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Clinical Research Study

Patients admitted on weekends have higher in-hospital mortality than those admitted on weekdays: Analysis of national inpatient sample

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ABSTRACT

Introduction: Since the 1999 Institute of Medicine report, hospitals have implemented a myriad of measures to protect patients from medical errors. At this point, looking beyond errors may bring additional safety benefits. This study aims to analyze predictors of in-hospital death regardless of underlying diagnoses in an effort to identify additional targets for improvement.
Methods: We performed a retrospective study of hospitalizations from the 2016-2019 National Inpatient Sample (NIS) database. Logistic regression analyses were used to calculate adjusted odds ratios (OR) for variables associated with in-hospital death.
Results: There were 121,026,484 adult hospital discharges in the database. Multivariable analysis showed the following variables were associated with higher in-hospital death: Age (OR, 1.04), Charlson Comorbidity Index (OR, 1.23), male (OR, 1.16), income Q1 (OR, 1.12), income Q2 (OR, 1.07), west region (OR, 1.07), non-elective admission (OR, 2.01), urban hospital location (OR, 1.17), and weekend admission (OR, 1.14). Percentage of deaths for weekend versus weekday admissions was 2.7% versus 2.1%. Fewer procedures (ICD-10-PCS) were done in first 24 hours of weekend admissions when compared to weekday admissions (34.8% vs 46.8%; $p<0.001$). Only 524,295 in-hospital deaths were expected for weekend admissions but 673,085 were observed.
Conclusion: Weekend hospital admissions were associated with higher adjusted mortality and a lower rate of procedures when compared to weekday admissions. Further studies should be done to further clarify and confirm if additional staffing and procedural availability on weekends could improve hospital outcomes.

Introduction

Hospitals have long strived to reduce complications, readmissions, and death. The Institute of Medicine (IOM) released a report in 1999 entitled "To Err Is Human: Building a Safer Health System[1]." They reported that between 44,000-98,000 Americans die every year due to preventable medical errors. Subsequently Makary et al concluded that medical errors were responsible for more than 250,000 inpatient deaths per year in the USA[2]. Since the IOM report, medical errors have been studied extensively and hospitals have implemented a myriad of measures to protect patients[3]. Although hospital outcomes are largely driven by specific diseases and their complications, socio-economic and health care specific factors also affect outcomes[4,5,6,7]. Additionally, multiple smaller analyses have implicated weekend hospital admission as a potential risk factor for poor outcomes[8,9,10,11,12, 13]. Unfortunately, most existing weekend analyses are not generalizable as the cohorts were restricted to individual disease subpopulations[8, 9,10, 11,12]. Further analysis of factors surrounding hospital mortality has potential to yield patient safety insights. This study fills knowledge gaps in this area by analyzing predictors of death for all hospitalizations regardless of underlying diagnoses in a large United States (U.S.) national database.

Methods

Data source: We performed a retrospective study of all adult hospitalizations from 2016-2019 in the NIS database. The National Inpatient Sample (NIS) is the largest all-payer hospitalization database in the U.S. and is part of the Healthcare Cost and Utilization Project (HCUP). The NIS is a stratified probability sample representative of all non-federal acute-care hospitals in the U.S. Hospitals are stratified according to bed size, geographic region, ownership, and rural vs urban location. The NIS includes a 20% probability sample of all hospitals within each stratum. All discharges are weighted to make them nationally representative.

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Table 1
Weighted Descriptive Characteristics of Adult Hospitalizations from the 2016 to 2019 National Inpatient Sample (n= 121,026,484)

Hospitalization Characteristics	Discharged Alive (n=118,326,840)	In-Hospital Death (n=2,699,644)	P-value
% of Total Hospitalizations	97.8 %	2.2%	–
Age, median (IQR) in years	61 (40-74)	73 (62-83)	<0.001
AgeGroups(%)			
Age 18-40 years	24.5%	4%	<0.001
Age 40-60 years	23.8%	16.2%	<0.001
Age 60-80 years	35.8%	45%	<0.001
Age > 80 years	16%	34.8%	<0.001
Male	42%	52%	<0.001
White	65%	69%	<0.001
African American	14.8%	13%	<0.001
Hispanic	10.8%	8%	<0.001
Asian or PI	2.7%	2.9%	<0.001
Native American	0.6%	0.6%	0.979
Other Race	2.9%	2.9%	0.985
LOS, median (IQR) days	3 (2-5)	4 (1-9)	<0.001
CCI, median (IQR)	1 (0-3)	3 (2-6)	<0.001
Household Income Q1	29.9%	30.3%	<0.001
Household Income Q2	25.7%	25.8%	0.157
Household Income Q3	23.4%	22.9%	<0.001
Household Income Q4	19.2%	19.2%	0.590
Medicare	47.2%	65.8%	<0.001
Medicaid	18.5%	9.3%	<0.001
Private Insurance	26.9%	16.6%	<0.001
Self-Pay	4%	3.1%	<0.001
No Charge	0.4%	0.2%	<0.001
Other Insurance	2.8%	4.8%	<0.001
Weekend Admission	20.5%	24.9%	<0.001
Small Bed Size	20.7%	17.4%	<0.001
Medium Bed Size	29.2%	28.7%	0.017
Large Bed Size	50%	53.9%	<0.001
Non-elective Admission	76.3%	90.8%	<0.001
Urban Hospital	90.9%	91.6%	<0.001
Northeast region	18.6%	19.2%	0.005
Midwest region	22.4%	20.9%	<0.001
South region	39.6%	39.4%	0.466
West region	19.4%	20.5%	<0.001
Total Charges, median (IQR)	$31,453 (16,897- 60,353)	$ 58,225 (24,018- 135,906)	<0.001
Procedures during hospitalization	73,173,468 (61.8%)	2,033,180 (75.3%)	<0.001

Abbreviations: CCI= Charlson Comorbidity Index; n= number; LOS=length of stay; PI=Pacific Islander; IQR=interquartile range; s.d.=standard deviation: Q=quartile

The 2016-2019 NIS sampling frame includes data from 47 statewide data organizations (46 states plus the District of Columbia) covering more than 97% of the U.S. population. Diagnoses for each hospitalization were recorded utilizing the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM). The ICD-10 Procedure Coding System (ICD10-PCS) (codes starting with 0-9 and B-X) were used to record procedures, advanced imaging, and many other interventions done by health professionals. We did not seek institutional review board permission as all NIS data is de-identified and publicly available. All rules and regulations of the HCUP data service agreement were followed.

Inclusion Criteria: We analyzed all adult hospitalizations in the NIS database with a recorded mortality status from 2016 to 2019.

Variables

Study variables included age, gender, race/ethnicity, length of stay (LOS), total hospital charges, in-hospital mortality, median household income by zip code, medical insurance type, weekend admission status, hospital bed size, location, and US region. Details of NIS variables are available at online http://www.hcup-us.ahrq.gov but here in is a basic summary of the NIS variables. Insurance types included: Medicare, Medicaid, private insurance, self-pay, no charge, or other insurance. Hospital bed size included: small, medium, and large. Hospital region was divided as follows: Northeast, Midwest, South, and West. Weekend admission was defined as Saturday or Sunday hospital admission. Hospital location was divided into urban or rural. Admission type included elective or non-elective. Median household income by zip code was divided into quartiles. In 2019, the U.S. dollar values for each quartile were as follows: quartile 1 (Q1) =$ 1 to 47,999; quartile (Q2) = $ 48,000 to 60,999; quartile 3 (Q3) to $ 61,000 - 81,999; and quartile 4 (Q4) ≥ $82,000.

Outcomes: The primary outcome was (1) identification of variables associated with in-hospital death. (2) characterization of relevant independent predictors of in-hospital death. Secondary outcomes of interest included description of demographic characteristics, insurance type, income quartiles, hospital bed size, geographic location, LOS, and total charges.

Statistical Analysis: Analyses were performed by using STATA, version 16.1 (StataCorp, Texas, USA). Baseline characteristics were summarized using descriptive statistics, Pearson's χ 2 and Wilcoxon rank-sum test as appropriate. Univariable logistic regression analyses were used to calculate unadjusted odds ratios (ORs) for in-hospital death. Variables were selected from literature review[8,9,10,11,12,13]. All variables with P values ≤ 0.2 were included in a multivariable logistic regression model. P values ≤ 0.05 were considered significant in the multivariable analysis. Charlson Comorbidity Index (CCI) was used to adjust for comorbidity burden[14].

Table 2
Univariable Mortality Analysis NIS 2016 to 2019

Variable	Odds Ratio	P value	95% C.I.
Age	1.04	<0.001	1.040-1.041
CCI	1.31	<0.001	1.312-1.317
Male	1.51	<0.001	1.499-1.520
White	1.19	<0.001	1.181-1.208
African American	0.86	<0.001	0.847-0.872
Hispanic	0.71	<0.001	0.699-0.727
Asian PI	1.10	<0.001	1.067-1.128
Native American	1.00	0.979	0.949-1.052
Other Race	1.00	0.985	0.966-1.034
Income Q1	1.02	<0.001	1.009-1.031
Income Q2	1.01	0.157	0.997-1.016
Income Q3	0.97	<0.001	0.962-0.981
Income Q4	1.00	0.590	0.983-1.010
Medicare	2.16	<0.001	2.129-2.187
Medicaid	0.45	<0.001	0.442-0.455
Private Insurance	0.54	<0.001	0.530-0.551
Self-Pay	0.76	<0.001	0.742-0.780
No Charge	0.50	<0.001	0.443-0.569
Other Insurance	1.73	<0.001	1.645-1.829
Small Bed Size	0.80	<0.001	0.784-0.826
Medium Bed Size	0.98	0.017	0.961-0.996
Large Bed Size	1.16	<0.001	1.144-1.184
Nonelective Admission	3.07	<0.001	2.934-3.204
Northeast Region	1.04	0.005	1.012-1.068
Midwest Region	0.92	<0.001	0.898-0.934
South Region	0.99	0.467	0.976-1.011
West Region	1.07	<0.001	1.048-1.088
Urban Hospital Location	1.09	<0.001	1.067-1.112
Weekend Admission	1.29	<0.001	1.277-1.295

Abbreviations: CCI= Charlson Comorbidity Index; PI=Pacific Islander; Q=quartile

Results

After weighting, 121,026,484 adult hospital discharges were analyzed from the combined 2016-2019 NIS database. Of those, 2,699,644 (2.2%) patients died while in the hospital and 118,326,840 (97.8%) hospitalizations were discharged alive (Table 1). The deceased patients had a higher median age in years (73 vs 61; p<0.001), were more likely to be male (52% vs 42%; p<0.001), had a higher median CCI (3 vs 1; p<0.001), were more likely to be a weekend admission (24.9% vs 20.5%; p<0.001), were more likely to be a non-elective admissions (90.8% vs 76.3%; p<0.001), were more likely to be at an urban location (91.6% vs 90.9%; p<0.001), had higher median total hospital charges ($58,225 vs $31,453; p<0.001), had higher median hospital LOS in days (4 vs 3; p<0.001), were more likely to have Medicare (65.8% vs 47.2; p<0.001), were less likely to have Medicaid (9.3% vs 18.5%; p<0.001), were less likely to have private insurance (16.6% vs 26.9%; p<0.001) and had a higher rate of billed procedures (75.3% vs 61.8 %; p<0.001).

Univariable analysis

Univariable analysis showed the following variables were associated with higher in-hospital death at a $p \leq 0.2$ (Table 2): Age, CCI, male gender, White, Asian/ Pacific Islander, Income Q1, Medicare or other insurance, large bed size, non-elective admission, northeast or west region, urban hospital location and weekend admission.

Multivariable analysis

Multivariable analysis showed the following variables were associated with higher in-hospital death (Table 3): Age (OR, 1.04; 95% C.I. 1.039-1.040), CCI (OR, 1.23; 95% C.I. 1.231-1.236), male gender (OR, 1.16; 95% C.I. 1.156-1.171), income Q1 (OR, 1.12; 95% C.I. 1.104-1.137), income Q2 (OR, 1.07; 95% C.I. 1.052-1.081), west region (OR, 1.07; 95% C.I. 1.050-1.094), non-elective admission (OR, 2.01; 95% C.I. 1.917-2.098), urban hospital location (OR, 1.17; 95% C.I. 1.142-1.192), and weekend admission (OR, 1.14; 95% C.I. 1.131-1.146). Multivariable analysis did not show higher odds for in-hospital mortality for insurance type, race/ethnicity, or hospital bed size. Large bed size was omitted from the multivariable analysis due to collinearity.

Weekend versus weekday admissions

24,966,440 (20.6%) of the admissions occurred on the weekends and 96,059,060 (79.4%) of admissions occurred on weekdays (table 4). The NIS database was missing day of admission data on 984 (0.0008%) of the recorded hospitalizations. The percentage of in-hospital deaths for weekend versus weekday hospital admissions was 2.7% versus 2.1%. Fewer billed procedures (ICD-10-PCS) were done in first 24 hours (34.8% vs 46.8%; p<0.001) and the first 48 hours (41.9% vs 51.6%; p<0.001) for weekend admissions when compared to weekday admissions. The median CCI for weekend admissions was 1 (IQR= 0-3) and the median CCI for weekday admissions was 1 (IQR= 0-3).

Using the weekday mortality rate of 2.1% as the reference, only 524,295 in-hospital deaths were expected for weekend admissions but 673,085 were observed. In other words, the weekend ratio of observed to expected (O/E) deaths was 1.28. In absolute numbers, weekend admissions had an average of 37,198 deaths more than expected annually from 2016 to 2019. The top 30 principal billing ICD-10 diagnosis codes were ranked by day of admission inTable 5. There were marked similarities between the groups and in fact 27 of the top 30 diagnoses codes were the same. Overall, the diagnoses were predominately infectious or cardiopulmonary in nature.

Discussion

We completed a comprehensive review of all adult hospitalizations to elucidate in-hospital mortality and its risk factors on a national level over a 4-year period. Most previous mortality studies have either studied specific subpopulations or utilized much smaller samples. We found that death occurred in 2.2% of all hospitalizations irrespective of the day

Table 3
Multivariable Mortality Analysis NIS 2016 to 2019

Variable	Odds Ratio	P value	95% C.I.
Age	1.04	<0.001	1.039-1.040
CCI	1.23	<0.001	1.231-1.236
Male	1.16	<0.001	1.156-1.171
White	0.80	<0.001	0.785-0.818
African American	0.72	<0.001	0.700-0.733
Hispanic	0.68	<0.001	0.667-0.701
Asian PI	0.85	<0.001	0.830-0.879
Income Q1	1.12	<0.001	1.104-1.137
Income Q2	1.07	<0.001	1.052-1.081
Income Q3	1.01	0.087	0.999-1.022
Medicare	0.36	<0.001	0.293-0.441
Medicaid	0.50	<0.001	0.408-0.613
Private Insurance	0.52	<0.001	0.423-0.637
Self-Pay	0.71	0.001	0.581-0.874
No Charge	0.47	<0.001	0.366-0.592
Other Insurance	1.04	0.690	0.846-1.287
Small Bed Size	0.78	<0.001	0.764-0.803
Medium Bed Size	0.89	<0.001	0.876-0.908
Northeast Region	1.01	0.603	0.980-1.036
Midwest Region	0.89	<0.001	0.876-0.914
West Region	1.07	<0.001	1.050-1.094
Nonelective Admission	2.01	<0.001	1.917-2.098
Urban Hospital Location	1.17	<0.001	1.142-1.192
Weekend Admission	1.14	<0.001	1.131-1.146

Abbreviations: CCI= Charlson Comorbidity Index; PI=Pacific Islander; Q=quartile
Note: Large Bed Size omitted because of collinearity

Table 4
Weekday versus Weekend Admissions

Hospitalization Characteristics, No (%)	**Weekday Admissions (n= 96,059,060)**	**Weekend Admissions (n=24,966,440)**	**P-value**
Deaths	2,026,524 (2.1%)	673,085 (2.7%)	<0.001
Procedures during hospitalization	61,415,617 (63.9%)	13,790,606 (55.2%)	<0.001
Procedures within 24 hours of admission	44,985,470 (46.8%)	8,699,202 (34.8%)	<0.001
Procedures within 48 hours of admission	49,585,339 (51.6%)	10,451,037 (41.9%)	<0.001

Abbreviations: No=number;

of admission. Multivariable analysis revealed numerous socio-economic and healthcare related predictors of in-hospital death including age, CCI, male gender, low-income brackets, west region of USA, non-elective admission, urban hospital location and weekend admission. The most interesting and potentially clinically relevant of these mortality predictors was weekend hospital admission. Intuitively weekend hospital admissions are different from those on weekdays since staffing is often lower and some medical testing may be delayed. Regardless of the day of admission, deceased inpatients underwent 13% higher rate of procedures during their hospitalization than those discharged alive. Weekend hospital admissions had a 9% lower number of billed procedures than those admitted on weekdays. In other words, weekend admissions when compared to the weekdays underwent fewer procedures and were slightly more likely to die. We cannot conclude causation, but the discrepancy forces us to ask if hospitals services are meaningfully different on the weekend. It may not be a "medical error" in the traditional sense but rather an availability and staffing issue. On the other hand, it is conceivable that different populations of patients were admitted on the weekends compared to weekdays who were sicker, had different procedural needs and in turn had worse outcomes. Though this notion is not supported by NIS data since the weekend mortality difference remained statistically significant even after controlling for comorbidities and socio-economic variables such as age, gender, race, type of insurance and income.

Unfortunately, the NIS database does not contain data on traditional social determinants of health such as outpatient medical access, health literacy, or ability to afford medications; but the NIS does contain several surrogates of those determinants such as income quartile, race/ethnicity, and insurance type. We found that the two lowest income quartiles had an elevated odds for in-hospital death whereas the upper two income quartiles showed no increased risk. Race/ethnicity and insurance type did not contribute to increased risk of in-hospital death after adjusting for covariates.

The "weekend effect" described as higher mortality for weekend hospital admissions has been investigated several times before although on a much smaller scale and mostly for specific diseases. Honeyford et al performed a meta-analysis of 39 studies from the United Kingdom (UK) and found that weekend admissions had higher adjusted odds of mortality (OR:1.06; 95% CI:1.02–1.10)[15]. Despite a vastly different study design and a different country, their results were consistent with our US claims based analysis. In another study by Tolvi et al, they examined the weekend effect at Helsinki University Hospital over a 14-year period and analyzed patients who died during the hospital stay or within 30 days of discharge[16]. They also found a statistically significant weekend effect for in-hospital mortality in multiple specialties supportive of our findings. Faust et al found patients admitted to intensive care units on the weekends with emergency surgery needs had higher adjusted odds for death (OR 2.03; 95% CI 1.52-2.71)[17]. Even though they studied a highly restricted subpopulation of patients, they reported fairly similar results to our unrestricted study.

In one of the few larger analyses, Bell et al analyzed nearly 4 million admissions in Ontario, Canada over a 10-year study period and found higher mortality on the weekends for 23 of the 100 leading causes of death despite no major differences in baseline characteristics[18]. Their

Table 5
Top 30 Principal Billing Diagnoses in Deceased Patients By Day of Admission

Weekday deaths (%)		Weekend deaths (%)	
Sepsis, unspecified organism A41.9	22.13%	**Sepsis, unspecified organism** A41.9	24.32%
Resp failure with hypoxia J96.01	2.69%	Resp failure with hypoxia J96.01	2.90%
Encounter for palliative care Z51.5	2.42%	**NSTEMI** I21.4	2.46%
NSTEMI I21.4	2.26%	**Cardiac arrest, cause unspecified** I46.9	1.75%
Hypertensive heart and CKD with HF and stage 1-4 CKD, or unspecified CKD I13.0	1.97%	**Pneumonia, unspecified organism** J18.9	1.74%
Acute kidney failure, unspecified N17.9	1.65%	**Hypertensive heart and CKD with HF and stage 1-4 CKD, or unspecified CKD** I13.0	1.73%
Pneumonia, unspecified organism J18.9	1.63%	**Encounter for palliative care** Z51.5	1.72%
Aspiration pneumonia J69.0	1.58%	Aspiration pneumonia J69.0	1.69%
Acute/chronic resp failure, hypoxia J96.21	1.58%	Acute/chronic resp failure, hypoxia J96.21	1.68%
Cardiac arrest, cause unspecified I46.9	1.43%	**Acute kidney failure, unspecified** N17.9	1.46%
Sepsis due to Escherichia coli A41.51	0.94%	**Sepsis due to Escherichia coli** A41.51	0.95%
Hypertensive heart disease with HF I11.0	0.93%	**Cerebral infarction, unspecified** I63.9	0.88%
Cerebral infarction, unspecified I63.9	0.84%	**Hypertensive heart disease with HF** I11.0	0.87%
Acute resp failure **unspecified whether with hypoxia or hypercapnia** J96.00	0.71%	**Sepsis due to Methicillin resistant Staphylococcus aureus** A41.02	0.74%
Sepsis due to Methicillin resistant Staphylococcus aureus A41.02	0.71%	Acute resp failure **unspecified whether with hypoxia or hypercapnia** J96.00	0.74%
Other specified sepsis A41.89	0.69%	**Other specified sepsis** A41.89	0.71%
Other pulmonary embolism without acute cor pulmonale I26.99	0.68%	**Sepsis due to Methicillin susceptible Staphylococcus aureus** A41.01	0.68%
Chronic obstructive pulmonary disease with (acute) exacerbation J44.1	0.65%	**Nontraumatic intracerebral hemorrhage, intraventricular** I61.5	0.68%
Sepsis due to Methicillin susceptible Staphylococcus aureus A41.01	0.63%	**STEMI involving other coronary artery of inferior wall** I21.19	0.64%
Nontraumatic intracerebral hemorrhage, intraventricular I61.5	0.59%	**Other pulmonary embolism without acute cor pulmonale** I26.99	0.64%
STEMI myocardial infarction involving other coronary artery of inferior wall I21.19	0.58%	**Chronic obstructive pulmonary disease with (acute) exacerbation** J44.1	0.63%
Malignant neoplasm of unspecified part of unspecified bronchus or lung C34.90	0.53%	**STEMI involving other coronary artery of anterior wall** I21.09	0.61%
Gastrointestinal hemorrhage K92.2	0.53%	**Gram-negative sepsis, unspecified** A41.50	0.60%
Administrative examinations, unspecified Z02.9	0.53%	**Gastrointestinal hemorrhage** K92.2	0.57%
Acute on chronic resp failure with hypercapnia J96.22	0.53%	Acute on chronic resp failure with hypercapnia J96.22	0.55%
Gram-negative sepsis, unspecified A41.50	0.52%	**Ventricular fibrillation** I49.01	0.54%
STEMI involving other coronary artery of anterior wall I21.09	0.49%	Traumatic subdural hemorrhage with LOC of unspecified duration S06.5X9A	0.54%
Other Gram-negative sepsis A41.59	0.46%	Acute resp failure with hypercapnia J96.02	0.54%
Hypertensive heart and CKD with HF and with stage 5 CKD, or ESRD I13.2	0.46%	**Other Gram-negative sepsis** A41.59	0.51%
Acute on chronic systolic HF I50.23	0.46%	STEMI of unspecified site I21.3	0.50%

Abbreviations: CKD=chronic kidney disease; ESRD= **end stage renal disease;** HF=heart failure; LOC= loss of consciousness **NSTEMI=Non-ST elevation myocardial infarction; Resp=respiratory; STEMI =ST elevation myocardial infarction**

study supports our finding even though their analysis was from a slightly different type of health care system, was smaller and was focused on specific diseases of interest.

Bressman et al analyzed day of admission status on approximately 10 million inpatients from 106 academic hospitals from the Vizient clinical database over a 3-year study period. They found significant associations between death and weekend admissions with an unadjusted OR=1.46 (95% CI 1.45–1.47) and an adjusted OR=1.05 (95% CI 1.04–1.06). Their results were less impressive than ours but their sample was much smaller, restricted to academic hospitals, and from a shorter timeperiod[19].

Several previous analyses of NIS database have shown conflicting results. All of them were different from our current study as they restricted cohorts to individual disease subpopulations. In an analysis of acute myocardial infarction (MI) from NIS 2000-2016, weekend admission did not increase mortality but was associated with fewer discharges to home[9]. In a different cardiac analysis by Pathak et al of acute MI from the NIS 2006-2011, they found an increased mortality for those admitted on weekends[11]. Unfortunately, the differences were not adjusted for covariates. An analysis of acute stroke from the NIS 2002-2007 showed weekend hospital admissions had longer LOS and higher total charges but no differences in mortality[10]. In a meta-analysis of NIS studies focused on weekend admission upper gastrointestinal (UGI) bleeds, Weeda et al found a 9% increase in mortality for non-variceal UGI bleeds when compared to weekdays but no difference for variceal UGI bleeds[12]. Coleman et all did a meta-analysis of NIS studies for weekend pulmonary emboli admissions and found significantly higher adjusted odds for in-hospital death when compared to those admitted on weekdays[20].

Our study is one of the most comprehensive analyses of in-hospital mortality in the U.S. ICD-10 era. The results provide insight into the multiple predictors of in-hospital death irrespective of cause. Meaningful comparison of hospital death rates requires adjustment for patient comorbidities for which we utilized the CCI in this study. Not surprisingly, the median CCI of deceased adult inpatients was three times higher than those discharge alive; but the CCI was identical for weekend and weekday admissions. Important limitations of this study include the following. First, our analysis relies exclusively on claims data rather than clinical details, hence it is not possible to verify the comorbidities. Second, we don't have data regarding critical care bed availability, staffing numbers, nursing ratios, outpatient medication compliance, ambulatory primary care access, or patient medical literacy. Third, we recorded all billed ICD-10-PCS procedures and many of them do not have a plausible connection with mortality. In other words, an alternative explanation for differences between weekend and weekday procedure rates was normal scheduling of non-essential procedures. That being said, lower procedural rates were a major difference between weekend and weekday admissions and could not be accounted for by differences in comorbidities or major differences in the top 30 principal diagnoses. Lastly, we were able to see differences in billed procedures but do not have data to show that staffing or procedural availability was in fact lower on the weekends in the USA. In a recent study from the UK, there was no improvement in mortality after increasing weekend specialty staffing[21]. During the study period, specialist input on weekends was still half that of weekday admissions and there was only a very modest overall increase in specialist work hours. They also concluded that weekend admissions in the UK had more comorbid disease. This study did not address if changes in overall weekend staffing or procedural access would change hospital outcomes.

Conclusion

Our analysis at the U.S. national level revealed in-hospital death occurred in more than 1/50 adult hospitalizations. Significant predictors of death included age, higher CCI, male gender, lower-income brackets, west region of the USA, non-elective admission, urban hospital location and weekend admission. Similar to existing literature, weekend hospital admissions were associated with higher adjusted mortality when compared to weekday admissions with an O:E ratio of 1.28. Additionally, weekend admissions had a lower rate of procedures when compared to weekday admissions. Further studies should be done to further clarify and confirm if additional staffing and procedural availability on weekends could improve hospital outcomes.

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Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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