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Components of Hospital Perioperative Infrastructure Can Overcome the Weekend Effect in Urgent General Surgery Procedures

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Abstract

Objective—We hypothesized that perioperative hospital resources could overcome the “weekend effect” (WE) in patients undergoing emergent/urgent surgeries.

Summary Background Data—The WE is the observation that surgeon-independent patient outcomes are worse on the weekend compared with weekdays. The WE is often explained by differences in staffing and resources resulting in variation in care between the week and weekend.

Methods—Emergent/urgent surgeries were identified using the Healthcare Cost and Utilization Project State Inpatient Database (Florida) from 2007 to 2011 and linked to the American Hospital Association (AHA) Annual Survey Database to determine hospital level characteristics. Extended median length of stay (LOS) on the weekend compared with the weekdays (after controlling for hospital, year, and procedure type) was selected as a surrogate for WE.

Results—Included were 126,666 patients at 166 hospitals. A total of 17 hospitals overcame the WE during the study period. Logistic regression, controlling for patient characteristics, identified full adoption of electronic medical records (OR 4.74), home health program (OR 2.37), pain management program [odds ratio (OR) 1.48], increased registered nurse-to-bed ratio (OR 1.44), and inpatient physical rehabilitation (OR 1.03) as resources that were predictors for overcoming the WE. The prevalence of these factors in hospitals exhibiting the WE for all 5 years of the study period were compared with those hospitals that overcame the WE ($P < 0.001$).

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Conclusions—Specific hospital resources can overcome the WE seen in urgent general surgery procedures. Improved hospital perioperative infrastructure represents an important target for overcoming disparities in surgical care.

Keywords

AHA annual survey; emergency general surgery; HCUP; health disparities; hospital perioperative resources; weekend effect

Numerous factors impact the quality of care for patients undergoing urgent surgical procedures. On the patient level, comorbid disease burden, age, race, and socioeconomic status represent some, but not all, of the potential influencers of in-hospital and postoperative outcomes.^{1–3} Moving beyond the individual patient, hospital-level characteristics, such as volume, trauma-level designation, and resident participation can also impact perioperative outcomes after urgent and emergent general surgery.^{4–7} The diversity of influences on surgical outcomes is further illustrated by temporal patterns seen in the quality of surgical care.

The weekend effect (WE) is the observation that patient outcomes are better on weekdays compared with weekends. Recent literature highlights the presence of the WE after emergent surgery for acute diverticulitis and emergent/urgent general surgery diagnoses.⁸ Beyond acute general surgery, the trend is also well-documented in both the medical and pediatric literature.^{9–11} The WE is often defined by differences in mortality; however, other metrics including hospital length of stay (LOS) and overall time to emergent endoscopy, have been shown to be inferior on the weekend compared with the weekdays.^{12,13}

Several hypotheses exist to explain temporal patterns in care delivery. Some suggest patient case-mix index can be responsible for these differences. Other hypotheses include limited trainee experience and weak on-shift support during “off-hours.” Differences in perioperative resources on the weekend compared with the weekdays, including availability of ancillary staff, care coordination, and operating room staff, is another hypothesis.¹⁴

The overarching goal of this study was to test if increased availability of hospital perioperative resources reduces the likelihood of a hospital having the WE. To accomplish this objective, we divided our analysis into 3 sections. First, we described the prevalence of the WE across hospitals in a single state over a 5-year period. Next, we identified hospitals that did not exhibit the WE and compared how the availability of perioperative resources at those centers compared with those with the WE. Finally, we identified the specific perioperative resources that were most important for protecting hospitals from having the weekend effect.

METHODS

Data Sources

Patient-level data were abstracted from the Health Care and Utilization Project State Inpatient Database (HCUP SID) for Florida. The development of HCUP SID was sponsored by the Agency for Healthcare Research and Quality (AHRQ) to inform health-related

decisions. HCUP SID includes all patient discharge records for all-payers in the 47 states that participate in the project. Each SID is unique to its individual state. Data are deidentified, protected, and include over 100 clinical and nonclinical variables.¹⁵

Hospital characteristics were assessed using the American Hospital Association (AHA) Annual Survey DatabaseTM from 2007 to 2011. The AHA database compiles responses from 6200 hospitals nationwide and contains 1000 fields of information categorizing an institution's organizational structure, facility and service lines, inpatient and outpatient utilization, operation expenses, and staffing. The methodology for linking HCUP SID data to the AHA Annual Survey database is described in previously reported work from our group and others.^{16,17}

Patient and Hospital Inclusion Criteria

Patients who underwent urgent/emergent general surgery procedures over a 5-year time period (2007–2011) in Florida at acute care hospitals performing greater than 10 such cases per year were included for study. Patients were identified using ICD-9-CM diagnosis and procedure codes and were included only if they underwent surgery for their principal diagnosis (eg, acute cholecystitis and underwent cholecystectomy) (Supplemental Table 1, <http://links.lww.com/SLA/A843>). All included patient encounters were compared with their associated diagnosis-related group code to verify the composition of the population. The selection of appendectomy, cholecystectomy, and hernia repair was based on consistency of administrative coding in HCUP SID and the ability to use uniform inclusion criteria to accurately abstract our patient population.

Patients were excluded if they underwent a procedure after hospital day number 2, were less than 18 years and 90 years, and had an overall hospital LOS greater than 30. Exclusion of patients who underwent a procedure after hospital day number 2 ensured the surgery was urgent/emergent and any prolongation in hospital LOS was not due to failure of a nonoperative treatment strategy.

For hospital-level analysis, each hospital was studied longitudinally to assess annual incidence of the WE and was classified into one of 5 groups: (1) no WE, (2) persistent WE, (3) overcame WE, (4) developed WE, and (5) oscillating WE (Fig. 1). Hospital-level explanatory variables contained within the AHA Annual Survey database included for study were grouped into 3 major categories: bed/staffing, inpatient, and aftercare (Table 1).

Defining Weekend Effect

The association between patient outcomes including LOS, major complications, moderate/minor complications, and mortality were assessed using regression analysis controlling for age and comorbid disease severity. Significant predictors for mortality were LOS ($P<0.001$) and major complications ($P<0.001$). Predictors of major complications were LOS and mortality ($P<0.001$). LOS also predicted for minor complications ($P<0.001$).

Results from our analysis suggested that LOS was related to each outcome and, therefore, hospitals with a longer LOS on the weekend compared with the weekday were defined as having the weekend effect. LOS was calculated using the median LOS for patients admitted

on a weekday, for each hospital, based on procedure, by year. For each study year, if observed LOS on the weekend was greater than observed LOS on weekdays, the hospital was defined as having the weekend effect (Supplemental Fig. 1, <http://links.lww.com/SLA/A843>).

Statistical Approach

The primary outcome for study was the presence or absence of the WE at the level of an individual hospital, for a given year. Univariate analysis described the characteristics of the patient population, including demographic, socioeconomic, and clinical factors using arithmetic means with standard deviation or medians with interquartile range for continuous variables distributed normally or non-normally, respectively. Categorical variables were reported using proportions.

Hospitals that overcame the WE or developed the WE were further subdivided into 2 eras: before and after. Bivariate analysis to test differences between the groups was done using one-way analysis of variance (ANOVA) or Kruskal-Wallis tests for continuous variables and χ^2 testing for categorical variables.

Additional univariate analysis was conducted to describe the perioperative resources available in hospitals of each group, including bed/staffing, inpatient, and aftercare factors. To further assess the relationship between hospital perioperative resources and hospital group membership, we used multilevel, mixed-effects logistic regression. Each model was constructed to assess how the main effect (Table 1) was associated with the outcome (hospitals that overcame the WE compared with hospitals with a persistent effect or developed the WE). Multivariable models controlled for patient-level covariates, including age, sex, comorbid disease severity [Charlson comorbidity index (CCI)], type of surgery, year, and random hospital effect. Logistic models were fit using backwards selection techniques based on significance at the $\alpha = 0.05$ level and minimization of Akaike information criterion. All statistical analyses were conducted in STATA Version 12 (StataCorp LP, College Station, TX).

RESULTS

The study sample included a total of 126,666 patients at 166 hospitals. A total of 41 hospitals exhibited a persistent WE overall 5 years of the study, accounting for 26,253 patients. No hospitals were immune from the WE for all 5 years. At 17 hospitals that overcame the WE, 8613 patients underwent surgery in the period with the WE and 3536 patients in the period without the WE. At 21 hospitals that developed the WE during the study period, 5419 patients underwent surgery in the era with the WE and 9709 patients in the era without the WE. A total of 73,136 patients underwent surgery at 87 hospitals with an oscillating WE (Fig. 1).

Patient Characteristics by Hospital Category

Results of univariate analyses, including baseline demographic, socioeconomic, comorbid disease burden, and admission characteristics are shown in Table 2. Baseline patient characteristics were compared with assess if differences in patient-level covariates impacted

hospital group membership. Mean age (range: 46.9–48.8 years) and the ratio of female patients to male patients was similar in all hospital groups ($P = 0.281$). Severity of comorbid disease was also comparable across groups, with mean CCI scores ranging from 1.8 (SD = 2.1) to 2.1 (SD = 2.3).

We did note differences in socioeconomic covariates based on hospital group membership. Hospitals with a persistent WE seemed to be comprised of patients with lower socioeconomic status when compared with the other hospital groups (Table 2). Patients at hospitals with a persistent WE were most likely to be insured by Medicare (27.6%, $P < 0.001$) and least likely to have private insurance (38.6%, $P < 0.001$). In addition, persistent WE hospitals were less likely to have patients in the highest income quartile than those that overcame the WE (8.7% vs. 23.8%, $P < 0.001$).

To further study if the baseline patient characteristics accounted for a hospital either overcoming or developing the WE, subgroup analyses were conducted comparing these 2 groups (Table 3). At hospitals that overcame the WE, there were several differences in comorbid disease burden of the patient population across eras (before and after overcoming the WE). In the era after overcoming the WE, patients actually had increased comorbid disease severity (CCI 2.0 vs. 1.8, $P = 0.004$). A similar difference was not seen at hospitals that developed the WE (2.0 vs. 2.0, $P = 0.260$).

Perioperative Infrastructure by Hospital Categories

Bivariate analysis comparing hospital group membership and perioperative hospital resources is shown in Table 4. Total bed size differed across hospital categories and posthoc testing demonstrated hospitals that overcame the WE were significantly larger than those with a persistent WE or developed the WE ($P < 0.001$). Hospitals that overcame the WE had a higher mean number of inpatient rehabilitation beds when compared with those with a persistent WE or developed the WE ($P < 0.024$). In addition, those hospitals that overcame the WE had a higher nurse-to-bed ratio (1.3) when compared to those with a persistent WE (1.1), developed the WE (1.1), or oscillating WE (1.2) ($P = 0.004$). In general, based on the bed and staffing components studied, hospitals with an oscillating weekend more closely resembled hospitals that overcame the WE than the other groups (Table 4).

The prevalence of several inpatient services was highest at hospitals that overcame the WE. In particular, of the 17 hospitals that overcame the WE, 30.0% had inpatient rehabilitation, 95.0% had patient-controlled analgesia, 70.0% had pain management programs, and 40.0% had fully implemented electronic medical records systems. Each of these were greater than hospitals with a persistent WE or those that developed the WE.

We also compared the prevalence of aftercare services across hospital groups. Acute long-term care, skilled nursing care, out-patient physical rehabilitation services, and social work programs were similar regardless of hospital classification. Hospitals that overcame the WE were more likely to have home health programs (20.0%, $P < 0.001$) and wound management programs (80.0%, 0.043) in comparison with each of the other hospital categories.

Components of Perioperative Infrastructure and Overcoming the Weekend Effect

Using the significant factors from univariate analysis, we developed multivariable models to assess if components of hospital perioperative infrastructure could predict hospitals that overcame the WE. Registered nurse-to-bed ratio, inpatient physical rehabilitation, pain management program, full implementation of electronic medical records, and presence of a home health program remained significant independent predictors for overcoming the WE.

As demonstrated in Figure 2, the most significant of these was the implementation of electronic medical records system, which increased the odds of overcoming the WE by 4.7 times (95% CI: 4.3, 5.2). Both home health programs [OR 2.4, (95% CI 2.1, 2.6)] and pain management programs [OR 1.5, (95% CI 1.3, 1.6)] also increased the odds of overcoming the WE. In addition, we found for every unit increase in nurse-to-bed ratio, the odds of overcoming the WE increased by 44% ($P < 0.001$).

DISCUSSION

This study demonstrates the significant impact of the WE on hospitals treating patients with urgent/emergent general surgery diagnoses in the state of Florida between 2007 and 2011. Although we found no hospitals without the WE for all 5 years of the study period, 17 hospitals were able to overcome the WE. Understanding the organizational structure and perioperative resources available at these hospitals, especially in the era without the WE, can guide future efforts to improve weekend surgical care.

At its core, the WE is best described as a temporal or time-dependent pattern and is well-described in several other specialties.^{18,19} Temporal patterns of healthcare delivery often are grouped into 2 categories: (1) long-term and (2) short-term variations. Long-term trends are the result sustained changes in policy or process and occur over a long period. In contrast, the WE, like the “July effect” or the “meeting effect,” is example of a short-term variation.^{14,20}

Short-term variations are thought to be related to resource availability, workforce, or delays in intervention and occur on the scale of hours, weeks, or months. In the present study, we found the WE does not need to be an inevitable phenomenon and hospital characteristics can predict those that will trump the effect. In particular, we noted full implementation of an electronic medical records system, inpatient rehabilitation, home health and pain management programs, and increasing registered nurse-to-bed ratio as the most important perioperative services predicting a hospital’s ability to overcome the WE. We hypothesize that the improvement in the WE is a result of the ability of the identified components of perioperative infrastructure to assist patients with increased discharge needs, improve transitional care, and ensure care continuity from the week to the weekend.

To date, this represents the first study of this scope, which supports that temporal patterns of care can be affected by modifying staffing and resource utilization dynamics. For factors we identified, previous literature also highlights the importance of each on efficient healthcare delivery.^{21–24} The next steps are validating these findings in other states and determining if

the same resources are essential to overcoming the WE for other diagnoses and/or procedures.

Moreover, the results of our study support a growing body of literature demonstrating that hospital-specific factors, independent of the patient, can influence the quality of healthcare delivery. We found that patient-level covariates, including case-mix, could not explain the WE. Interestingly, the significant patient-level differences noted were largely socioeconomic and further investigation into how these impact the WE certainly deserves further study.

An important point of clarification is our approach to defining the WE. Unlike other studies in the surgical literature that use differences in adverse events to define the WE, we used LOS. From a statistical standpoint, we chose length of stay because of its association with both mortality and complications. More importantly, many surgeons observe a relationship between prolonged LOS and difficulty with planning for discharge on the weekend. However, little empiric evidence exists to support this observation. The perioperative hospital resources identified in this study all influence transitional care and by studying LOS, we provide evidence for that observation.

Our analysis has several limitations. Although the ability to link data between the AHA Annual Survey database and the HCUP SID allows the assessment of hospital-level variables on patient outcomes, the completeness of the data fields in the AHA Annual Survey Database relies on an individual hospital completing all parts of the survey. We did not include in variables that were answered by less than 90% of hospitals. Several potentially important components of hospital peri-operative infrastructure that are surveyed by the AHA were, therefore, unable to be assessed, including operating room staffing, number of overall surgeries performed by a hospital per year, radiology technician availability, pharmacy resources, and complete operating cost data.

The AHA Annual Survey data also does not offer the granularity to compare resource availability on the weekend compared with weekdays at individual hospitals. Therefore, we could only assess for the presence or absence of specific perioperative infrastructure at a given hospital. As a result, we likely overestimate the impact of individual resources on the weekend effect. With increasing importance of hospital-level influences on patient outcomes, we propose the inclusion of several new elements to the AHA Annual Survey to further achieve the database's goal of contributing to health services research, benchmarking, and time-series analysis. Specifically, the addition of models of surgical care (including acute care surgery program), surgeon staffing/availability, and distribution of resources (weekend vs. weekday, on-hours vs. off-hours).

Finally, we relied on administrative clinical data to identify patients with the WE. Patients coded as having a weekend admission were either on Saturday or Sunday; therefore, we could not capture and classify late Friday admissions as occurring on the weekend. In addition, our patient and hospital population were from a single state. Although HCUP SID data allow us to assess each patient discharge from nearly all acute care hospitals within the state, we acknowledge that our results may not be generalizable to a national population. Nevertheless, we chose the state of Florida because it has been used in prior studies of health

delivery characteristics due to its diverse network of health systems and the relative completeness of the state's AHA Annual Survey data.²⁵

CONCLUSIONS

Our findings demonstrate the WE in urgent and emergent general surgery is related to hospital-level factors. Specifically, components of perioperative infrastructure including staffing, inpatient, and aftercare resources can play important roles in allowing hospitals to overcome this temporal pattern of care. Our results have clear implications for patient safety and quality efforts, as these “bread-and-butter” surgical procedures are performed at nearly all centers providing surgical care. Bolstering perioperative support, as our data suggests, can play an important role in ensuring patients are not disadvantaged by being admitted to the hospital on the weekend.

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FIGURE 1.

Overview of study design and classification of included hospitals after defining the weekend effect at the patient level.

FIGURE 2. Components of hospital peri-operative infrastructure that increase the odds of overcoming the weekend effect. *** $P < 0.001$. Error bars represent 95% confident intervals. †Odds based on patients at hospitals in the era after overcoming the weekend effect compared to those at hospitals with a persistent weekend effect or in the era after developing the weekend effect. ‡Adjusted for patient age, sex, procedure type, comorbid disease severity, year, and random hospital effect. $n = 39,498$ patients, years 2007 to 2011.

TABLE 1

Components of Perioperative Infrastructure Included for Study, by Category, Based on Availability in AHA Annual Survey Database

Bed/Staffing	Inpatient	Aftercare
Skilled nursing beds	Physical rehabilitation	Skilled nursing care
ICU beds	Occupational health	Acute long-term care
Rehab beds	Patient-controlled analgesia	Home health program
Skilled nursing beds	Pain management program	Physical rehabilitation (outpatient)
Registered nurse-to-bed ratio	High-resolution CT scan	Social work program
Practical/vocational nurse-to-bed ratio	Ultrasound	Wound management services
	MRI	
	Electronic medical records	

CT indicates computed tomography; ICU, intensive care unit; MRI, magnetic resonance imaging.

TABLE 2

Baseline Characteristics of All Patients Comprising the Study Population, Overall (n = 126,666 Patients) and by Hospital Category, Years 2007–2011

Characteristics	Overall (n = 126,666)	Persistent WE (n = 26,253)	Overcame WE (n = 12,149)	Developed WE (n = 15,128)	Oscillating WE (n = 73,136)	P
Mean Age (years, SD)	47.5 (SD = 18.9)	48.8 (SD = 19.4)	47.2 (SD = 18.8)	48.2 (SD = 19.3)	46.9 (SD = 18.7)	<0.001
Sex (% female)	66,429 (52.4%)	13,895 (52.9%)	6313 (52.0%)	7932 (52.4%)	38,289 (52.4%)	0.281
Race/ethnicity						
White	79,407 (63.1%)	17,462 (67.2%)	7291 (60.4%)	9746 (64.8%)	44,908 (61.8%)	<0.001
African-American	12,068 (9.6%)	2314 (8.9%)	1351 (11.2%)	1147 (7.6%)	7256 (10.0%)	
Hispanic	27,567 (21.9%)	5322 (20.5%)	2758 (22.8%)	2520 (16.8%)	16,967 (23.3%)	
Other	6780 (5.4%)	892 (3.4%)	680 (5.6%)	1622 (10.8%)	3586 (4.9%)	
Insurance type (n, %)						
Medicare	29,589 (23.4%)	7235 (27.6%)	2705 (22.3%)	3724 (24.6%)	15,925 (21.8%)	<0.001
Medicaid	14,780 (11.7%)	3526 (13.4%)	1486 (12.2%)	1737 (11.5%)	8031 (11.0%)	
Private	55,112 (43.5%)	10,126 (38.6%)	5523 (45.5%)	6207 (41.0%)	33,256 (45.5%)	
Other	27,185 (21.5%)	5366 (20.4%)	2435 (20.0%)	3460 (22.9%)	15,924 (21.8%)	
Income (% in quartile, by zip code)						
1 (\$0–\$38,999)	34,963 (27.6%)	10,773 (41.0%)	3856 (31.7%)	3609 (23.9%)	16,725 (22.9%)	<0.001
2 (\$39,000–\$47,999)	37,714 (29.8%)	8307 (31.6%)	3014 (24.8%)	5362 (35.4%)	21,031 (28.8%)	
3 (\$48,000–\$63,999)	34,931 (27.6%)	4882 (18.6%)	2383 (19.6%)	3877 (25.6%)	23,789 (32.5%)	
4 (\$64,000+)	19,058 (15.1%)	2291 (8.7%)	2896 (23.8%)	2280 (15.1%)	11,591 (15.9%)	
Comorbidities						
Chronic hypertension	40,742 (32.2%)	8931 (34.0%)	3871 (31.9%)	4968 (32.8%)	22,972 (31.4%)	<0.001
Disorder of electrolytes	15,955 (12.6%)	3234 (12.3%)	1573 (13.0%)	2109 (13.9%)	9039 (12.4%)	<0.001
Chronic lung disease	12,071 (9.5%)	2765 (10.5%)	1168 (9.6%)	1520 (10.1%)	6618 (9.1%)	<0.001
Anemia	9720 (7.7%)	2055 (7.8%)	850 (7.0%)	1302 (8.6%)	5513 (7.5%)	<0.001
Hypothyroidism	7673 (6.1%)	1540 (5.9%)	755 (6.2%)	881 (5.8%)	4497 (6.2%)	0.192
Diabetes mellitus	12,920 (10.2%)	2764 (10.5%)	1232 (10.1%)	1543 (10.2%)	7381 (10.1%)	0.255
Depression	6114 (4.8%)	1316 (5.0%)	542 (4.5%)	698 (4.6%)	3558 (4.9%)	0.065
Chronic renal failure	3513 (2.8%)	761 (2.9%)	344 (2.8%)	458 (3.0%)	1950 (2.7%)	0.038
Congestive heart failure	3103 (2.5%)	741 (2.8%)	343 (2.8%)	428 (2.8%)	1591 (2.2%)	<0.001
Peripheral vascular disease	2607 (2.1%)	606 (2.3%)	253 (2.1%)	354 (2.3%)	1394 (1.9%)	<0.001

Characteristics	Overall (n = 126,666)	Persistent WE (n = 26,253)	Overcame WE (n = 12,149)	Developed WE (n = 15,128)	Oscillating WE (n = 73,136)	P
Neurologic disorder	2845 (2.3%)	638 (2.4%)	271 (2.2%)	326 (2.2%)	1610 (2.2%)	0.1510
Valvular disease	3225 (2.6%)	708 (2.7%)	365 (3.0%)	474 (3.1%)	1678 (2.3%)	<0.001
Liver disease	3525 (2.8%)	707 (2.7%)	291 (2.4%)	404 (2.7%)	2123 (2.9%)	0.007
CCI (mean, SD)	1.9 (SD = 2.2)	2.1 (SD = 2.3)	1.9 (SD = 2.1)	2.0 (SD = 2.2)	1.8 (SD = 2.1)	<0.001
Admission characteristics						
Weekend admission	30,076 (23.7%)	6183 (23.6%)	2862 (23.6%)	3534 (23.4%)	17,497 (23.9%)	0.347
Appendectomy	64,209 (50.7%)	12,621 (48.1%)	6363 (52.4%)	7374 (48.7%)	37,851 (51.8%)	<0.001
Weekend appendectomy	16,048 (25.0%)	3193 (25.3%)	1583 (24.9%)	1827 (24.8%)	9445 (25.0%)	0.827
Cholecystectomy	51,134 (40.4%)	11,045 (42.1%)	4577 (37.7%)	6299 (41.6%)	29,213 (39.9%)	<0.001
Weekend cholecystectomy	11,767 (23.0%)	2463 (22.3%)	1037 (22.7%)	1430 (22.7%)	6837 (23.4%)	0.095
Hernia repair	15,282 (12.1%)	3423 (13.0%)	1609 (13.2%)	1969 (13.0%)	8281 (11.3%)	<0.001
Weekend hernia Repair	3140 (20.6%)	719 (21.0%)	332 (20.6%)	398 (20.2%)	1691 (20.4%)	0.882

Baseline Characteristics of Patients Across Eras (Before and After) If Hospital Overcame Weekend Effect or If Hospital Developed Weekend Effect (n = 27,277 Patients)

	Overcame WE (n = 12,149)			Developed WE (n = 15,128)		
	Before (n = 8613)	After (n = 3536)	P	Before (n = 5419)	After (n = 9709)	P
Mean age (years, SD)	46.8 (SD = 18.7)	48.3 (SD = 19.2)	0.0001	47.9 (SD = 19.3)	48.3 (SD = 19.4)	0.8988
Sex (% female)	4493 (52.2%)	1820 (51.5%)	0.486	2806 (51.8%)	5126 (52.8%)	0.23
Race/ethnicity						
White	5155 (60.2%)	2136 (60.8%)	<0.001	3460 (64.4%)	6286 (65.1%)	<0.001
African American	914 (10.7%)	437 (12.4%)		395 (7.4%)	752 (7.8%)	
Hispanic	1956 (22.8%)	802 (22.8%)		766 (14.3%)	1752 (18.2%)	
Other	543 (6.3%)	137 (3.9%)		751 (14.0%)	871 (9.0%)	
Insurance type (%)						
Medicare	1830 (21.3%)	875 (24.8%)	<0.001	1288 (23.8%)	2436 (25.1%)	<0.001
Medicaid	974 (11.3%)	512 (14.5%)		549 (10.1%)	1188 (12.2%)	
Private	4123 (47.9%)	1400 (39.6%)		2328 (43.0%)	3879 (40.0%)	
Other	1686 (19.6%)	749 (21.2%)		1254 (23.1%)	2206 (22.7%)	
Income (% in quartile, by zip code)						
1 (\$0–\$38,999)	2685 (31.2%)	1171 (33.1%)	<0.001	1354 (25.0%)	2255 (23.2%)	<0.001
2 (\$39,000–\$47,999)	2148 (24.9%)	866 (24.5%)		1895 (35.0%)	3467 (35.7%)	
3 (\$48,000–\$63,999)	1646 (19.1%)	737 (20.8%)		1484 (27.4%)	2393 (24.7%)	
4 (\$64,000+)	2134 (24.8%)	762 (21.6%)		686 (12.7%)	1594 (16.4%)	
Comorbidities						
Chronic hypertension	2649 (30.8%)	1222 (34.6%)	<0.001	1763 (32.5%)	3205 (33.0%)	0.549
Disorder of electrolytes	1033 (12.0%)	540 (15.3%)	<0.001	709 (13.1%)	1400 (14.4%)	0.023
Chronic lung disease	836 (9.7%)	332 (9.4%)	0.590	548 (10.1%)	972 (10.0%)	0.843
Anemia	557 (6.5%)	293 (8.3%)	<0.001	439 (8.1%)	863 (8.9%)	0.098
Hypothyroidism	528 (6.1%)	227 (6.4%)	0.548	283 (5.2%)	598 (6.2%)	0.018
Diabetes mellitus	850 (9.9%)	382 (10.8%)	0.121	556 (10.2%)	987 (10.2%)	0.854
Depression	373 (4.3%)	169 (4.8%)	0.276	229 (4.2%)	469 (4.8%)	0.089
Chronic renal failure	245 (2.8%)	99 (2.8%)	0.893	160 (3.0%)	298 (3.1%)	0.688

	Overcame WE (n = 12,149)			Developed WE (n = 15,128)		
	Before (n = 8613)	After (n = 3536)	P	Before (n = 5419)	After (n = 9709)	P
Congestive heart failure	240 (2.8%)	103 (2.9%)	0.702	167 (3.1%)	261 (2.7%)	0.162
Peripheral vascular disease	164 (1.9%)	89 (2.5%)	0.032	126 (2.3%)	228 (2.4%)	0.928
Neurologic disorder	191 (2.2%)	80 (2.3%)	0.879	114 (2.1%)	212 (2.2%)	0.746
Valvular disease	254 (3.0%)	111 (3.1%)	0.577	185 (3.4%)	289 (3.0%)	0.139
Liver disease	172 (2.0%)	119 (3.4%)	<0.001	124 (2.3%)	280 (2.9%)	0.029
CCI	1.8 (SD = 2.1)	2.0 (SD = 2.2)	0.004	2.0 (SD = 2.2)	2.0 (SD = 2.3)	0.260
Admission characteristics						
Weekend admission	2028 (23.6%)	834 (23.6%)	0.962	1250 (23.1%)	2284 (23.5%)	0.524
Appendectomy	4570 (53.1%)	1793 (50.7%)	0.018	2750 (50.8%)	4624 (47.6%)	<0.001
Weekend appendectomy	1158 (25.3%)	425 (23.7%)	0.174	639 (23.2%)	1188 (25.7%)	0.018
Cholecystectomy	3172 (36.8%)	1405 (39.7%)	0.003	2139 (39.5%)	4160 (42.9%)	<0.001
Weekend cholecystectomy	696 (21.9%)	341 (24.3%)	0.083	511 (23.9%)	919 (22.1%)	0.107
Hernia repair	1145 (13.3%)	464 (13.1%)	0.800	702 (13.0%)	1267 (13.1%)	0.867
Weekend hernia repair	230 (20.1%)	102 (22.0%)	0.395	140 (20.0%)	258 (20.4%)	0.824

TABLE 4

Hospital-level Comparison of Perioperative Resource Availability at Hospitals With a Persistent Weekend Effect, Overcame Weekend Effect, Developed Weekend Effect, and Oscillating Weekend Effect

	Persistent WE (n = 41)	Overcame WE (n = 17)	Developed WE (n = 21)	Oscillating WE (n = 87)	P
Bed/staffing (mean, SD)					
Total beds	245.9 (171.0)	291.8 (180.9)	257.5 (159.1)	344.6 (361.5)	<0.0001
ICU beds	18.2 (15.8)	21.9 (13.2)	21.6 (14.2)	25.5 (28.5)	<0.0001
Rehab beds	5.9 (13.3)	9.3 (20.6)	3.4 (10.9)	9.3 (18.5)	0.0235
Skilled nursing beds	2.9 (16.8)	7.5 (17.1)	0.6 (2.9)	11.5 (50.1)	0.0538
Registered nurse-to-bed ratio	1.1 (0.4)	1.3 (0.4)	1.1 (0.3)	1.2 (0.4)	0.0036
Practical/vocational nurse-to-bed ratio	0.09 (0.07)	0.08 (0.06)	0.1 (0.09)	0.09 (0.07)	<0.0001
Inpatient (%)					
Intensive care	97.2%	100.0%	100.0%	98.4%	0.691
Physical rehabilitation	22.5%	30.0%	6.5%	25.6%	0.017
Occupational health	73.9%	80.0%	78.3%	75.2%	0.936
Patient-controlled analgesia	80.3%	95.0%	82.6%	87.8%	0.110
Pain management program	49.3%	70.0%	63.0%	69.5%	0.001
High-resolution CT scan	40.1%	55.0%	34.8%	64.3%	<0.001
Ultrasound	96.5%	100.0%	100.0%	98.8%	0.324
MRI	94.4%	90.0%	97.8%	95.0%	0.522
Electronic medical records	12.2%	40.0%	15.5%	15.8%	0.010
Aftercare (%)					
Home health program	12.7%	20.0%	4.4%	20.9%	0.001
Acute long-term care	7.3%	4.0%	2.9%	6.3%	0.670
Skilled nursing care	32.7%	40.0%	39.1%	39.3%	0.415
Physical rehabilitation (outpatient)	67.3%	76.0%	65.2%	71.6%	0.501
Social work program	75.5%	80.0%	78.3%	83.1%	0.264
Wound management services	61.5%	80.0%	55.1%	67.9%	0.043

Results for overcome weekend effect and developed weekend effect represent eras after overcoming or developing the effect, respectively. Years, 2007 to 2011 (n = 166 hospitals). CT indicates computed tomography; ICU, intensive care unit; MRI, magnetic resonance imaging.