Published in final edited form as:

J Stroke Cerebrovasc Dis. 2020 October ; 29(10): 105106. doi:10.1016/j.jstrokecerebrovasdis.2020.105106.

Weekend Effect on In-Hospital Mortality for Ischemic and Hemorrhagic Stroke in US Rural and Urban Hospitals

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Abstract

Introduction: Previous studies have reported a "weekend effect" on stroke mortality, whereby stroke patients admitted during weekends have a higher risk of in-hospital death than those admitted during weekdays.

Aims: We aimed to investigate whether patients with different types of stroke admitted during weekends have a higher risk of in-hospital mortality in rural and urban hospitals in the US.

Methods: We used data from the 2016 National Inpatient Sample and used logistic regression to assess in-hospital mortality for weekday and weekend admissions among stroke patients aged 18 and older by stroke type (ischemic or hemorrhagic) and rural or urban status.

Results: Crude stroke mortality was higher in weekend admissions (p <0.001). After adjusting for confounding variables, in-hospital mortality among hemorrhagic stroke patients was significantly greater (22.0%) for weekend admissions compared to weekday admissions (20.2%, p

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= 0.009). Among rural hospitals, the in-hospital mortality among hemorrhagic stroke patients was also greater among weekend admissions (36.9%) compared to weekday admissions (25.7%, p = 0.040). Among urban hospitals, the mortality of hemorrhagic stroke patients was 21.1% for weekend and 19.6% for weekday admissions (p=0.026). No weekend effect was found among ischemic stroke patients admitted to rural or urban hospitals.

Conclusions: Our results help to understand mortality differences in hemorrhagic stroke for weekend vs. weekday admissions in urban and rural hospitals. Factors such as density of care providers, stroke centers, and patient level risky behaviors associated with the weekend effect on hemorrhagic stroke mortality need further investigation to improve stroke care services and reduce weekend effect on hemorrhagic stroke mortality.

Keywords

In-hospital mortality; Weekend admission; Ischemic stroke; Hemorrhagic stroke

INTRODUCTION

In the US, about 795,000 people have a stroke each year, of which, 600,000 are first-time events.[1] The prevalence of stroke survivors during 2011–2014 was 2.7%. In 2014, an estimated 7.2 million Americans aged 20 or older self-reported a history of stroke.[1] The highest prevalence has been reported among older adults, blacks, people with low socioeconomic status, and people living in the Southeast.[1] Stroke ranks fifth among all causes of death in the US and is a leading cause of serious physical and cognitive long-term disability in adults.[1]

Stroke mortality is associated with time of patients' arrival at the hospital after experiencing a stroke and the geographic location of patients. For example, stroke mortality is 30% higher in rural than in urban counties[2]. The risk of adverse outcomes such as death or serious long-term disability is higher for stroke patients admitted to the hospital on weekends compared to weekdays, the so-called "weekend effect." A previous study argued that the latter association is due to reduction in hospital staffing on weekends[3]. Others have reported that the difference is due to patient characteristics. For example, a study of ischemic stroke hospital admissions in South Carolina based on 2012–2013 data[4] found that ischemic stroke patients admitted on weekends had higher observed stroke severity than those admitted on weekdays.

A population-based study examined potential associations of weekend admissions with in-hospital stroke mortality in Canada[5]. The authors used data from April 2003 to March 2004 from the Hospital Morbidity Database. The study found that ischemic stroke patients admitted on weekends had a higher mortality rate (8.5% vs. 7.4%), and the weekend effect was larger in rural hospitals than urban hospitals. A retrospective cohort study using a 2004 US national database found that weekend admissions for intracerebral hemorrhage were associated with a 12% higher risk-adjusted mortality than weekday admissions[6]. Many studies have examined stroke in-hospital mortality and admission day, but none to our knowledge have analyzed it by both main types of stroke—ischemic and hemorrhagic. We examined mortality among patients with ischemic or hemorrhagic stroke independently by weekend and weekday admission and by rural-urban status of the treatment hospitals.

METHODS

Data and sample

In this observational analysis, we used data from the 2016 National Inpatient Sample (NIS) collected by the Healthcare Cost Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ). The 2016 NIS is the most recent dataset available for analyses. The *International Classification of Diseases, 10th Revision, Clinical Modification* (ICD-10-CM) diagnosis and procedure codes were used for classification. We did not include data from prior years due to changes in ICD coding[7,8]. The NIS database comprises hospital inpatient stays obtained from hospital billing data. The 2016 NIS sampling frame covers more than 96% of the total hospitalizations in the US, making it the largest available hospital discharge database. It covers all patients including those enrolled in Medicare, Medicaid, and private insurance, and the uninsured population who were admitted to community hospitals. HCUP defines community hospitals to be “all non-Federal, short-term, general, and other specialty hospitals, excluding hospital units of other institutions, such as prisons.” The NIS sample was constructed annually by including 20% national patient-level sample, excluding those in inpatient rehabilitation hospitals and long-term acute care facilities, thus sampling weights were provided to generalize nationally representative estimates. This study was limited to adult patients aged 18 and older with a diagnosis of hemorrhagic (intracerebral or subarachnoid hemorrhage) or ischemic stroke. Patients discharged with a hemorrhagic stroke (sample n = 19,042; weighted N=96626) were identified using principal diagnosis ICD-10 codes I60.x and I61.x[9]. Patients discharged with ischemic stroke (sample n = 101,683; weighted N=507,288) were identified using principal diagnosis ICD-10 codes: I63.x[9].

Variable Selection

Our outcome measure was in-hospital mortality, a binary variable meaning the patient died during the hospitalization. The primary predictor variable was admission day. This binary variable is coded 1 for Saturday or Sunday admissions and 0 for Monday through Friday admissions. The secondary predictor variable was rural-urban status of the hospital. We followed definitions provided by the American Hospital Association, that a Metropolitan Statistical Area (MSA) is considered urban and a non-MSA is considered rural[10].

Confounding variables were age, sex, race/ethnicity, neighborhood median household income[11], payers[12], calendar quarter of discharge[13], number of comorbidities[14], hospital’s location (rural or urban)[15], hospital teaching status[16,17], and bed size[16–18]. We divided age groups into 18–44, 45–64, 65–74, and 75 and older. Race was defined as non-Hispanic white, non- Hispanic black, Hispanic, and non-Hispanic other, which included Asians, Pacific Islanders and American Indians/Alaska Natives. Neighborhood median household income quartiles were based on the 2016 NIS income ranges: $1-$39,000, $40,000-$50,999, $51,000-$65,999, and $66,000 or above. Payers were categorized as Medicare, Medicaid, private insurance, and other, which included self-pay. We analyzed the discharge season in four quarters: January–March, April– June, July–September, and October–December. Number of comorbidities was estimated by the Charlson Comorbidity Index and categorized into two groups: with 1 comorbidity and 2 or more comorbidities. Location and teaching status are binary variables: urban and rural for locations and teaching and non-teaching for teaching status. Hospital size was categorized as small, medium, and large by number of beds depending on hospitals' rural/urban location, region and teaching status.[19]

Statistical Analysis

Since the percentage of missing values in all variables were below 1%, we ran the analyses using the complete sample by dropping all missing values. We compared the selected stroke cases identified using the ICD-10 codes with the ones using HCUPNet recommended coding instructions (https://hcupnet.ahrq.gov/#setup) and found the two numbers were identical. We first examined statistical significance of our sample characteristics for weekday versus weekend admission and stroke mortality by the patient and hospital factors using Pearson Chi-Square test (χ^2). Then, we performed logistic regression for in-hospital mortality between weekday and weekend admissions among adult stroke patients, adjusting for types of stroke (ischemic or hemorrhagic stroke), sex, race/ethnicity, neighborhood median household income, payers, calendar quarter of discharge, number of comorbidities, hospital's location, hospital teaching status, rural-urban status and bed size. These confounding variables were chosen based on existing literature that shows differences in in-hospital mortality by patient, neighborhood, and hospital characteristics[20]. In the regression, we use age as a continuous measure and create an age-squared term to account for the nonlinear relationship between age and mortality. A 2014 study that used admission diagnosis of an acute injury demonstrated a nonlinear relationship between age and mortality and existence of an inflection point (about 84 years old)[21]. We further performed logistic regressions among patients with ischemic stroke and those with hemorrhagic stroke separately, as well as patients admitted to rural hospitals and those admitted to urban hospitals separately, adjusting for the aforementioned confounding variables. All analyses were done using weighted data. We used Stata SE 14 for all statistical analyses (StataCorp, College Station, TX).

RESULTS

Table 1 shows sample characteristics by weekday versus weekend admissions and stroke mortality. Patients aged 75 and older accounted for 40.6% of the deaths. Approximately half of all admissions and deaths were among females. Household income did not differ by weekday admission nor by in hospital mortality. The most common payer for stroke was Medicare followed by private insurance. Over 90% of patients were admitted to an urban hospital (Table 1). About 76% of admissions were to non-teaching hospitals, and 76% of stroke-related deaths were observed in non-teaching hospitals. Over half of admissions were to hospitals with at least 75 beds based on hospital location and teaching status (Table 1).

Adjusted analyses showed that all stroke mortality was greater on weekend vs. weekday admission (6.2% vs. 5.8%, p = 0.004). Adjusted analyses also showed the mortality for hemorrhagic stroke was greater for weekend than weekday admission (22.0% vs. 20.2%, p =

0.009), whereas mortality for ischemic stroke admission didn't differ by weekend vs. weekday admission (Table 2). Mortality for weekend admission for hemorrhagic stroke was greater in rural hospitals vs. urban hospitals (36.92% vs. 21.11%) but not for ischemic stroke admission (Table 3).

DISCUSSION

Previous studies have reported higher mortality on weekend admissions for cancer, pulmonary embolism, and stroke[22]. This "weekend effect" could be due to different staffing approaches on weekends than on weekdays[14]. Another study suggested that differences in resources, expertise, and availability of hospital staff on weekends contribute to excess weekend mortality[5]. A 2006 national telephone survey of a random sample of rural hospitals in the U.S. with 100 or fewer beds found that hospitals were more likely to use a combination of medical staff and contracted professionals on evenings and weekends to cover their emergency departments[23]. Emergency department errors associated with temporary staff have been found to be more harmful than those associated with permanent staff (including life-threatening errors)[24], though there was no documented linkage between stroke mortality and staffing with contracted professionals. Patients discharged on the weekends were significantly less likely to receive stroke education and weight reduction counseling suggesting that the quality of care may be compromised on weekends for both stroke types[25]. To our knowledge, our study is the first to examine the weekend effect on stroke mortality by stroke type and urban-rural status of the hospital. We found that ischemic stroke mortality was not significantly higher for weekend admissions after adjustment for confounding variables, which differs from previous literature[26]. However, mortality was significantly higher for patients with hemorrhagic stroke admitted during weekends compared to weekdays. This pattern among hemorrhagic patients was also identified by a Swedish study reporting excess mortality on weekends among hemorrhagic stroke patients[27]. In the present study, we further identified that this weekend effect among hemorrhagic stroke patients was greater in rural compared to urban hospitals. The different pattern between ischemic stroke patients and hemorrhagic stroke patients could result from the fact that the hemorrhagic stroke patients typically have significantly worse outcomes (especially during the early days after the stroke symptom onset)[28] and thus hemorrhagic stroke patients could be more of a challenge to the weekend shift that might receive less support from specialists[29].

The rural-urban disparity in hemorrhagic stroke mortality may be attributed to differences in patient characteristics and risk factors, for example higher prevalence of smoking, hypertension and obesity in rural areas[30]. Furthermore, there are also fewer primary and comprehensive stroke centers (PSCs) in rural areas[31], as well as a national shortfall in the number of neurologists, especially vascular neurologists, and the problem is more prevalent in rural areas[32]. Moreover, rural residents are also less likely to have access to health insurance, access to certified stroke centers and stroke medications, and limited rural health infrastructure could cause increased travel time for patients[33]. A study showed that tissue plasminogen activator (tPA) utilization growth rate was quadrupled from 2001 to 2010 in urban hospitals compared to rural hospitals[33]. However, a retrospective study of patients experiencing acute ischemic stroke found that they were more likely to receive tissue plasminogen activator on weekends than on weekdays.

We did not find an association in ischemic stroke patients between admission day and mortality or by rural-urban status. A Canadian study based on 2003–2004 data[5] and a study of ischemic stroke patients in South Carolina using 2012–2013 data[4] found that ischemic stroke patients admitted on weekends had higher risk-adjusted mortality than those admitted on weekdays. One possible explanation for the difference between our finding using the 2016 NIS data from the US and these previous findings could be that earlier studies were conducted prior to more recent quality improvement efforts for acute stroke care. The present study used data approximately 10 years after modern quality improvement efforts in stroke care began. In addition, prior literature studied the weekend effect in certain local regions or states or in other countries,[34] whereas our study assessed the effect in the US nationally. Some regions, especially regions with a lower mortality, may do better than other regions in weekday care,[17] which could have masked the rural-urban differences and thus our study did not show significant gaps nationwide. The difference in weekend effect between ischemic and hemorrhagic stroke patients could also be due in part to the difference in treatments between stroke types. Specifically, hemorrhagic strokes have high rates of early neurological deterioration and thus early interventional or surgical treatment is often needed[35]. Patients with hemorrhagic stroke require more resources to treat effectively[36] due to higher baseline stroke severity, longer hospitalization stays, lower independence rates at discharge and higher mortality rates during the hospitalization. These challenges may be even more difficult to address at lower-resourced rural hospitals. Rural areas may be lacking access to stroke centers that are capable of providing neurosurgical, neurointerventional, and neurocritical care services especially for hemorrhagic stroke patients[37]. Therefore, as was found in this study, hemorrhagic stroke patients might be more vulnerable to risk of death posed by a weekend admission if they were admitted in a rural hospital.

This study had several limitations. First, this is a cross-sectional analysis, so we cannot infer cause and effect. Second, demographic and mortality data were taken from available medical records and data errors are possible. Third, the possibility of underreported comorbid conditions and other relevant confounders cannot be excluded. Fourth, because of limited sample size, we were unable to stratify the hemorrhagic stroke patients by intracerebral hemorrhage and subarachnoid hemorrhage and analyze them separately. Finally, our analysis did not include measures on stroke severity, time from stroke onset to hospital admission, status of hospital certification for acute stroke care, nor could we observe intra-hospital transfers. Some of the factors that our study could not account for might also affect outcomes and vary by day of admission ("omitted variable bias"[38]), such as case transfers from a rural hospital to a high-volume medical center[39].

CONCLUSIONS

We found that hemorrhagic stroke patients admitted on weekends had a significantly higher in-hospital mortality than those admitted on weekdays, particularly in rural hospitals. Our study adjusted for patient characteristics such as sex, age, and race, comorbidities, and hospital characteristics such as hospital's location, teaching status, and bed size. However, factors such as patient-level behavioral risks, availability of care providers, and stroke care centers associated with stroke mortality that we were unable to account for in this study could be investigated in future studies to inform hemorrhagic stroke care services and stroke systems of care, particularly in rural regions.

ACKNOWLEDGEMENTS

BM analyzed the data and completed the first draft of the manuscript; GW critically reviewed and revised the manuscript; JT critically reviewed and revised the manuscript; LS conceptualized the study and provided guidance for the data analysis; KT initiated the descriptive analysis; ZZ assisted in interpreting the results and critically revised the manuscript; DZ obtained the data, designed the study, interpreted the results, edited and critically revised the manuscript. All authors approved the submitted version of the manuscript.

SOURCES OF FUNDING

Financial Disclosures: The study was partly funded by a National Institute on Minority Health and Health Disparity R01 grant (No. R01MD013886). The funding agreement ensured the authors' independence in designing the study, interpreting the data, writing, and publishing the report. Donglan Zhang is the PI of the grant.

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Table 1.

Sample Characteristics by Weekday versus Weekend Admission and Stroke Mortality for patients with Ischemic or Hemorrhagic stroke, National Inpatient Sample 2016 (n = 120,664; weighted N=603,125)

Variable	Weekday Admission[a]	Weekend Admission	P-value	Died	Alive	P-value
Age Group			0.077			<0.001
18–44	30578 (5.07%)	31785 (5.27%)		31182 (5.17%)	27382 (4.54%)	
45–64	182144 (30.20%)	178163 (29.54%)		183772 (30.47%)	144569 (23.97%)	
65–74	142277 (23.59%)	141734 (23.50%)		143363 (23.77%)	125269 (20.77%)	
75+	248186 (41.15%)	251503 (41.70%)		244808 (40.59%)	305965 (50.73%)	
Sex			0.196			<0.001
Male	297703 (49.36%)	295109 (48.93%)		298306 (49.46%)	279187 (46.29%)	
Female	305423 (50.64%)	308016 (51.07%)		304819 (50.54%)	323938 (53.71%)	
Race			0.899			<0.001
NH White	412176 (68.34%)	412357 (68.37%)		411874 (68.29%)	417121 (69.16%)	
NH Black	102109 (16.93%)	101325 (16.80%)		103315 (17.13%)	82387 (13.66%)	
Hispanic	49215 (8.16%)	49939 (8.28%)		49034 (8.13%)	54945 (9.11%)	
Other	39625 (6.57%)	39505 (6.55%)		38962 (6.46%)	48612 (8.06%)	
Household Income Quartiles			0.680			0.164
$1–39,999	187150 (31.03%)	185521 (30.76%)		186908 (30.99%)	185099 (30.69%)	
$40,000–50,999	153073 (25.38%)	154400 (25.60%)		153797 (25.50%)	148369 (24.60%)	
$51,000–65,999	144569 (23.97%)	145655 (24.15%)		144629 (23.98%)	148308 (24.59%)	
$66,000+	118333 (19.62%)	117489 (19.48%)		117790 (19.53%)	121349 (20.12%)	
Payers			0.090			<0.001
Medicare	383829 (63.64%)	386905 (64.15%)		384311 (63.72%)	389498 (64.58%)	
Medicaid	57478 (9.53%)	58262 (9.66%)		57960 (9.61%)	53316 (8.84%)	
Private insurance	121288 (20.11%)	117248 (19.44%)		121168 (20.09%)	107236 (17.78%)	
Other	40590 (6.73%)	40711 (6.75%)		39686 (6.58%)	53075 (8.80%)	
Discharge Quarter			0.428			<0.001
Jan – Mar	150902 (25.02%)	151023 (25.04%)		150419 (24.94%)	159044 (26.37%)	

Variable	Weekday Admission[a]	Weekend Admission	P-value	Died	Alive	P-value
Apr - Jun	149756 (24.83%)	152349 (25.26%)		150480 (24.95%)	150299 (24.92%)	
July - Sep	149575 (24.80%)	147826 (24.51%)		150058 (24.88%)	137211 (22.75%)	
Oct - Dec	152892 (25.35%)	151927 (25.19%)		152168 (25.23%)	156571 (25.96%)	
Comorbidities			0.241			<0.001
1	107839 (17.88%)	106029 (17.58%)		106210 (17.61%)	123098 (20.41%)	
2+	495286 (82.12%)	497096 (82.42%)		496915 (82.39%)	480027 (79.59%)	
Location			<0.001			<0.001
Urban	558433 (92.59%)	562716 (93.30%)		558795 (92.65%)	569048 (94.35%)	
Rural	44692 (7.41%)	40409 (6.70%)		44330 (7.35%)	34077 (5.65%)	
Teaching Status			0.487			<0.001
Yes	143845 (23.85%)	142699 (23.66%)		146378 (24.27%)	104099 (17.26%)	
No	459280 (76.15%)	460426 (76.34%)		456747 (75.73%)	499026 (82.74%)	
Hospital Bed Size[b]			<0.001			<0.001
Small	88961 (14.75%)	86368 (14.32%)		90167 (14.95%)	64052 (10.62%)	
Medium	170564 (28.28%)	164231 (27.23%)		170202 (28.22%)	153314 (25.42%)	
Large	343600 (56.97%)	352527 (58.45%)		342756 (56.83%)	385759 (63.96%)	

Note: P-values were calculated using Chi-square tests. All statistics were adjusted using sampling weights.

[a.] Results were presented as weighted N (%).

[b.] Defined based on location (rural, urban, Northeast region, Midwest region, South region, and West region) and teaching status (nonteaching, teaching) of the hospital. Northeast region – Rural: Small (1–49); Medium (50–99) and Large (100+); Urban, nonteaching: Small (1–124); Medium (125–199) and Large (200+); Urban, teaching: Small (1–249); Medium (250–424) and Large (425+). Midwest region – Rural: Small (1–29); Medium (30–49) and Large (50+); Urban, nonteaching: Small (1–74); Medium (75–174) and Large (175+); Urban, teaching: Small (1–249); Medium (250–374) and Large (375+). Southern region – Rural: Small (1–39); Medium (40–74) and Large (75+); Urban, nonteaching: Small (1–99); Medium (100–199) and Large (200+); Urban, teaching: Small (1–249); Medium (250–449) and Large (450+). Western region – Rural: Small (1–24); Medium (25–44) and Large (45+); Urban, nonteaching: Small (1–99); Medium (100–174) and Large (175+); Urban, teaching: Small (1–199); Medium (200–324) and Large (325+).

Table 2:

In-Hospital Mortality between Weekday and Weekend Admissions Among Adult Stroke Patients by Types of Stroke, National Inpatient Sample 2016 (n = 120,664; weighted N=603,125)

In-hospital mortality	Weekday admissions[a]	Weekend admissions	P-value
Unadjusted	40771 (6.76%)	44330 (7.35%)	<0.001
Adjusted[b]	34981 (5.80%)	37575 (6.23%)	0.004
Unadjusted ischemic	24969 (4.14%)	25573 (4.24%)	0.471
Adjusted ischemic[b]	13993 (2.32%)	13932 (2.31%)	0.897
Unadjusted hemorrhagic	127561 (21.15%)	137090 (22.73%)	0.018
Adjusted hemorrhagic[b]	121831 (20.20%)	132627 (21.99%)	0.009

Note: P-values were calculated using Chi-square tests. All statistics were adjusted using sampling weights.

[a.]Results were presented as weighted N (%).

[b.]Models adjusted for patients' age, sex, race/ethnicity, neighborhood median household income, payers, discharge quarter, number of comorbidities, hospital location, hospital teaching status and hospital bed size. Marginal probabilities were estimated from the logit regression model and converted from odds ratios.

Table 3:

In-Hospital Mortality between Weekday and Weekend Admissions Among Adult Stroke Patients by Rural – Urban Status, National Inpatient Sample 2016 (n = 120,664; weighted N=603,125)

	Rural			Urban		
In-hospital mortality	**Weekday admissions**[a]	**Weekend admissions**	**P-value**	**Weekday admissions**	**Weekend admissions**	**P-value**
Unadjusted	31121 (5.16%)	37213 (6.17%)	0.077	41555 (6.89%)	44812 (7.43%)	0.002
Adjusted[b]	12364 (2.05%)	14656 (2.43%)	0.127	36610 (6.07%)	39083 (6.48%)	0.010
Unadjusted ischemic	22738 (3.77%)	23884 (3.96%)	0.700	25150 (4.17%)	25693 (4.26%)	0.534
Adjusted ischemic[b]	9771 (1.62%)	9771 (1.62%)	0.992	14415 (2.39%)	14354 (2.38%)	0.876
Unadjusted hemorrhagic	166764 (27.65%)	233048 (38.64%)	0.018	126415 (20.96%)	134557 (22.31%)	0.045
Adjusted hemorrhagic[b]	154762 (25.66%)	222674 (36.92%)	0.040	118273 (19.61%)	127320 (21.11%)	0.026

Note: P-values were calculated using Chi-square tests. All statistics were adjusted using sampling weights.

[a.] Results were presented as weighted N (%).

[b.] Models adjusted for patients' age, sex, race/ethnicity, neighborhood median household income, payers, discharge quarter, number of comorbidities, hospital location, hospital teaching status and hospital bed size. Marginal probabilities were estimated from the logit regression model and converted from odds ratios.