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Did the introduction of comprehensive stroke centers impact the "weekend effect" on mortality for patients with intracranial hemorrhage in the United States?

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ABSTRACT

Objectives: Over the last two decades, various studies have evaluated the impact of weekend admission to the hospital on inpatient mortality. Our study sought to identify whether or not the "weekend effect" was true for patients with Intracranial Hemorrhage (ICH) admitted to United States hospitals and whether or not the introduction of comprehensive stroke centers (CSCs) made an impact on the "weekend effect" for ICH.

Patients and methods: Searched the Nationwide Inpatient Sample for the ICH discharges between 2006 and 2014. Multivariate regression analysis was performed to evaluate the factors that impacted in-hospital mortality. Additional subgroup analysis was performed based on two time periods, before CSCs (2006–2009) and afterward (2010–2014).

Results: 146,587 discharges with ICH were reported by the NIS with 37,471 (25.6%) weekend admissions. The weekday admission cohort was 50.6% male with a mean age of 67.1 years. There was a total of 35,362 deaths among ICH admissions. The in-hospital mortality rate was significantly higher for weekend admissions compared to that of weekday admissions (25.2% vs. 23.8%, $p < 0.001$). Multivariate analysis of mortality for the 2006–2009 subgroup demonstrated a statistically significant higher odds of death with weekend admission (OR = 1.15, 95% CI [1.10, 1.20], p = 0) but not for the 2010–2014 subgroup (OR = 1.03, 95% CI [0.99, 1.07], p = 0.09).

Conclusion: Our study showed that in-hospital mortality was found to be increased for patients with ICH admitted on a weekend; however, this association was lost after the initiation of CSCs. Further prospective studies are warranted to gain a better understanding regarding this association.

1. Introduction

Primary intracerebral hemorrhage (ICH) accounts for up to 15% of strokes with an annual incidence of approximately 120,000 strokes [1]. Stroke is the fifth-leading cause of death in the United States and the second-leading cause of death worldwide with approximately 14,000 deaths related to ICH annually [2,3]. It is associated with high rates of mortality with nearly half of all patients dying within 30 days, and half of all deaths occurring within the first two days of presentation [4,5]. Moreover, it is accompanied by high rates of morbidity with only a fifth of patients achieving meaningful functional recovery at six months [4]. Previous scoring systems (derived from presenting characteristics) have been developed for prognostication and to provide patients and their families with estimates of morbidity [6,7]. While these systems offer guidance for medical decision making, they can overlook certain aspects about clinical outcomes based on the location of the ICH. There is a subset of patients who experience a hemorrhagic lacunar stroke who have been found to have more favorable outcomes in regards to in-hospital mortality and permanent neurologic deficit [8]. Because the rate of ICH increases strongly with age and the average age of the global population continues to increase, ICH rates and incidence are expected to increase in the future [9,10]. This is of particular clinical and practical significance as very old people experience a higher rate of moderate or severe neurological deficit at the time of hospital discharge

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Table 1
Baseline Cohort Characteristics for Weekday and Weekend Admissions for 2006-2014.

	Weekday, n (%)	Weekend, n (%)	p-value*
Sample size, n	109,116	37,471	
Age (mean ± SD)	67.13 ± 17.01	67.28 ± 16.98	0.14
Length of stay (mean ± SD)	9.28 ± 13.43	8.85 ± 12.53	<0.001
Gender			0.50
Male	55,256 (50.64)	19,052 (50.84)	
Female	53,860 (49.36)	18,419 (49.16)	
Region			0.050
Northeast	22,924 (21.01)	7678 (20.49)	
Midwest	17,747 (16.26)	6059 (16.17)	
South	44,198 (40.51)	15,194 (40.55)	
West	24,247 (22.22)	8540 (22.79)	
Payer			<0.001
Medicare	63,867 (58.65)	22,084 (59.03)	
Medicaid	10,769 (9.89)	3904 (10.44)	
Private payer	24,678 (22.66)	8013 (21.42)	
Self-payer	6053 (5.56)	2274 (6.08)	
No Charge	554 (0.51)	188 (0.5)	
Other	2966 (2.72)	948 (2.53)	
Race			<0.001
White	72,411 (66.36)	24,369 (65.03)	
Black	17,531 (16.07)	6117 (16.32)	
Hispanic	10,142 (9.29)	3698 (9.87)	
Asian	4821 (4.42)	1779 (4.75)	
Native American	500 (0.46)	170 (0.45)	
Other	3711 (3.4)	1338 (3.57)	
Teaching Hospital/Location			<0.001
Rural	5765 (5.28)	1842 (4.92)	
Urban non-teaching	34,051 (31.21)	11,323 (30.22)	
Urban teaching	69,300 (63.51)	24,306 (64.87)	
Income quartiles by Zip Code			0.55
1st	31,027 (28.43)	10,758 (28.71)	
2nd	26,885 (24.64)	9275 (24.75)	
3rd	25,786 (23.63)	8738 (23.32)	
4th	25,418 (23.29)	8700 (23.22)	
Mortality	25,927 (23.76)	9435 (25.18)	<0.001
Cost (mean ± SD)	24,728.35 ± 40,462.87	24122.95 ± 37,158.43	0.011
Charge (mean ± SD)	89,821.51 ± 152,359.7	88771.86 ± 147,312	0.25

* p-value based on two-sample *t*-test or Pearson's Chi-squared test.

[11]. Furthermore, the use of anticoagulation and development of novel oral anticoagulants have added another level of complexity to the management of patients with ICH. Concentrated efforts and attention have been directed at improving outcomes of stroke patients in the acute period as well as implementing primary and secondary prevention measures. To this end, the development of stroke centers and networks has promoted higher standards of stroke.

Factors that contribute to the outcomes of this patient population are multifactorial, ranging from access to care to variability in implementation of acute interventions to continued management in the post-acute setting. Over the last two decades, various studies have evaluated the impact of weekend versus weekday admission to the hospital on the inpatient mortality of diseases [12–17]. They have identified a "weekend effect", which manifests as the phenomenon that hospital admission on a weekend can significantly alter mortality rates for a given disease [13]. In this study, we sought to identify whether or not this phenomenon was true for patients with ICH admitted to United States hospitals between 2006 and 2014.

2. Patients and methods

This study analyzed data extracted from the National Inpatient Sample (NIS), which is a database within the Healthcare Cost and Utilization Project (HCUP) and sponsored by the Agency for Healthcare Research and Quality. The NIS is the largest publicly available all-payer inpatient healthcare database in the United States, representing a 20% random stratified sample of all discharges from U.S. community hospitals, excluding rehabilitation and long-term acute care hospitals and yielding national estimates of hospital inpatient stays. Using the International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9 CM) Diagnosis Code 431, we generated our cohort sample consisting of inpatients admitted with a diagnosis of non-traumatic ICH between 2006 and 2014. We included all patients who had complete data available in the NIS and excluded those who lacked complete data needed for the statistical analysis. Our institution exempted this analysis from full review by the institutional review board.

Our primary outcome measure was all-cause in-hospital mortality, defined as deaths that occurred during the initial hospitalization, on the day of admission, or on the discharge date, provided the length of stay was ≤30 days. Additionally, we attempted to correlate the introduction of specific policies and standards for acute stroke care with overall outcomes by performing subgroup analysis on HCUP data. We hypothesized that outcome measures, specifically overall 30-day mortality, should have improved with the advent of comprehensive stroke centers.

All univariate odds ratios, confidence intervals, and p-values were obtained from mixed effects linear models with adjustment for clustering within hospitals in data collected during the period from 2006 to 2014. A multivariate logistic model of in-hospital mortality in terms of age, gender, race, teaching status of hospitals, income quartile by zip code, and comorbidities was fit without model reduction and the model was validated on data collected in 2014. These variables were controlled for by using dummy variables or continuous variables, depending on the type of data, and by including them in the same comprehensive regression; this allows us to have a better sense of the direction of causality in weekend versus weekday mortality in our

cohort by accounting for common factors that may affect patient mortality in any hospital stay. Similar subgroup analysis was performed for time periods 2006 through 2009 and 2010 through 2014. We chose 2010 as transition point as we felt it reflects the culture change surrounding the advent of comprehensive stroke centers. Furthermore, rates of mortality of the patients admitted during the weekend were compared between urban teaching and urban non-teaching hospitals using a logistic regression of odds ratios to calculate a chi-squared value. All statistical testing was two-sided with a p-value of 0.05 used as a marker of statistical significance. Stata Version 15.1 for Mac was used throughout.

3. Results

Over the nine years of the study period, 146,587 total discharges with ICH were reported by the NIS. Of these discharges, 109,116 (74.4%) were admitted on a weekday and 37,471 (25.6%) were admitted during the weekend. Baseline characteristics for cohorts by weekday and weekend admission are depicted in Table 1. The weekday admission cohort was 50.6% male with a mean age of 67.1 years. Patients admitted during the weekend were more likely to have self, Medicare, or Medicaid payer status, and to be admitted to an urban teaching hospital.

There was a total of 35,362 deaths among all ICH admissions reported by the NIS between 2006 and 2014. The in-hospital mortality rate was significantly higher for weekend admissions compared to that of weekday admissions (25.2% vs. 23.8%, $p < 0.001$). Our multivariate analysis demonstrated that weekend admission alone was a statistically significant prognostic factor for mortality when compared to weekday admission (Table 1). Subgroup analysis demonstrated that in both urban non-teaching and teaching hospitals, weekend admission is associated with greater in-hospital mortality rates. Teaching hospitals, however, showed a significantly lower mortality rate for weekend admissions compared to non-teaching hospitals (Table 1, $p < .001$). A statistically significant difference between the length of stay was noted between weekday and weekend ICH admissions as well (9.28 vs 8.85 days, $p < .001$).

Subgroup analysis was performed after separating the date into two distinct time periods, 2006 through 2009 and 2010 through 2014 (Table 2). The absolute mortality rate by year demonstrates a general gradual decrease in absolute mortality rates for both weekday and weekend admissions (Fig. 1). There was a statistically significant and positive association with weekend admission and absolute mortality rates in the first half of years studied (2006–2009) in this cohort, when compared to weekday admission. Multivariate analysis of mortality for the 2006–2009 subgroup demonstrated a significantly greater odds of mortality with weekend admission (OR = 1.15, 95% CI [1.10, 1.20], $p = 0$) but not for the 2010–2014 subgroup (OR = 1.03, 95% CI [0.99, 1.07], $p = 0.09$). Further sub-analysis using multivariate regression demonstrated no statistically significant association during the first half of the cohort time period of in-hospital mortality for either urban teaching (OR = 0.98 [0.90, 1.06], $p = 0.55$) or urban non-teaching hospitals (OR = 0.98 [0.90, 1.06], $p = 0.58$) when compared to rural centers from 2006–2009. However, there was statistically significant decreased mortality in the second half of the cohort time period, from 2010 to 2014, for both urban teaching hospitals (OR = 0.83, 95% [0.77, 0.89], $p = 0$) and urban non-teaching hospitals (OR = 0.86, 95% CI [0.79. 0.93], $p = 0$), in comparison to rural hospitals (Table 2).

4. Discussion

The “weekend effect” has been a topic of considerable discussion since its inception, particularly in the areas of critical and intensive care medicine. Among the first researchers to report this phenomenon were Bell and Redelmeier, who examined admissions to emergency departments in Ontario, Canada over a 9-year period [13]. In their 2001 study, they reported “significantly higher in-hospital mortality rates” in “some serious medical conditions”, to include ruptured abdominal aortic aneurysm ($p < .001$), acute epiglottitis ($p = 0.04$), and pulmonary embolism ($p = .009$) for patients admitted during the weekend.

A number of studies have continued to examine the “weekend effect” in patients with ICH, albeit with differing conclusions. Crowley et al. [14] examined in a retrospective cohort if short-term mortality at 7, 14, and 30 days was affected by weekend admission, and found that at all three points of time, mortality was increased when patients were admitted on a weekend versus on a weekday. In this series, weekend admission was an independent predictor of mortality. Similarly, other studies have found positive associations between weekend admission for ICH and mortality rate such as Patel et al. [15] who observed the “weekend effect” for ICH admissions in a nationwide in-patient sample from 2002 to 2011. In this study, 27.5% of patients were admitted during weekend. Weekend effect was more pronounced in non-teaching hospitals compared to teaching hospitals. More recently, Nguyen et al. [16] observed the “weekend effect” for ICH admissions over a four-year

Table 2
Multivariate analysis of intracranial hemorrhage in-hospital mortality during two time periods: 2006–2009 and 2010–2014.

2006-2009				2010-2014			
	Odds Ratio	95% CI	p-value*		Odds Ratio	95% CI	p-value*
Weekend Admission	1.1463	1.0975–1.1974	0	Weekend Admission	1.0311	0.9949–1.0685	0.092
Teaching Status/Location[a]							
Urban non-teaching	0.9763	0.8973–1.0623	0.578	Urban non-teaching	0.8593	0.7971–0.9265	0
Urban teaching	0.9751	0.8975–1.0593	0.551	Urban teaching	0.8270	0.7696–0.8887	0
Race[b]							
Black	0.9271	0.8720–0.9856	0.015	Black	0.9593	0.9155–1.0052	0.082
Hispanic	0.9468	0.8830–1.0151	0.124	Hispanic	0.8740	0.8243–0.9267	0
Asian	0.9027	0.8202–0.9935	0.036	Asian	0.9284	0.8580–1.0046	0.065
Native American	0.7875	0.5940–1.0439	0.097	Native American	1.1679	0.9238–1.4766	0.194
Other	1.0446	0.9373–1.1642	0.429	Other	1.0244	0.9404–1.1159	0.579
Income Quartile by Zip Code[c]							
2nd	0.9583	0.9075–1.0119	0.125	2nd	0.9668	0.9258–1.0096	0.127
3rd	0.9384	0.8869–0.9929	0.027	3rd	0.9266	0.8862–0.9688	0.001
4rd	0.9628	0.9098–1.0189	0.19	4rd	0.8966	0.8562–0.9389	0
Age	1.0117	1.0103–1.0130	0	Age	1.0106	1.0095–1.0117	0
Female	1.0643	1.0224- 1.1079	0.002	Female	1.0833	1.0487–1.1190	0

* p-value based on two-sample *t*-test or Pearson’s Chi-squared test.
[b] base = white/Caucasian.
[c] base = 1st quartile.

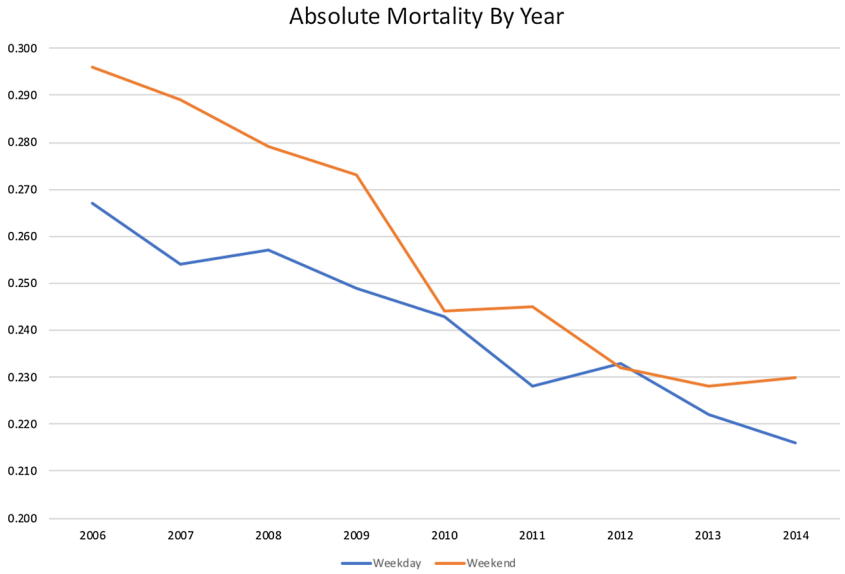

Fig. 1. 30-day In-hospital Mortality Rates in ICH patients by Year, 2006-2014.

study period from 2008 through 2011. In their multivariate analysis, admission during the weekend was associated with increased in-hospital mortality. McDowell et al. [17] studied the weekend effect in a cohort of patients with ICH in a specialized stroke center with a high volume of hospitalizations, finding no significant differences in mortality or functional results assessed by the modified Rankin at 3 months of admission. This study suggests that consideration should be given to the effects of temporality on outcome measures and the tools that are applied to determine outcome measures.

In our study, we found that from 2006 through 2014 there was overall a statistically significant increased mortality in ICH patients admitted during the weekend compared to those admitted on a weekday. Further subgroup analysis demonstrated that this statistically significant difference in mortality rates was noted from 2006 through 2009; however, from 2010 through 2014, the differences in mortality rates was not significant. The magnitude of the "weekend effect" was quite large in the period of 2006–2009, when a weekend admission for ICH corresponded to a likelihood of mortality about 15 percentage points higher than a weekday admission, when controlling for common confounding factors. Additionally, our analysis showed that there was not a significant difference in performance based on mortality rates in rural facilities compared to urban facilities between weekday and weekend admission from 2006 through 2009; however, from 2010 through 2014, the data reflected statistically worse outcome for ICH patients admitted to rural facilities compared to urban facilities. Our analysis highlights trends towards improving stroke care, specifically improvement in care provided to patients presenting on the weekend in urban facilities in more recent years. However, we still found that the absolute increase in mortality risk for weekend admissions was greater in urban non-teaching hospitals than in teaching hospitals. Rural and/or non-teaching facilities appear to lag behind their urban/teaching counterparts for patients presenting with ICH.

What contributes to the "weekend effect" on mortality? Previous studies have suggested that decreased staffing, particularly with senior medical personnel in hospitals on weekends may be the root of the problem [13,18–22]. A recent meta-analysis evaluated 16 studies collectively involving over 900,000 patients admitted to a general adult ICU and found increased mortality when patients were admitted on the weekend, a risk further enhanced by the absence of a routine overnight on-site intensivist [23]. Other studies have suggested less familiarity of staff with patients, decreased or delayed access to diagnostic procedures or services, and decreased or delayed access to interventional life-saving procedures all may play a part in the increased mortality rate associated with weekend admissions [24–29].

What can be done to diminish the "weekend effect" for patients with ICH? One answer may lie with effective utilization of Comprehensive Stroke Centers (CSCs). First discussed in 2005 by the Brain Attack Coalition, the original description of each CSC was to be able to "deliver the full spectrum of care to seriously ill patients with stroke and cerebrovascular disease" [30]. In short, CSCs were to provide 24/7 access to neuro-critical care by a multi-disciplinary team for patients with suspected or confirmed stroke. Instituting CSCs has shown promise in recent studies for mitigating the "weekend effect" on mortality rates for patients with stroke. McKinney et al. [30] examined 90-day mortality for over 130,000 patients admitted for ischemic stroke to New Jersey area hospitals that were non-stroke centers (NSCs), primary stroke centers (PSCs), or CSCs. The study found that patients continued to be subject to a "weekend effect" if admitted to NSC or PSC. However, if admitted to CSC, there was no statistically significant difference in 90-day mortality for weekend versus weekday admissions. Two other recent studies by Albright et al found a similar absence of the "weekend effect" on mortality in ischemic stroke patients admitted to CSCs [31,32]. While these studies have supported the benefits conferred by CSCs in ischemic stroke management, it remains to be seen if similar benefits will be found with ICH management. Further studies should focus on determining if admission to CSC diminishes the weekend effect on mortality for ICH patients, and if so, what specific components of a CSC contribute most to such trends.

5. Conclusions

In-hospital mortality rates were found to be significantly increased for patients with ICH when they were admitted on a weekend versus on a weekday between 2006 and 2014 in United States hospitals. This was true in both teaching and non-teaching hospitals, but to a greater extent in non-teaching hospitals. Overall there has been a trend of decreasing mortality rates for patients admitted for ICH management on both weekdays and weekends. The association between weekend admission and increased mortality was statistically significant in the subgroup of 2006 through 2009, but failed to reach significance in the 2010 through 2014 subgroup. A lack of standardization of evidence driven practices, lack of metrics for enforcing evidence base practices and lack of formal systems for managing stroke and ICH patients have contributed to this phenomenon. The lower mortality observed in the second half of the

cohort time period indirectly reflects, the advent of comprehensive stroke centers, aimed to evaluate and standardize management practices by developing a formal network for optimizing efficiency and safety of patient care. While we have seen an overall improvement in stroke mortality outcomes, there remain areas for improvement in the management of these patients.

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