Weekend Effects and the July Phenomenon in Patient Safety
Final Research Report to AHRQ

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Structured Abstract

Purpose: The purpose of this study was to examine whether adverse events or complications in hospitals occur more often on weekends and holidays and, in teaching hospitals, whether there is a July phenomenon of heightened risk of complications corresponding to the arrival of new house officers.

Scope: We examined records from 4,967,114 admissions to acute care hospitals in three states from 1999-2001.

Methods: We analyzed complication rates using the Patient Safety Indicators (PSIs) developed by AHRQ. For Aim 1, we selected eight PSIs 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 comparing weekends versus weekdays were adjusted for patient 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. For aim 2, we assigned PSIs to the month in which they occurred and examined relative rates in teaching versus non-teaching hospitals and by month of the year.

Results: For Aim 1, four of the eight complications occurred more frequently on weekends: postoperative hemorrhage (OR 1.07, $p<0.05$), newborn trauma (OR 1.06, $p<0.05$), vaginal deliveries without instrumentation (OR 1.03, $p<0.05$), and obstetric trauma during C-sections (OR 1.36, $p<0.01$). 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, $p<0.01$). For Aim 2, the relative risk of PSIs in major teaching hospitals and minor teaching hospitals versus non-teaching hospitals varied, as did the relative rates by month of the year.

Key Words: Patient safety, weekend, teaching status

Purpose (Objectives of Study).

The purpose of this study was to examine whether adverse events or complications in hospitals occur more often on weekends and holidays, and, in teaching hospitals, whether there is a July phenomenon of heightened risk of complications corresponding to the arrival of new house officers. We used AHRQ's newly developed Patient Safety Indicators (PSIs) software and applied it to several large states participating in HCUP's State Inpatient Databases (SIDs). The capacity for identification of risk factors for patient safety events has increased with the recent release of the PSIs, but, as of yet, no studies have used the PSIs to examine events that occurred during specific time periods. The idea that patient safety may be compromised on certain days of the week or during times of low staffing levels has intuitive appeal and, furthermore, is based on theories of human error. Using administrative data, we determined rates of PSIs per selected time period and analyzed the data for trends based on the day of the event. Our study had two aims:

Aim 1) PSIs were developed to identify rates of potential safety-related complications relative to patient discharges. No published algorithm exists assigning an "event" to a particular patient day. Therefore, using literature review and physician consultants, we identified clinically valid days for each PSI relative to the admission, discharge, and procedure date. Then, using state discharge data, we investigated whether PSIs occurred more frequently on weekends.

Aim 2) Using state discharge data, we investigated whether PSIs occurred more frequently in teaching hospitals and, among teaching hospitals, whether PSIs occurred more frequently in July.

We addressed the following study questions:

- Are rates of patient safety incidents higher on weekends and holidays than on weekdays, controlling for patient and hospital characteristics?
- Is there a "July phenomenon" in patient safety? That is, does patient safety in teaching hospitals drop with arrival of new house officers in July?

Scope (Background, Context, Settings, Participants, Incidence, Prevalence).

It is commonly suspected that weekends and holidays are dangerous times to get sick. During weekends, a higher proportion of patients are admitted into hospitals through the emergency room,[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 though 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 attempted to illustrate differences in outcomes for patients seen in hospitals on weekdays and weekends, with mixed results. Barnett found increased length of stay and modestly increased patient mortality in patients admitted to the ICU on weekends, and Ensminger showed the same for surgical ICUs.[4, 5]

Bell and Redelmeier found an increase in mortality of patients admitted through the emergency rooms on weekends for conditions that require immediate care, and their results have recently been replicated in California by Cram, who also showed greater discrepancy in outcomes between teaching and non-teaching hospitals.[1, 6] Staffing levels and working conditions, commonly thought to influence patient safety, also vary between weekends and weekdays. Fewer nurses, senior physicians, pharmacists – and a higher average patient acuity – all may tax safety mechanisms over the weekends and during holidays. Several recent studies, as well as an IOM report, show an increase in mortality and adverse events with increased patient-to-nurse ratio and decreased physician staffing.[7-11]

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 due to the absence of validated measures and because the scarcity of inpatient complications requires large databases in order to identify sufficient numbers of cases. Our study was conducted using all admissions to inpatient facilities in three states over 3 years and employed a tool developed for identifying complication rates using administrative data. We hypothesized that, controlling for measurable differences between weekend and weekday admissions, rates of complications during weekends would be higher.

Another finding in the literature is that it reveals a mixed picture concerning how safety of care in teaching hospitals compares to safety in other inpatient settings. The Medical Practice Study suggested that, after adjusting for patient characteristics, teaching hospitals in New York State during the mid-1980s tended to have fewer safety problems – measured as preventable adverse events (PAEs) – than did non-teaching hospitals.[12] A more recent study by Romano and colleagues[13] examined administrative data from a national sample of hospitals over the period 1995-2000 using a modified version of the Patient Safety Indicators (PSIs) developed by the Agency for Health Research and Quality (AHRQ) for the specific purpose of identifying possible safety problems using administrative data. Romano found that several types of PSIs were higher in urban teaching hospitals than in urban non-teaching hospitals or non-urban institutions. Given the imperfections of administrative data and the experimental nature of PSIs, these results can hardly be taken as definitive. For example, is the pattern of association between PSIs and teaching status consistent with a July effect? More specifically, are the associations between PSIs and teaching status, when they exist, worse during periods of relative inexperience (e.g., July/August)?

The remainder of this report is divided into two parts, reflecting each aim.

Aim One: Complication Rates on Weekends and Weekdays in U.S. Hospitals

Methods (Study Design, Data Sources/Collection, Interventions, Measures, Limitations).

Data Sources

We collected state administrative inpatient data from 1999-2001 for New York and Massachusetts and from 2000-2001 for North Carolina. The data were obtained from the Healthcare Utilization Project's (HCUP) State Inpatient Databases (SIDs), which are compilations of data from 35 participating states containing the universe of those states' non-federal hospital discharge abstracts.[14] The data quality has been investigated, and the databases have been used extensively in health services and outcomes research.[14-17] They contain standardized data on hospital admissions, including data on diagnoses and procedures that are obtained directly from providers. According to some measures, they are considered more reliable than household surveys.[16] The SIDs are subject to the same data quality issues that appear in other administrative data sets, including possible errors in diagnostic coding, missing codes, absence of clinical nuances, and lack of notation for whether the diagnosis was present on admission[18]; however, there is no known difference between coding of weekend and weekday data that may systematically bias this study.

We chose the three 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 non-federal acute care facility during that period was identified, regardless of whether the patient was discharged home, 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, C-sections, and births. The data were purchased from HCUP, and the study was approved by the IRB at Massachusetts General Hospital.

Identifying Adverse Events on Weekdays and Weekends

We used the Agency for Healthcare Research and Quality's (AHRQ) Patient Safety Indicators (PSIs) to identify patients who had complications or were exposed to a risk of complication on weekends and weekdays. The PSI program (Ver. 2.1), developed by AHRQ in collaboration with the Stanford-UCSF Evidence-Based Practice Center and first released in May 2003, classifies 20 medical, surgical, newborn, and obstetric complications using administrative data. For each complication, the PSI algorithm determines a unique population at risk for the complication (denominator) and then identifies those in the population that had the complication of interest (numerator).[19] Thus, it identifies *rates* of complications, for which each complication has its own unique numerator and denominator. Each PSI was selected after a literature search for relevance and was determined to have face and construct validity by a team of clinicians and methodologists at the Stanford-UCSF Evidence-based Practice Center.[13, 19, 20] Importantly, though safety indicators relying on administrative data may lack sensitivity, their specificity is high, especially for surgical complications.[18] The PSIs were constructed to indicate trends of safety problems, with the idea of using them 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 eight types of complications for which we could determine a *singular* date of exposure and complication (Table 1). An example of a PSI included in our study is birth trauma. The PSIs identify "birth trauma" in low-risk births with documentation of hypoxic injury, nerve injuries, and several other types of injuries. We posited that the complication occurred on the date of birth, and we therefore could 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, allowing us to determine the date on which the event occurred. Complications for which we could not identify a singular date (e.g., nosocomial infections) were not analyzed. Table 1 lists the eight complications selected for study, the relevant population at risk, and the rule used for determining the date of the complication.

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 (New Year's Day, Martin Luther King's Day, President's day, Memorial Day, Independence Day, Labor Day, Columbus Day, Veterans' Day, Thanksgiving Day, and Christmas Day) as "weekends"; however, because that analysis did not significantly alter any results, it is not reported.

The data from all states were combined for the analysis in order to ensure that the size of the study sample would allow sufficient power to detect changes in rates of rare events. We identified populations at risk for each of the eight types of complication and then calculated rates of complications for each.

Control for confounding is critical to the appropriate attribution of effects when using administrative data. The key maneuvers we employed controlled for relative heterogeneity in the risk pools in terms of admission characteristics as well as comorbidities. We followed the methods established by Cram and Bell, et al, who found that controlling for route and type of admission minimized the differences in the cohorts of patients admitted on weekends and weekdays.[1, 6] Admission route refers to whether the patient was admitted through the ER or not, and admission type indicates whether the admission was an emergent admission or not. Comorbidity was measured using the Elixhauser comorbidity method, which accounts for the influence of selected comorbidities on patient outcomes.[21, 22] Individual comorbidities were used as independent adjusters in the logistic regressions. Some of these comorbidities, such as coagulopathy or anemia, may be important confounders of some of the complications, such as postoperative hemorrhage.

In order to verify the stability of our results, we used two analytical methods. Our principal approach used logistic regression to estimate odds ratios adjusted for demographic characteristics, comorbidities, and admission characteristics (route and type).[23] We used direct standardization to the demographic and comorbidity characteristics of the full study cohort, and we accounted for clustering of patients within hospitals.[24, 25] To test the stability of our findings, we used propensity scores as a method to control for confounders. This refers to a technique for analyzing treatment effects in observational studies when randomization is not possible.[25-28] The technique uses measured characteristics to construct a propensity score, which predicts group membership rather than the dependent variable, and then uses the scores to replicate a control group that matches the case group on key characteristics. We calculated a propensity score using the same adjusters (including admission characteristics) and then used the scores as predictors.[25, 29] Because the results were similar to those obtained using the logistic regression, we only present the latter.

In a subgroup analysis, we hypothesized that certain procedures that require specialist surgeons or that involve a high level of complexity would be more adversely affected by weekend working conditions. That is, if rates of complications are dependent on the one hand on the demands of patient care and on the other hand on the supply of resources and staffing, then the weekend effect might be most pronounced when the demands of patient care are intensified. Patients undergoing vascular procedures and cardiac procedures were selected for analysis, because these procedures are sensitive to staffing levels, have a relatively high degree of complexity, and are common. Using ICD-9 codes, we selected the most frequent vascular surgical procedures (ICD-9 codes 38.7 <IVC filter placement>, 39.49 <thrombectomy>, 38.12 <CEA>, 39.29 <fem-pop bypass>, 39.27, and 39.42 <new hemodialysis shunt or catheter placement>) and the most frequent cardiac procedures (ICD-9 codes 36.13, 36.14, 36.15, 36.12 <various CABGs>, 36.01, 36.05, and 36.02 <PCIs>, 37.83 <pacemaker or ICD device placement>, and 37.72 <temporary pacing wires>) among the 100 most frequent procedures in our population and restricted our cohort to those who were exposed to these surgeries. We then performed a similar logistic regression on these subgroups. In this analysis, to allow for sufficient power of discrimination and because the surgical complications are defined with similar denominator populations, we combined the rates for all four surgical PSIs. We then calculated differences in rates of complications as the odds ratio of having a complication, with significance determined by the 95% confidence intervals.

Results (Principal Findings, Outcomes, Discussion, Conclusions, Significance, Implications).

Characteristics of the Population

We collected data on 4,967,114 admissions of patients at risk for at least one of the eight study complications during our study period as indicated by the PSI algorithm. The baseline characteristics of patients who were at risk for a complication on weekends compared to weekdays are shown in Table 2. Patients admitted on weekends constituted 14.8% of the total number of admissions and, on average, were younger and were 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.

The rates are consistent with published literature,[30, 31] although they are based on a subset of PSIs. 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 one of the four surgical complications – postoperative hemorrhages – occurred more frequently on weekends (227 vs. 212 per 100,000 admissions, OR 1.07, $p<0.05$). We found no significant differences in the rates of retained foreign bodies or accidental cuts and lacerations between weekends and weekdays. Complications of anesthesia occurred less frequently on weekends compared with weekdays (54 vs. 63 per 100,000 admissions, OR 0.86, $p<0.05$).

For patients undergoing vascular procedures, we found a significant increase in the weekend rates of complications (OR 1.46, CI 1.16-1.85). That increase was stable whether we used the logistic regression model or the propensity score model of analysis. There were no significant differences in the rates of complications in patients with cardiac procedures (OR 1.12, CI 0.89-1.41).

Newborn and Obstetric Complications

Complication rates for birth trauma and two of the three obstetric trauma indicators were significantly greater on weekends than on weekdays. Newborn trauma and vaginal deliveries without instrumentation were significant at $p<0.05$. The largest effect was observed with obstetric trauma following C-sections, an OR of 1.36 ($p<0.01$). The adjusted odds ratios are shown in Table 4.

Discussion

This study aimed to shed light on the existing debate about safety of in-hospital care on weekends by looking at specific complications rather than crude measures of safety. We analyzed data from nearly 5 million hospital admissions in three states and found small but significantly increased rates of several types of complications on weekends for both surgical and obstetric patients. We also found one type of complication (related to anesthesia) that occurred significantly less frequently on weekends and three complications for which there were no differences.

Our results show that, for surgical cases, there is a small but significantly increased risk of postoperative hemorrhage for operations done 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 compared with weekdays, most notably a 36% increase in risk of complications related to Cesarean sections.

Though it would be hasty to 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. That is consistent with our hypothesis that surgeries requiring specialized and complex medical care are more sensitive to weekend working conditions.

Second, the finding of an increase in complication rates of weekend C-sections was stable even after adjusting for emergent admissions and for measured case-mix variables. Although unmeasured variables could still confound the analysis, one explanation is that complications among urgent, high-risk C-sections are related to staffing and skill levels, which may in turn be compromised on weekends. This is a potentially concerning finding. Third, our modest findings (with the exception of C-sections) should be interpreted in light of the fact that we only examined eight 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 a lower rate of anesthesia complications on weekends is provocative. It is known that anesthesiologists have been effective at identifying factors, such as production pressure and communication failures that lead to errors and, as a result, have dramatically lowered the risks of anesthetic death and brain damage over the past 20 years.[32-35] Perhaps their processes of care are even more effective on weekends, when surgeries are fewer in number and there is more slack in the system.

Several important limitations of our study are worth mentioning and have been expressed in previous publications.[36, 37] There are two related and systematic sources of bias that may apply here: a case-mix bias, and a triage effect. The former has to do with the data sources and the latter, with the behavior of hospitals and patients on weekends. 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, in part, to the triage effect, which suggests that hospitals may defer all but the most acute procedures to weekdays, so that patients admitted or operated on the weekend are, in general, sicker than patients with identical administrative data admitted on weekdays.[38] We believe that our case-mix adjusters and controls for route and type of admission control for much, but perhaps not all, of this bias. Finally, our study used the administrative data to identify whether the complication occurred on a weekend. Our date assignment rules introduced imprecision into our analysis, but any bias was cancelled 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 a week? The feasibility and cost-benefit arguments remain open issues.

In conclusion, we present evidence that the weekend effect affects the rates of few complications in acute care hospitals. This increase is small, for the most part, but pronounced for C-sections and patients undergoing vascular procedures. We believe that it may be explained by hospital staffing structures and resource utilization. However, though changes to these underlying issues may take some time to materialize, hospitals and healthcare providers in selected specialties should be aware of the increased weekend rates of complications and take steps to improve patient safety.

TABLES

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 procedure 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, pre-term 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 w/o 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

Source: Patient Safety Indicators Ver 2.1 Rev 1
S – Surgical complication
N – Newborn complication
O – Obstetric complication

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

		Weekend	Weekday	Total
Surgical admissions				
	Number	256,084	2,678,118	2,934,202
	Age	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%
	Avg # of Comorbidities	0.45	0.40	0.41
Newborns				
	Number	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				
	Number	211,342	655,865	867,207
	Age	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%
	Avg # of Comorbidities	0.09	0.09	0.09
C-sections*				
	Number	50,423	241,528	291,951
	Age	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%
	Avg # of Comorbidities	0.17	0.15	0.16
Total # of admissions†		733,375	4,233,739	4,967,114

Source: HCUP SID data for NY (1999-2001), MA (1999-2001), and NC (2000-2001) and Patient Safety Indicators Ver 2.1 Rev 1

* Admissions with C-sections were analyzed for surgical complications as well as for complications specific to C-sections.

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

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

Complication	New York			N. Carolina			Mass.			All States		
	#	Percent	Rate	#	Percent	Rate	#	Percent	Rate	#	Percent	Rate
1 Anesthesia	875	1.5%	49	384	1.3%	72	538	2.0%	87	1,797	1.6%	61
2 Foreign bodies	422	0.7%	24	178	0.6%	33	141	0.5%	23	741	0.6%	25
3 Postop hemorrhage	3,284	5.6%	210	928	3.2%	199	1,277	4.9%	229	5,489	4.8%	212
4 Cuts and lacerations	11,878	20.1%	761	6,556	22.8%	1,406	5,634	21.4%	1,010	24,068	21.1%	931
5 Birth Trauma	3,095	5.2%	429	1,669	5.8%	782	1,737	6.6%	722	6,501	5.7%	553
6 OB Trauma, Vaginal deliv. w/ instr.	6,446	10.9%	22,572	3,636	12.7%	26,935	2,737	10.4%	24,446	12,819	11.2%	24,072
7 OB Trauma, Vaginal deliv. w/o instr.	32,197	54.5%	6,535	14,934	52.0%	9,867	13,667	52.0%	8,017	60,798	53.3%	7,479
8 OB Trauma, C-section	916	1.5%	504	419	1.5%	781	542	2.1%	959	1,877	1.6%	643
Total	59,113	100.0%		28,704	100.0%		26,273	100.0%		114,090	100.0%	

Table 4 - Adjusted* Complication Rates per 100,000 Admissions, by Weekend vs. Weekday Occurrence

	Complication	*Adjusted wkend rate*	*Adjusted wkday rate*	*Odds Ratio (CI)*
1	Anesthesia	54	63	0.86** (0.78-0.95)
2	Foreign bodies	25	26	0.96 (0.82-1.11)
3	Postop 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	OB trauma, vaginal deliv. w/ instr.	24,359	24,355	1.00 (0.98-1.02)
7	OB trauma, vaginal deliv. w/o instr.	7,840	7,650	1.03** (1.02-1.04)
8	C-section	852	626	1.36** (1.29-1.44)
	Total # of complications	21,480	92,610	114,090

* 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 6-8 not adjusted for sex.

Aim Two: Teaching Hospitals and the AHRQ Patient Safety Indicators: A Complex Relationship.

Methods (Study Design, Data Sources/Collection, Interventions, Measures, Limitations).

Data Sources

We collected state administrative inpatient data from 1999-2001 for New York and Massachusetts and from 2000-2001 for North Carolina. We chose the three states for their geographic diversity and the availability of procedure dates in the inpatient database needed for identification of weekend and weekday complications.

The data were obtained from the Healthcare Utilization Project's (HCUP) State Inpatient Databases (SIDs), which are a compilation of data from 35 participating states containing the universe of those states' non-federal hospital discharge abstracts. The data have been used extensively in health services and outcomes research. They contain standardized discharge variables on hospital admissions, including diagnoses and procedures (ICD-9 codes) that are obtained directly from providers. According to some experts, they are considered more reliable than household surveys. Nevertheless, because they represent administrative data, the SIDs are subject to some data quality limitations, including possible coding errors, missing codes, absence of clinical detail, and lack of notation for whether the diagnosis was present on admission.

Every patient admitted to a non-federal acute care facility during that period was identified, regardless of whether the patient was discharged home, transferred to another institution, or deceased. We obtained patient information that included demographics, admission type, admission route, and 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, C-sections, and births. The study was approved by the IRB at Massachusetts General Hospital.

Identifying Adverse Events using PSIs

We used the Agency for Healthcare Research and Quality's (AHRQ) Patient Safety Indicators (PSIs) to identify patients who had complications or were exposed to a risk of complication during their hospital stay. The PSI program (Ver. 2.1), developed by AHRQ in collaboration with the Stanford-UCSF Evidence-Based Practice Center and first released in May 2003, classifies 20 medical, surgical, newborn, and obstetric complications using administrative data. For each complication, the PSI algorithm determines a unique population at risk for the complication (denominator) and then identifies those in the population that had the complication of interest (numerator). Thus, it identifies rates of complications, for which each complication has its own unique numerator and denominator. Each PSI was selected following a literature search for relevance and was determined to have face and construct validity by a team of clinicians and methodologists at the Stanford-UCSF Evidence-based Practice Center. Importantly, though safety indicators relying on administrative data may lack sensitivity, their specificity is high, especially for surgical complications.

The PSIs were constructed with the idea of using them as research tools, to identify broad trends or perhaps to screen for more detailed review. It is in this spirit that we applied them to the study of complications in teaching hospitals.

For the analysis of the July phenomenon, it was necessary to assign a complication to a particular month. Therefore, for this analysis, we restricted the sample only to patients whose entire hospital stay occurred within a given month. Thus, the PSIs will be assigned to the month in which the admission occurred. Preliminary analysis suggests that few cases were lost when we omitted patients whose admissions overlap months. There is a slight bias in terms of longer length of stay admissions being excluded. Although teaching hospitals tend to have longer lengths of stay, there is no reason to believe a priori that these would be disproportionately distributed by month of the year.

Other Variables

We used the American Hospital Association Identification code to determine hospital characteristics such as teaching status, urban/rural location, and number of beds.

Results (Principal Findings, Outcomes, Discussion, Conclusions, Significance, Implications).

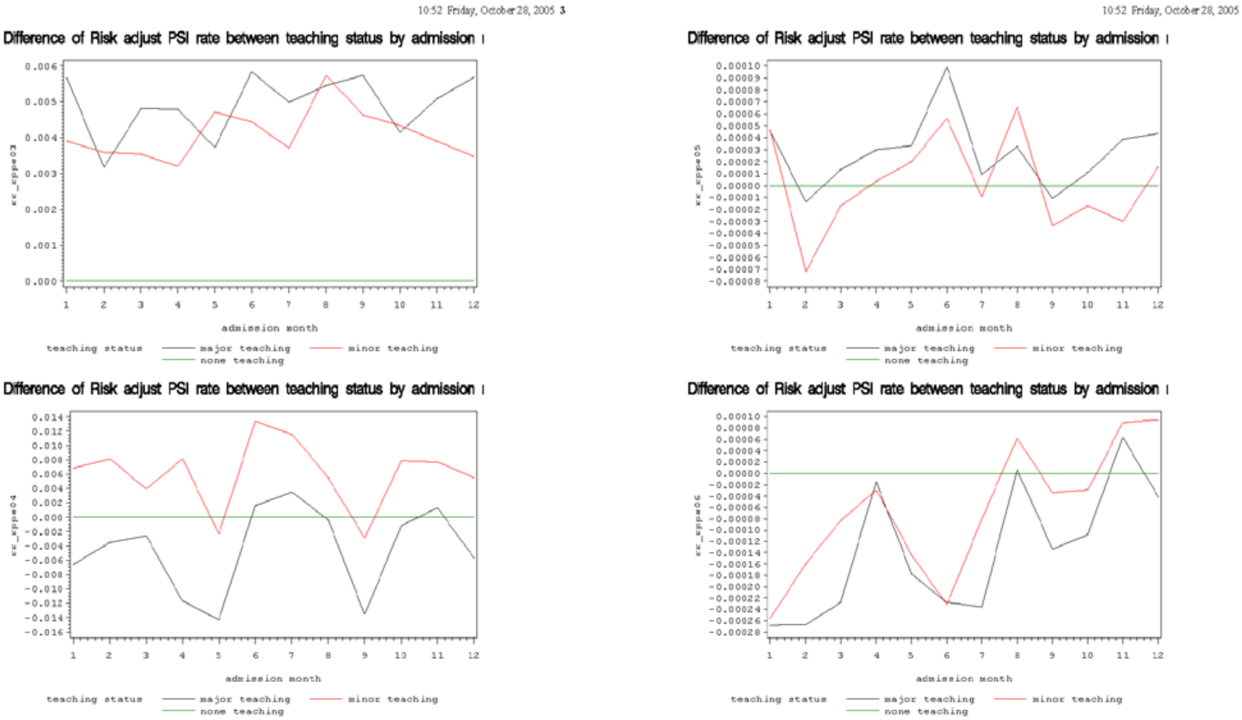
As can be seen in Table 5, the relative risks of PSIs in major teaching hospitals versus non-teaching hospitals and minor teaching hospitals versus non-teaching hospitals vary. Figure 1 contains selected graphic representations of an analysis of the July effect for selected PSIs. The effect is quite prominent for PSI 4, less prominent for PSI 5, and not apparent for other PSIs.

Ours and Romano's work[13] demonstrates that some of the PSIs were sometimes associated with teaching status, but future research should examine the direction of the association and the specific pattern of association in order to provide a more specific and definitive evidence. For example, some of the PSIs reflect activities that residents would have little involvement in. Are PSIs covering activities with high resident involvement more likely to be associated (positively or negatively) with teaching status? Could there be a bimodal distribution of PSI performance (e.g., both better and worse performance) for teaching hospitals (in other words, some teaching hospitals perform better on specific PSIs than non-teaching hospitals and some do worse)?

Table 5 - PSI Rates in Teaching and Non-Teaching Hospitals

PSI #	rrisk_ma	P-value (major/none)	rrisk_mi	P-value (minor/none)	None teaching hospital	Numerator (total)	Denominator (total)	Overall rate (Risk adjusted)
1	0.61978	<.0001	0.67155	<.0001	0.000871	1380	2280993	0.000650
2	1.15932	0.0061	1.07145	0.2707	0.000648	1692	2838309	0.000701
3	1.26113	<.0001	1.21604	<.0001	0.01855	40331	2267966	0.02149
4	0.96620	0.0086	1.03658	0.0169	0.1506	25349	179868	0.1497
5	1.49297	<.0001	1.05567	0.6545	0.000058	549	8394924	0.000070
6	0.79908	<.0001	0.93769	0.1689	0.000520	3616	6574658	0.000471
7	1.09696	<.0001	0.93643	0.0124	0.001298	7197	7306263	0.001328
8	1.01599	0.8996	0.94926	0.7426	0.000206	185	1284369	0.000206
9	0.84156	<.0001	0.87042	0.0066	0.001717	3116	1966324	0.001532
10	1.09972	0.1294	1.00051	0.9949	0.000629	474	1043750	0.000661
11	0.76769	<.0001	0.89319	0.0389	0.002304	1047	878025	0.001984
12	1.20963	<.0001	1.00119	0.9695	0.005013	9373	1967514	0.005532
13	0.86870	0.0067	0.88344	0.0494	0.005935	775	269284	0.005364
14	0.91564	0.2965	1.06567	0.5064	0.001322	481	480727	0.001290
15	1.16044	<.0001	1.08573	0.0044	0.002413	17751	7170231	0.002619
16	.	.	.	.	.	30	8395082	0.002619
17	0.70556	<.0001	0.93008	0.3014	0.006314	5673	1042925	0.005447
18	1.16776	<.0001	1.17295	<.0001	0.2001	14697	66166	0.2219
19	1.04864	0.0334	1.19526	<.0001	0.06694	52476	749336	0.07174
20	1.60482	<.0001	1.10765	0.2338	0.004812	1542	248828	0.006107
27	1.20744	<.0001	1.10572	<.0001	0.2320	17022	66166	0.2565
28	1.07653	0.0003	1.15081	<.0001	0.07430	58380	749336	0.07959
29	1.65118	<.0001	1.10848	0.2137	0.005079	1652	248828	0.006544

Figure 1 - Examples of July Effects



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List of Publications and Products

Peer reviewed manuscripts

In addition to writing a final report for the agency, we are currently writing original articles for peer-reviewed journals. One article is under review, and the other is still in preparation.