Incidence of “never events” among weekend admissions versus weekday admissions to US hospitals: national analysis

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ABSTRACT

OBJECTIVE

To evaluate the association between weekend admission to hospital and 14 hospital acquired conditions recently considered by the Centers for Medicare and Medicaid as “never events,” serious, costly, and preventable medical errors, for which resulting healthcare costs are not reimbursed.

DESIGN

National analysis.

SETTING

US Nationwide Inpatient Sample discharge database.

PARTICIPANTS

351 million patients discharged from US hospitals, 2002–10.

MAIN OUTCOME MEASURES

Univariate rates and multivariable likelihood of hospital acquired conditions among patients admitted on weekdays versus weekends, as well as the impacts of these events on prolonged length of stay and total inpatient charges.

RESULTS

From 2002 to 2010, 351 170 803 patients were admitted to hospital, with 19% admitted on a weekend. Hospital acquired conditions occurred at an overall frequency of 4.1% (5.7% among weekend admissions versus 3.7% among weekday admissions). Adjusting for patient and hospital cofactors the probability of having one or more hospital acquired conditions was more than 20% higher in weekend admissions compared with weekday admissions (odds ratio 1.25, 95% confidence interval 1.24 to 1.26, $P<0.01$). Hospital acquired conditions have a negative impact on both hospital charges and length of stay. At least one hospital acquired condition was associated with an 83% (1.83, 1.77 to 1.90, $P<0.01$) likelihood of increased charges and 38% likelihood of prolonged length of stay (1.38, 1.36 to 1.41, $P<0.01$).

CONCLUSION

Weekend admission to hospital is associated with an increased likelihood of hospital acquired condition, cost, and length of stay. Future protocols and staffing

regulations must be tailored to the requirements of this high risk subgroup.

Introduction

“Never events” are an assembly of purportedly egregious and preventable hospital occurrences first introduced by the National Quality Forum in 2001. The list was generated in response to a heightened awareness of avertable errors leading to in-hospital morbidity and mortality.¹ Defined as serious, costly, and preventable medical errors, these events were subsequently consolidated by the Centers for Medicaid and Medicare Services (CMS) into a list of hospital acquired conditions that would not qualify for federal compensation for any subsequent treatment relating to the condition (see supplementary table).² The creation of these events is designed to shift the burden of complications from the patient and government to the individual hospitals and to motivate hospitals to accelerate patient safety programs.² However, these events have been met with considerable resistance, with many leaders of American healthcare systems suggesting that not all hospital acquired conditions are preventable.^{2–4} Others suggest that CMS’s policy for hospital acquired conditions could potentially drive hospitals to be less likely to treat sicker patients.⁵ However, a press release in December 2014 highlights the correlation between saving 50 000 lives and \$12 bn (£8 bn; €11 bn) from 2010 to 2014, with a 17% decrease in hospital acquired conditions over that period.⁶ Hospital acquired conditions have been aptly increasing as a metric for quality of patient healthcare.

Previous investigations have tackled risk factors associated with inpatient complications.^{1 2 7–12} Though studies have attempted to isolate exposures associated with hospital acquired conditions and quantify resultant increases in attributable costs, published reports are restricted to specific medical or surgical subspecialties or patient demographics.^{1 2 7–10 13} The occurrence of hospital acquired conditions has not been evaluated across all patient subgroups on a national scale.

Hospital acquired conditions are events thought to be preventable through effective hospital systems and administrative processes. However, healthcare delivery may be most susceptible to the occurrence of these conditions at times when staffing or standard leadership is reduced. Total numbers of hospital staff and available expertise are often diminished on weekends,¹⁴ with differences in mortality between weekend and weekday admissions documented for conditions that require aggressive intervention. Weekend admission is associated with increased mortality among all hospital admissions and within subgroups of patients with pulmonary

WHAT IS ALREADY KNOWN ON THIS TOPIC

Multiple studies have correlated increased mortality with weekend admission. A set of “never events,” termed hospital acquired conditions (HACs), have been defined as quality measures for which resulting healthcare costs are not reimbursed.

WHAT THIS STUDY ADDS

Weekend admission was associated with an increased likelihood of HAC occurrence when adjusting for disease severity and admission urgency in multivariate analysis.

embolism, stroke, subarachnoid hemorrhage, intracerebral hemorrhage, and myocardial infarction.^{15–22}

We established standards for rates of hospital acquired conditions across an entire inpatient sample of greater than 350 million admissions. Incidence rates are determined for weekend versus weekday admissions across all patients included in the Nationwide Inpatient Sample hospital discharge database from 2002 to 2010. We hypothesized that weekend admission would be associated with a higher frequency of hospital acquired conditions.

Methods

Data source

We carried out a cross sectional analysis study using data from the 2002 to 2010 extracts of the Nationwide Inpatient Sample. This is the largest publicly available all payer inpatient database in the United States, capturing 20% of all US hospital discharges.²³ This database is assembled annually by the Agency for Healthcare Research and Quality and provides information on more than eight million annual admissions from more than 40 states and more than 1000 hospitals.²³ The Nationwide Inpatient Sample is a stratified sample of hospitals drawn from existing state databases that make their information available to the Healthcare Cost and Utilization Project (HCUP) with data that can be matched to the American Hospital Association annual survey of hospitals.²⁴ It also contains a weighting system that allows for population estimates to be calculated.²³ The discharge weights are calculated within each sampling stratum as a ratio of discharges in the universe to the sample.²⁴ Universe discharges are calculated from the total discharges reported in American Hospital Association hospital survey data from non-rehabilitation hospitals.²⁴ Multiple prior studies have utilized this database and the weighting system, focusing on subspecialty cohorts.^{2 12 25–30}

Study population

We included all patients admitted to hospital between 2002 and 2010. Because the National Inpatient Sample does not contain unique patient identifiers we treated each discharge as an independent event, even if it might represent repeated admissions by the same patient. For each hospital stay we recorded covariates at both patient and hospital level.

Outcomes

The primary outcome of interest was the ever occurrence of a hospital acquired condition; these were identified using international classification of diseases, ninth edition, clinical modification (ICD-9CM) codes and verified with literature from CMS (see supplementary table).³¹ We tabulated the frequency of individual hospital acquired conditions in this population and the demographic relation to patient and hospital variables. Secondary outcomes of interest included inpatient charges (≥ 90 th centile, $\geq \$118\,505.27$) and prolonged length of stay (≥ 90 th centile, ≥ 11 days).

Covariates

For the analysis we used nominal covariates such as race (white American, black American, Hispanic, Asian Pacific Islander, Native American, other), payer information (Medicare, Medicaid, private insurance, no charge, self pay, other), and sex (male, female), and ordinal covariates, such as age categories (<18, 19–30, 31–40, 41–50, 50–65, 66–80, >80 years) and length of stay. Similarly, hospital factors, such as bed size (small <200, medium 201–400, large >400 beds), teaching status (teaching, non-teaching), hospital region (north east, Midwest, south, west), and location (rural, urban) were included covariates. We coded missing data fields as missing values and included these in analysis.

The severity of the cause for hospital admission was defined by the All Patient Refined Disease Related Group algorithm (3M Health Information Systems, Wallingford, CT), admission type (emergency, urgent, elective, newborn, trauma, other), and admission source (emergency department, another hospital, other health facility, court or law enforcement, routine admissions, including births, and other sources). The All Patient Refined Disease Related Groups are a system of proprietary risk adjustment methods that builds upon the existing structure of the disease related group and classifies patient admissions in approximately 500 categories with similar clinical features and patterns of resource utilization. The All Patient Refined Disease Related Group from the National Inpatient Sample is categorized into five primary designations: no class specified, minor loss of function, moderate loss of function, major loss of function, and extreme loss of function. To adjust for the severity of injuries requiring admission, we included All Patient Refined Disease Related Group, admission type, and admission source in our models for analysis.

Statistical analysis

We used survey adjusted univariate and means analysis to calculate population demographics. To assess the relation between the outcome of having at least one hospital acquired condition with patient and hospital factors we conducted multivariable logistic regressions using survey adjusted generalized estimating equations. The primary predictor variable of interest was the timing of admission (weekend versus weekday). We ran secondary analyses to assess the outcome of inpatient mortality with adjustments for the occurrence of a hospital acquired condition and patient, hospital, and severity factors. Similarly, we assessed the impact of neurological comorbidities on occurrence of hospital acquired conditions. We also fit multivariable survey logistic regression models to examine the risk factors of prolonged length of stay and charges. We also conducted a multiple imputation using the methods outlined elsewhere.³²

For a complex sample data with categorical variables we used a four step procedure for multiple imputation. We created five imputed datasets using the Markov Chain Monte Carlo method and produced a monotone missing data pattern in this large dataset. Using the

Table 1 | Population demographic, 2002–10

Characteristics	No (%) by admission type		P value
	Weekend (n=67 869 246)	Weekday (n=283 278 574)	
No of hospital acquired conditions:			
0	64 010 108 (94.3)	272 868 006 (96.3)	<0.01
>1	3 859 138 (5.7)	10 410 568 (3.7)	<0.01
Inpatient mortality:			
Died	1 731 783 (2.6)	5 486 665 (1.9)	<0.01
Did not die	66 078 088 (97.4)	277 547 658 (98.0)	<0.01
Missing	59 365 (1.0)	24 4251 (0.1)	0.5037
Race:			
White American	33 408 370 (49.2)	145 479 404 (51.4)	<0.01
Black American	7 847 842 (11.6)	29 895 824 (10.6)	<0.01
Hispanic	7 219 628 (10.6)	27 677 183 (9.8)	<0.01
Asian Pacific Islander	1 469 751 (2.2)	5 568 293 (2.0)	<0.01
Native American	322 788 (0.5)	1 289 827 (0.5)	<0.01
Other	1 816 947 (2.7)	7 308 392 (2.6)	<0.01
Missing	15 783 920 (23.3)	66 059 651 (23.3)	<0.01
Payer information:			
Medicare	25 403 449 (37.4)	104 560 419 (36.9)	<0.01
Medicaid	14 088 122 (20.8)	53 514 983 (18.9)	<0.01
Private insurance	21 708 750 (32.0)	100 817 045 (35.6)	<0.01
Self pay	4 153 791 (6.1)	13 406 659 (4.7)	<0.01
No charge	368 212 (0.5)	1 261 684 (0.4)	<0.01
Other	2 020 948 (3.0)	9 208 418 (3.3)	<0.01
Missing	125 975 (0.2)	509 366 (0.2)	<0.01
Sex:			
Female	28 533 139 (42.0)	116 172 863 (41.0)	<0.01
Male	39 159 898 (57.7)	166 350 325 (58.7)	<0.01
Missing	176 209 (0.3)	755 387 (0.3)	<0.01
No of comorbidities:			
0	24 033 497 (35.4)	102 447 854 (36.25)	<0.01
1	12 241 204 (18.0)	54 782 189 (19.3)	<0.01
≥2	30 845 040 (45.4)	122 931 679 (43.4)	<0.01
Missing	749 506 (1.1)	3 116 851 (1.1)	<0.01
Age group (years):			
<18	12 684 772 (18.7)	48 733 195 (17.2)	<0.01
19–30	8 631 399 (12.7)	32 684 847 (11.5)	<0.01
31–40	6 467 587 (9.5)	27 657 135 (9.8)	<0.01
41–50	6 389 447 (9.4)	29 082 664 (10.3)	<0.01
51–65	10 937 715 (16.1)	51 617 250 (18.2)	<0.01
66–80	12 909 567 (19.0)	58 095 331 (20.5)	<0.01
>80	9 848 759 (14.5)	35 408 152 (12.5)	<0.01
All Patient Refined Disease Related Group—severity:			
No class specified	44 743 (0.1)	177 046 (0.1)	<0.01
Minor loss of function	24 858 060 (36.6)	113 347 265 (40.0)	<0.01
Moderate loss of function	24 897 962 (36.7)	102 808 742 (36.3)	<0.01
Major loss of function	13 415 105 (19.8)	50 876 315 (18.0)	<0.01
Extreme loss of function	3 903 870 (5.8)	12 952 355 (4.6)	<0.01
Missing	749 506 (1.1)	3 116 851 (1.1)	0.0693
Hospital region:			
North east	13 434 138 (19.8)	55 559 783 (19.6)	<0.01
Midwest	15 550 498 (22.9)	65 236 854 (23.0)	<0.01
South	25 455 415 (37.5)	108 789 617 (38.4)	<0.01
West	13 429 195 (19.8)	53 692 320 (19.0)	<0.01
Hospital location:			
Rural	9 169 797 (13.5)	37 241 421 (13.1)	<0.01
Urban	58 431 027 (86.1)	244 913 991 (86.5)	<0.01
Missing	268 422 (0.4)	1 123 162 (0.4)	0.7530
Hospital teaching status:			
Non-teaching	37 086 724 (54.6)	152 161 037 (53.7)	<0.01
Teaching	30 514 100 (45.0)	129 994 375 (45.9)	<0.01
Missing	268 422 (0.4)	1 123 162 (0.4)	0.7530

(Continued)

monotone logistic aspect of the multiple imputation procedure, we imputed the missing data. To estimate associations for each imputed dataset we used PROC SURVEYLOGISTIC.

Finally, we synthesized the results from the five surveylogistic models by fully incorporating the variance adjustment from both surveylogistic and multiple imputations (PROC MIANALYZE).³² We defined statistical significance as the α level of 0.05. All analyses were performed using SAS 9.3 (Cary, NC).

Results

From 2002 to 2010, there were 351 170 803 inpatient admissions, of which 4.1% (14 269 706) had at least one hospital acquired condition (table 1). Approximately 81% (283 278 574) of inpatient admissions were on a weekday, whereas 19% (67 869 246) were on a weekend, and less than 1% (22 983) was missing the day of admission. The frequency of hospital acquired conditions was higher in patients admitted on weekends than on weekdays (5.7% v 3.7%). Patient and hospital factors differed marginally between populations admitted on weekends and those admitted on weekdays (table 1). Most patients were white (51%), insured by Medicare (37%), and male (59%). Additionally, most weekday admissions were for routine problems (40.1%), whereas weekend admissions were from the emergency department (44.4%). In both groups the majority of admissions were for emergencies (table 1). Overall, weekend admissions were associated with more severe problems in terms of admission type, admission source, and All Patient Refined Disease Related Group severity status (table 1).

The most common hospital acquired conditions were falls or trauma (12 621 763), pressure ulcers (495 495), and catheter associated urinary tract infections (432 681) (table 2). The frequency of hospital acquired conditions noticeably increased from 2002 to 2010 (1.6% increase overall) (table 3). Additionally, the most common diagnoses were diabetes mellitus (ICD-9CM: 250.00), hyperlipidemia (272.4), coronary atherosclerosis of a native coronary artery (414.01), outcome of delivery or single liveborn infant (V27.0), and congestive heart failure (428.0). The most common procedures were transfusion of packed cells (99.04), venous catheterization (38.93), manually assisted delivery (73.59), coronary arteriography with two catheters (88.56), and left heart cardiac catheterization (37.22).

Hospital acquired conditions

In a multivariable logistic regression adjusting for patient (race, payer status, age, sex), hospital (region, location, teaching status, bed size), and severity (All Patient Refined Disease Related Group, admission source, and admission type) factors, the probability of having at least one hospital acquired condition was 25% higher for patients admitted on weekends compared with weekdays (odds ratio 1.25, 95% confidence interval 1.24 to 1.26, $P<0.01$) (table 4). The day of admission was the strongest predictor for complications, with teaching status (1.29, 1.23 to 1.35, $P<0.01$,

Table 1 | Population demographic, 2002–10

Characteristics	No (%) by admission type		P value
	Weekend (n=67 869 246)	Weekday (n=283 278 574)	
Hospital bed size:			
Small (<200)	8 116 805 (12.0)	34 517 847 (12.2)	<0.01
Medium (201–400)	16 997 083 (25.0)	69 576 844 (24.6)	<0.01
Large (>400)	42 486 935 (62.6)	178 060 721 (62.9)	<0.01
Missing	268 422 (0.4)	1 123 162 (0.4)	0.7530
Admission type:			
Emergency	36 758 898 (54.2)	104 427 823 (36.9)	<0.01
Urgent	10 243 917 (15.1)	50 133 494 (17.7)	<0.01
Elective	6 377 005 (9.4)	71 188 912 (25.1)	<0.01
Newborn	6 399 279 (9.4)	25 783 151 (9.1)	<0.01
Delivery	285 522 (0.4)	599 526 (0.2)	<0.01
Other	24 916 (0.0)	136 489 (0.0)	<0.01
Missing	7 779 709 (11.5)	31 009 179 (10.9)	<0.01
Admission source:			
Emergency department	30 113 041 (44.4)	82 311 348 (29.1)	<0.01
Another hospital	1 590 294 (2.3)	7 172 875 (2.5)	<0.01
Other health facility	673 715 (1.0)	3 013 992 (1.1)	<0.01
Court or law enforcement	51 884 (0.1)	229 600 (0.1)	<0.01
Routine	16 915 596 (24.9)	113 735 341 (40.1)	<0.01
Missing	18 524 715 (27.3)	76 815 418 (27.1)	<0.01

teaching versus non-teaching institutions) ranking as another significant predictor (table 4). The associations between medium and large bed size facilities were statistically similar, showing an increased probability of incurring a hospital acquired condition (1.06, 1.01, 1.12, $P<0.01$, medium versus small; 1.11, 1.06 to 1.16, $P<0.01$, large versus small). Hospital region, though statistically significant, had marginal associations with the probability of incurring a hospital acquired condition during admission. Patients with comorbid neurological conditions were 35% more likely than those without to incur a hospital acquired condition during admission (1.35, 1.34, 1.37, $P<0.01$; results not shown).

Being from a minority ethnic group and of a younger age were associated with a decreased likelihood of incurring a hospital acquired condition, compared with being older and of white ethnicity (table 4). Patient payer type had mixed associations with the probability of incurring a hospital acquired condition; the likelihood was decreased in Medicare and Medicaid patients, whereas all other payers experienced an increased odds compared with privately insured patients (table 4). Additionally, females were 12% less likely to incur a hospital acquired condition than male patients in our sample (table 4). More severe All Patient Refined Disease Related Groups, admission types, and admission sources were associated with higher likelihoods of incurring a hospital acquired condition compared with less severe All Patient Refined Disease Related Group, routine admissions, and elective admissions (table 4).

During our multiple imputation analysis, we found that patients admitted on the weekends were 21% more likely to incur a hospital acquired condition than patients admitted on a weekday (1.21, 1.20 to 1.22, $P<0.01$). This result was seen to be similar to our non-imputed analysis (see supplementary table).

Table 2 | Incidence of hospital acquired conditions per year, 2002–10

Year	Air embolism	Foreign objects retained after surgery	Blood incompatibilities	Pressure ulcers	Catheter associated UTI	Vascular catheter associated infection	Surgical site infections					After cardiac implantable electronic device	After bariatric surgery for obesity	DVT and PE after certain orthopaedic procedures	Iatrogenic pneumothorax with venous catheterization	Total
							Poor glycaemic control	Falls/trauma	Mediastinitis after CABG	After certain orthopaedic procedures	After cardiac implantable electronic device					
2002	155	3006	581	0	28 721	0	20 733	1 275 689	276	1639	5112	116	162	2718	9453	1 348 199
2003	177	3118	488	0	31 505	0	21 842	1 339 431	270	1985	6027	162	162	2962	9988	1 415 155
2004	195	3040	580	0	34 245	0	20 962	1 400 159	298	1645	5465	482	482	4204	10 097	1 481 372
2005	217	3040	639	0	36 835	0	21 368	1 367 923	175	1929	5785	489	489	7411	11 467	1 457 278
2006	171	3240	673	0	45 859	0	23 943	1 401 587	233	1970	6970	446	446	7282	11 168	1 503 542
2007	236	3094	650	0	47 921	16 047	25 934	1 402 836	203	2165	7951	249	249	7774	11 558	1 526 618
2008	291	3012	516	51 512	61 108	80 432	27 841	1 437 457	156	2209	8550	327	327	8987	13 694	1 696 092
2009	257	2800	162	219 852	67 459	99 129	30 971	1 428 226	167	2126	10 795	314	314	7983	14 267	1 884 508
2010	178	2814	164	224 130	79 027	103 416	34 177	1 568 455	113	2266	9156	239	239	7572	12 865	2 042 572
Total	1877	27 164	4454	495 495	432 681	299 023	227 772	12 621 763	1891	17 934	65 813	2824	2824	56 893	104 557	14 360 141

UTI=urinary tract infection; CABG=coronary artery bypass graft; DVT=deep vein thrombosis; PE=pulmonary embolism.

Table 3 | Number of cases with hospital acquired conditions by year

Year	No with hospital acquired condition	% of population
2002	1 345 557	3.6
2003	1 415 175	3.7
2004	1 478 298	3.8
2005	1 453 571	3.7
2006	1 499 152	3.8
2007	1 521 342	3.8
2008	1 683 755	4.2
2009	1 858 018	4.7
2010	2 015 318	5.2

Higher inpatient charges and prolonged length of hospital stay

The presence of one or more hospital acquired conditions was associated with higher inpatient charges (1.83, 1.77, 1.90, $P<0.01$), when adjusting for timing of admission, patient factors (age, race, payer status, sex, admission severity), and hospital factors (region, location, teaching status, bed size). The occurrence of one or more hospital acquired conditions was also associated with prolonged length of stay (1.38, 1.36 to 1.41, $P<0.01$) (table 5). Mean inpatient charges for patients with at least one hospital acquired condition was \$48 788 and length of stay was 6.56 days, significantly greater than patients with no hospital acquired conditions (table 6).

Discussion

Medical care throughout the world has faced scrutiny and increased public awareness as focus has turned to improving public safety, outcomes, and access.³³ The current US healthcare focus on public safety and cost effectiveness mandates increased attention to quality outcome measures. Estimates suggest that \$ 9.3bn have been attributed annually to the treatment of potentially preventable medical errors, with recent estimates of \$12 bn saved with a 17% reduction in hospital acquired conditions since 2010.^{6 34} Determining incidence rates and characterizing the external factors associated with such events is critical. The current study is the first to examine the occurrence of Centers for Medicaid and Medicare Services (CMS) defined hospital acquired conditions—hospital events for which resulting costs of treatment are not federally reimbursed—across all inpatient admissions using a large, administrative database. The data provide baseline frequencies and enable subsequent monitoring of trends over time.

National rates for hospital acquired conditions

Analysis of 351 million US hospital admissions from 2002 to 2010 at least one hospital acquired condition in 4.8% of hospital admissions (16.7 million inpatient stays). This rate is concordant with previous estimates for hospital acquired conditions reported across the subspecialty literature (range 2.4–15.0%).^{27 13} Falls were the most common event, occurring in 14 million admissions and accounting for 85% of all hospital acquired conditions.

Hospital acquired conditions occurred more often among patients admitted on weekends (5.7%) than among those admitted on weekdays (3.7%). Weekend admission was associated with a 21% increased likelihood of incurring a hospital acquired condition (odds ratio 1.25, 95% confidence interval 1.24 to 1.26, $P<0.01$) after adjusting for patient, hospital, and severity of admission characteristics.

Factors potentially affecting rates of hospital acquired conditions

Multiple factors may impact the association between weekend admission and the occurrence of a hospital acquired condition. Staff volume (physicians, nurses, and ancillary staff) and level of medical expertise are diminished during weekend shifts.^{14 35 36} Reduced staffing may result in more limited attention to each patient at the point of admission. Further, medical staff often provide weekend coverage for one another and may be less familiar with both the acute and the chronic medical conditions of patients requiring hospital admission. Typically, a reduced infrastructure and fewer resources are allocated towards diagnostic testing and operative intervention on weekends. At weekends, delays have been reported in door to balloon time in the setting of acute myocardial infarction, placement of triple lumen catheters in those with acute myeloid leukemia, and performance of endoscopy in patients with hemorrhagic peptic ulcers and esophageal varices.^{22 37–39} Delays have been noted in patients with metastatic spine tumors receiving surgical intervention on weekends.⁴⁰ These disparities are not restricted to hospitals in the United States. In a retrospective English population cohort study, the authors reported a decrease in quality and safety of stroke care for patients presenting on weekends.⁴¹

Numerous studies from multiple countries have shown significant increases in mortality (from 3% to 20%) associated with weekend hospital admissions.^{18–21 41–43} This finding was also consistent with our tertiary analysis, indicating that the likelihood of mortality in patients admitted at weekends was 11% higher than that of patients admitted on weekdays (odds ratio 1.11, 95% confidence interval 1.10 to 1.12, $P<0.01$). However, the frequency of preventable hospital events may actually be a more accurate reflection of overwhelmed medical systems in the weekend environment. Such events reflect errors in systems and processes. Though mortality rates are heavily influenced by disease severity, medical comorbidities, and goals of care, hospital acquired conditions represent perceived deficiencies in healthcare delivery and are theoretically preventable. Further, deficiencies in weekend care may not always result in mortality but can impact patient care, length of stay, and hospital costs. Studies have found that delays in endoscopy during weekend admissions for patients presenting with hemorrhage from peptic ulcers and esophageal varices do not result in mortality but are associated with significant increases in hospital charges.³⁷

Table 4 | Predictors of hospital acquired conditions by multivariable analysis

Predictors	Odds ratio (95% CI)	P value
Patient predictors		
Admission day:		
Weekend	1.25 (1.24 to 1.26)	<0.01
Weekday	Reference	
Race:		
White American	Reference	
Black American	0.66 (0.63 to 0.68)	<0.01
Hispanic	0.73 (0.69 to 0.77)	<0.01
Asian Pacific Islander	0.65 (0.62 to 0.68)	<0.01
Native American	0.93 (0.84 to 1.03)	0.17
Other	0.90 (0.85 to 0.95)	<0.01
Payer information:		
Medicare	0.89 (0.86 to 0.91)	<0.01
Medicaid	0.67 (0.66 to 0.70)	<0.01
Private insurance	Reference	
Self pay	1.45 (1.38 to 1.51)	<0.01
No charge	1.16 (1.03 to 1.30)	0.01
Other	2.07 (1.97 to 2.18)	<0.01
Sex:		
Female	0.88 (0.86 to 0.90)	<0.01
Male	Reference	
No of comorbidities:		
0	Reference	
1	0.72 (0.71 to 0.74)	<0.01
≥2	0.57 (0.56 to 0.59)	<0.01
Age (years):		
<18	0.47 (0.45 to 0.49)	<0.01
19–30	0.41 (0.40 to 0.42)	<0.01
31–40	0.37 (0.35 to 0.38)	<0.01
41–50	0.41 (0.40 to 0.42)	<0.01
51–65	0.41 (0.40 to 0.42)	<0.01
66–80	0.56 (0.56 to 0.57)	<0.01
>80	Reference	
All Patient Refined Disease Related Group—severity:		
Minor loss of function	Reference	
No class specified	0.34 (0.27 to 0.43)	
Moderate loss of function	1.40 (1.37 to 1.43)	<0.01
Major loss of function	1.77 (1.72 to 1.83)	<0.01
Extreme loss of function	2.60 (2.50 to 2.71)	<0.01
Hospital predictors		
Hospital region:		
North east	Reference	
Midwest	1.14 (1.05 to 1.23)	<0.01
South	1.21 (1.13 to 1.30)	<0.01
West	1.25 (1.13 to 1.37)	<0.01
Hospital location:		
Rural	Reference	
Urban	0.97 (0.94 to 1.01)	0.13
Hospital teaching status:		
Non-teaching	Reference	
Teaching	1.29 (1.23 to 1.35)	<0.01
Hospital bed size:		
Small (<200)	Reference	
Medium (200–400)	1.06 (1.01 to 1.12)	<0.01
Large (>400)	1.11 (1.06 to 1.16)	<0.01
Admission type:		
Emergency	2.09 (1.97 to 2.22)	<0.01
Urgent	1.42 (1.35 to 1.49)	0.06
Elective	Reference	
Newborn	0.02 (0.02 to 0.02)	<0.01
Trauma	40.39 (23.24 to 70.21)	<0.01
Other	2.51 (1.67 to 3.76)	<0.01

(Continued)

Disease severity

Severity of illness at the time of admission could predispose to adverse events and hospital acquired conditions.⁴⁴ Further, inability to contact or visit a doctor's office may skew the demographics and disease severity of patients who present for emergency weekend hospital admission.¹³ To deal with this potential confounder, we incorporated the All Patient Refined Disease Related Group algorithm, admission source, and admission type, into our multivariable analysis. The All Patient Refined Disease Related Group algorithm attempts to account for diagnosis severity by characterizing functional impairment. Admissions are classified as minor, moderate, major, and extreme loss of function. Not surprisingly, analysis shows that patients admitted with moderate to extreme loss of function were 34% to 157% more likely to incur a hospital acquired condition during their hospital admission. Furthermore, neurologic condition has also been significantly linked to decreased outcome, with our results also noting increased hospital acquired conditions among those with neurologic impairments (P<0.01).

Secondary outcomes

The occurrence of hospital acquired conditions was associated with a 76% higher inpatient hospital charge. The mean charge of hospital stay for patients who experienced at least one hospital acquired condition was \$47 066, and for patients who had no hospital acquired condition was \$27 092. The rise in cost was independent of patient and hospital factors or day of admission (odds ratio 1.76, 95% confidence interval 1.69 to 1.82, P<0.001).

That hospital acquired conditions are associated with increased costs is not surprising. Early data reports on surgical complications suggest a total cost of \$58 237 for each nursing related event (fracture from fall) and \$86 833 per infection. The cost of surgery in the absence of an associated event was reported to be \$18 284.⁴⁵ Though increases in cost associated with hospital acquired conditions seem implicit, the magnitude of the calculated increase is notable. As current policy withholds reimbursement for costs associated with hospital acquired conditions, the financial burden on treating institutions remains substantial. Hospital acquired conditions are also associated with increased length of stay, independent of admission day, as well as hospital and patient characteristics. Mean length of stay is increased from 4.53 to 6.26 days in patients with at least one hospital acquired condition. This is concordant with findings from previous studies. In patients undergoing head and neck surgeries, deep vein thrombosis was associated with significant increases in length of hospital stay.⁴⁶ Surgical site infections and decubitus ulcers were associated with a 5.6 to 10 day increase in hospital stay.⁸ It is notable that increased length of stay in the presence of hospital acquired conditions is independent of admission day. This suggests that the reported length of stay variables are not confounded by patients admitted on weekends waiting longer in the hospital for availability of relevant tests or their primary doctor. It is not clear

Table 4 | Predictors of hospital acquired conditions by multivariable analysis

Predictors	Odds ratio (95% CI)	P value
Admission source:		
Emergency department	2.25 (2.11 to 2.40)	<0.01
Another hospital	2.31 (2.08 to 2.55)	<0.01
Other health facility	1.89 (1.76 to 2.04)	<0.01
Court or law enforcement	1.00 (0.67 to 1.49)	0.99
Routine	Reference	

from the current analysis whether hospital acquired conditions contribute to increased hospital costs and prolonged length of stay or if the reverse is true. The analysis simply establishes an association; causative inference is not possible with the data provided. Increased time spent in hospital typically results in higher inpatient costs and certainly may render an individual susceptible to hospital acquired conditions.

Limitations of this study

The current study is limited by the natural constraints of a large administrative database. ICD-9 coding within an administrative data source is reported to be 80% accurate.⁴⁷ Coding is performed by a wide variety of staff without strict oversight. Reported data are therefore subject to information bias and local variability. It is unlikely, however, that the weekend and weekday cohorts would be differentially affected. Also, patients admitted on a Sunday night for elective surgery were included as weekend admits, though we adjusted for this population by controlling for elective admission within our multivariable model.

Two of the codes for hospital acquired conditions were not present in the earlier years of the National Inpatient Sample. Pressure ulcers were not coded prior to 2008 and vascular catheter infections were not coded prior to 2007. This prohibits their inclusion in the analysis of hospital acquired conditions in the years with missing data. This could marginally lower the overall reporting frequency of hospital acquired conditions but would unlikely exhibit differential effects on the weekday and weekend rates of hospital acquired conditions. Furthermore, our study sample includes significant het-

erogeneity and limits the ability in this mixed cohort to make procedure specific or admission specific conclusions. An inherent limitation in the use of the National Inpatient Sample is not being able to distinguish patients with multiple admissions, resulting in an inability to follow subsequent hospital admissions from the original admission of hospital acquired conditions. Because of this, long term implications of hospital acquired conditions may result in prolonged and subsequent hospital stays that cannot be taken into account. Also, patients who sustain a hospital acquired condition may have subsequent repeat hospital admissions where their prior hospital acquired condition may be either documented as a new occurrence or not documented at all, with the former leading to a possibly inflated estimate. Finally, documentation of hospital acquired conditions does not distinguish events that occur after admission from pre-existing conditions. However, most of the hospital acquired conditions studied are single events or conditions highly unlikely to have occurred prior to hospital admission.

Improving future rates of hospital acquired conditions

The volume of hospital admissions on weekends is unlikely to decline substantially in the foreseeable future. Added resources and efforts of healthcare administrators and providers are needed to tackle the potential shortcomings in quality of patient care during susceptible periods. Hospital acquired conditions reflect deficiencies in systems and processes. The reasons for an increased frequency of “never events” in patients admitted to hospitals over the weekend is likely multifactorial. Staffing problems are a universal concern. Further training and implementation of prescribed protocols may help mitigate the “weekend effect.” Studies attribute human factors such as medical errors to systemic inadequacies within a larger context of less stringent adherence to safety.^{48 49} Improved implementation of protocols for patient care may prevent hospital acquired conditions, especially during times of decreased staffing. It is estimated that at least 20% of hospital acquired infections are preventable with proper training.⁵⁰ Current nationwide efforts to implement technical practices designed to reduce urinary tract infections are underway.⁵¹ Such programs, providing a standard for the initiation of common practice treatments, whether on weekends or weekdays, may be of large scale benefit.

Conclusion

Documentation of hospital acquired conditions represents a reproducible metric for quality of patient care, whereas event occurrence is a large financial burden for healthcare providers and institutions. Evaluation of the frequency of hospital acquired conditions across all medical specialties and admission profiles from 2002–10 showed a significant increase in hospital acquired conditions for patients admitted on weekends, with associated increases in hospital costs and length of patient stay. Improved education, staffing, and protocols may reduce this observed effect.

Table 5 | Inpatient charges and length of stay in relation to hospital acquired conditions

Variables	Odds ratio (95% CI)	P value
Higher inpatient charges:		
Hospital acquired condition	1.83 (1.77 to 1.90)	<0.01
No hospital acquired condition	Reference	
Prolonged length of stay:		
Hospital acquired condition	1.38 (1.36 to 1.41)	<0.01
No hospital acquired condition	Reference	

Table 6 | Mean inpatient costs and length of stay by hospital acquired conditions, 2002–10

Variables	Mean (95% CI)	
	Hospital acquired condition	No hospital acquired condition
Inpatient cost (\$)	48 788.00 (47 119.23 to 50 457.25)	27 165.00 (26 501.40 to 27 829.20)
Length of stay (days)	6.56 (6.46 to 6.67)	4.53 (4.49 to 4.57)

\$1.00 (£0.67; €0.93).

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