and complications 6 to 8 not adjusted for sex.

† $P < .05$.

effect was observed with obstetric trauma after cesarean sections, 36% more frequent on weekends ($P < .01$).

DISCUSSION

This study aimed to add to the existing debate about the safety of hospital care on weekends by looking at specific complications rather than mortality. We analyzed data from approximately 5 million hospital admissions in 3 states and found small but significantly increased rates of several types of complications on weekends for surgical, newborn, and obstetric patients. We also found complications related to anesthesia occurred less frequently on weekends, and 3 complications for which there were no differences.

Overall, the rates of adverse events we found were consistent with published literature, although they represent only a subset of the Patient Safety Indicators.^{31,32} Our results show that, for surgical admissions, there is a small but significantly increased risk of postoperative hemorrhage for operations performed on weekends. Otherwise, there was no overall increased risk of complications on weekends in patients undergoing surgical procedures. However, the risk for patients undergoing vascular procedures on weekends was 46% higher. In addition, we found a greater risk of newborn and obstetric complications on weekends, most notably a 36% increase in risk of complications related to cesarean sections.

Although we cannot definitively conclude that quality of care is compromised on weekends, several points are worth mentioning. First, we found a meaningful increase in the rates of complications involving vascular surgeries, which is consistent with our hypothesis that surgeries requiring specialized and complex medical care are more sensitive to weekend working conditions. Second, the increase in complication rates of cesarean sections was stable after adjusting for urgent admissions and measured case-mix variables. Although unmeasured variables could still confound the analysis, 1 explanation is that complications among urgent, high-risk cesarean sections are related to staffing and skill levels, which may be compromised on weekends. This is a potentially concerning finding. Third, our modest findings should be interpreted in light of the fact that we examined only 8 types of complications out of dozens of known complications that occur daily in US hospitals. Thus, a small effect may be an underestimate of the true magnitude of the weekend effect as a whole, and improved measurement techniques in the future may enable better quantification. Finally, our finding of reduced rates of anesthesia complications is interesting. It is known that anesthesiologists have been leaders at identifying factors such as production pressure and communication failures, and as a result, they have dramatically decreased the risks of anesthetic death and brain damage during the last 20 years.³³⁻³⁶ Perhaps their processes of care are even more effective on weekends, when surgeries are fewer in number.

What can be done to improve weekend care? Making US hospitals "7 day-a-week" operations is both costly and unpopular at a time when physicians are searching for higher quality of life and policy makers are searching for ways to curb health care costs. On the other hand, expanding hospital operations may, in fact, be safer and cost-effective. Hospitals are expensive entities with high fixed costs, and weekend "down time" is a waste of resources.³⁷ Recent investigations have suggested that operating during weekends may enhance patient satisfaction and increase hospital incomes.^{38,39}

Several important limitations of our study are worth mentioning.^{40,41} There are 2 systematic sources of bias that may apply here: a case-mix bias and a triage effect. The case-mix bias suggests that there are differences in the patient populations between the weekend and weekday cohorts that cannot be detected or controlled using administrative data. It is related to the triage effect, which suggests that hospitals may defer all but the most acute procedures to weekdays, so that patients who are admitted or who undergo operation on the weekend are, in general, more ill than similar patients admitted on weekdays.⁴² We believe (supported by previous literature) that by adjusting for case-mix and controlling for route and type of admission, we eliminated most of this bias.

We used the State Inpatient Databases as the source of information for the Patient Safety Indicators. The State Inpatient Databases are subject to common data quality issues in administrative data sets that rely of physician documentation and coder reliability, including errors in diagnostic coding, missing codes, absence of clinical nuances, and lack of notation for whether the diagnosis was present on admission²⁰; however, there is no known difference between coding of weekend and weekday data that may systematically bias this study. Finally, our date assignment rules introduced imprecision into our analysis, but any bias was canceled out by equal imprecision introduced to the weekend and weekday cohorts.

Our study leaves several questions for future research: What about other types of complications? How many complications would be prevented by reducing the weekend complication rates? What is the cost of expanding hospital services to 7 days per week? The feasibility and cost-benefit arguments remain open issues.

CONCLUSION

We present evidence that weekend care affects the rates of few complications in acute care hospitals. This increase is mostly small but pronounced for cesarean sections and vascular procedures. We believe it may be explained by hospital staffing structures and resource use. However, although changes to these underlying issues occur slowly, hospitals and some health care providers should be aware of the increased weekend rates of complications and take steps to improve patient safety.

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