Impact of Weekend Admission on In-Hospital Outcomes of Endovascular Therapy for Acute Ischemic Stroke

NIS Analysis for the RCOP Match Mentorship Program

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## Preamble:

* **Reference Studies:**
  + [Kalra et al., 2024](https://doi.org/10.1016/j.xjon.2024.02.005)
* **Study Objective:** To evaluate the association between weekend admission and in-hospital outcomes among adult patients hospitalized with acute ischemic stroke (AIS) who underwent endovascular thrombectomy (EVT). The goal is to assess whether care on weekends is associated with worse clinical outcomes, complications, or resource utilization in this time-sensitive patient population.
* **Data Source:** A retrospective cross-sectional study using the National Inpatient Sample (NIS), years 2018–2020. The NIS, developed as part of the Healthcare Cost and Utilization Project (HCUP), provides a stratified, nationally representative sample of U.S. inpatient discharges across all payers and regions.
* **Cohort Definition:** Hospitalizations were included if they met the following criteria
  + Age ≥18 years
  + Principal diagnosis of acute ischemic stroke (AIS), defined using ICD-10-CM codes I63.x
  + Underwent endovascular thrombectomy, identified using ICD-10-PCS codes matching the regular expression 03C[A-Z]3ZZ, which captures mechanical clot removal from intracranial, carotid, vertebral, or basilar arteries via percutaneous approach
  + Non-missing values for admission timing
* **Exposure of Interest:** Weekend admission, categorizing admissions as Saturday–Sunday (weekend) vs. Monday–Friday (weekday).
* **Outcomes of Interest:**
  + **Primary Outcome:**
    - In-hospital mortality
  + **Secondary Outcomes:**
    - Length of stay (LOS), in days
    - Inflation-adjusted total hospital charges (in 2020 USD)
    - Mechanical ventilation use
    - Incidence of secondary intracranial hemorrhage (ICH)
    - Favorable discharge (discharge to home or home health)
* **Outcome Definitions (ICD-10-CM and ICD-10-PCS):**
  + Acute Ischemic Stroke (AIS):
    - ICD-10-CM codes: I63.x (all subtypes of cerebral infarction)
  + Endovascular Thrombectomy (EVT):
    - ICD-10-PCS codes matching: 03C[GHJKLMN]3ZZ (extirpation of cerebral artery via percutaneous approach)
  + Mechanical Ventilation:
    - ICD-10-PCS codes: 5A09B5K, 5A09C5K, 5A09D5K, 5A1935Z, 5A1945Z, 5A1955Z
  + Intracranial Hemorrhage (ICH):
    - ICD-10-CM codes: I61.x (nontraumatic intracerebral hemorrhage), I62.x (other nontraumatic hemorrhages)
    - **Note:** I60.x (subarachnoid hemorrhage) was **excluded** to focus on secondary bleeding events more commonly associated with EVT
  + Favorable Discharge:
    - Derived from DISPUNIFORM values:
      * "Routine discharge to home/self-care"
      * "Home health care"
    - All other dispositions were classified as unfavorable.
* **Covariates for Adjustment:** All models adjusted for the following
  + **Demographic Factors:** Age (continuous), sex, race/ethnicity
  + **Socioeconomic Factors:** Primary payer, ZIP code–based income quartile
  + **Clinical Factors:** Elixhauser comorbidity index, thrombolytic drugs given
  + **Hospital-Level Factors:** Hospital region, bed size, and teaching status
* **Statistical Methods:**
  + **Univariable Analysis:**
    - Categorical variables: Compared using Pearson’s chi-square test with Rao & Scott adjustment
    - Continuous variables: Analyzed using the design-based Kruskal–Wallis test, a non-parametric alternative suitable for survey-weighted data
  + **Multivariable Analysis:**
    - Binary outcomes (e.g., mortality, MV, ICH, discharge): Survey-weighted logistic regression using the quasibinomial family
    - Continuous outcomes (e.g., LOS, hospital charges): Survey-weighted linear regression using the gaussian family
    - Results reported as adjusted odds ratios (aORs) or beta coefficients with 95% confidence intervals
* **Software:** All statistical analyses were performed using the R Statistical Language (Version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria), incorporating survey-weighted procedures via the *survey* package to account for the complex sampling design of NIS.

## Baseline table:

| **Characteristic** | **Overall** N = 61,955*1* | **Monday-Friday** N = 45,105*1* | **Saturday-Sunday** N = 16,850*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age, y | 69 (15) | 69 (14) | 69 (15) | 0.3 |
| Sex |  |  |  | >0.9 |
| Female | 30,830 (50%) | 22,435 (50%) | 8,395 (50%) |  |
| Male | 31,120 (50%) | 22,665 (50%) | 8,455 (50%) |  |
| Race |  |  |  | 0.5 |
| White | 41,605 (70%) | 30,385 (70%) | 11,220 (69%) |  |
| Asian or Pacific Islander | 1,960 (3.3%) | 1,355 (3.1%) | 605 (3.7%) |  |
| Black | 9,030 (15%) | 6,510 (15%) | 2,520 (16%) |  |
| Hispanic | 4,720 (7.9%) | 3,450 (8.0%) | 1,270 (7.8%) |  |
| Other | 2,155 (3.6%) | 1,585 (3.7%) | 570 (3.5%) |  |
| Thrombolytic drugs given | 17,745 (29%) | 12,840 (28%) | 4,905 (29%) | 0.5 |
| Insurance payer |  |  |  | 0.3 |
| Medicaid | 6,245 (10%) | 4,410 (9.8%) | 1,835 (11%) |  |
| Medicare | 37,830 (61%) | 27,670 (61%) | 10,160 (60%) |  |
| Other | 4,075 (6.6%) | 2,955 (6.6%) | 1,120 (6.7%) |  |
| Private | 13,710 (22%) | 9,995 (22%) | 3,715 (22%) |  |
| Income quartile |  |  |  | 0.8 |
| $1 - $51,999 | 17,480 (29%) | 12,745 (29%) | 4,735 (29%) |  |
| $52,000 - $65,999 | 16,120 (26%) | 11,635 (26%) | 4,485 (27%) |  |
| $66,000 - $87,999 | 14,830 (24%) | 10,810 (24%) | 4,020 (24%) |  |
| $88,000 or more | 12,505 (21%) | 9,190 (21%) | 3,315 (20%) |  |
| Hospital region |  |  |  | 0.6 |
| Midwest | 12,590 (20%) | 9,225 (20%) | 3,365 (20%) |  |
| Northeast | 9,380 (15%) | 6,915 (15%) | 2,465 (15%) |  |
| South | 26,370 (43%) | 19,105 (42%) | 7,265 (43%) |  |
| West | 13,615 (22%) | 9,860 (22%) | 3,755 (22%) |  |
| Hospital bedsize |  |  |  | 0.5 |
| Large | 45,035 (73%) | 32,755 (73%) | 12,280 (73%) |  |
| Medium | 12,960 (21%) | 9,405 (21%) | 3,555 (21%) |  |
| Small | 3,960 (6.4%) | 2,945 (6.5%) | 1,015 (6.0%) |  |
| Hospital location/teaching status |  |  |  | 0.3 |
| Rural | 180 (0.3%) | 145 (0.3%) | 35 (0.2%) |  |
| Urban, non-teaching | 4,620 (7.5%) | 3,295 (7.3%) | 1,325 (7.9%) |  |
| Urban, teaching | 57,155 (92%) | 41,665 (92%) | 15,490 (92%) |  |
| No. of comorbidities |  |  |  | >0.9 |
| One comorbidity | 3,695 (6.0%) | 2,690 (6.0%) | 1,005 (6.0%) |  |
| Two or more comorbidities | 58,260 (94%) | 42,415 (94%) | 15,845 (94%) |  |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

## Univariable analysis:

| **Characteristic** | **Overall** N = 61,955*1* | **Monday-Friday** N = 45,105*1* | **Saturday-Sunday** N = 16,850*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| In-hospital mortality | 7,175 (12%) | 5,235 (12%) | 1,940 (12%) | 0.9 |
| Length of stay (days) | 6 (3, 10) | 6 (3, 10) | 5 (3, 10) | 0.3 |
| Inflation-adjusted total charge ($) | 157,360 (101,758, 250,491) | 157,137 (101,896, 250,498) | 158,470 (101,405, 250,348) | 0.9 |
| Mechanical ventilation use | 15,435 (25%) | 11,215 (25%) | 4,220 (25%) | 0.8 |
| Secondary intracranial hemorrhage | 12,025 (19%) | 8,660 (19%) | 3,365 (20%) | 0.3 |
| Favorable discharge | 19,380 (31%) | 14,195 (31%) | 5,185 (31%) | 0.5 |
| *1*n (%); Median (Q1, Q3) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; Design-based KruskalWallis test | | | | |

## Multivariable logistic regression:

### In-hospital mortality:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Weekend admission |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 0.99 | 0.87, 1.12 | 0.9 |
| Age, y | 1.02 | 1.02, 1.03 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.23 | 1.09, 1.38 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.75 | 0.52, 1.09 | 0.14 |
| Black | 0.86 | 0.71, 1.04 | 0.12 |
| Hispanic | 0.87 | 0.69, 1.09 | 0.2 |
| Other | 0.97 | 0.71, 1.32 | 0.9 |
| Thrombolytic drugs given |  |  |  |
| No | — | — |  |
| Yes | 0.85 | 0.74, 0.97 | 0.013 |
| Insurance payer |  |  |  |
| Medicaid | — | — |  |
| Medicare | 0.85 | 0.66, 1.08 | 0.2 |
| Other | 1.12 | 0.84, 1.50 | 0.4 |
| Private | 0.76 | 0.59, 0.97 | 0.027 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.93 | 0.80, 1.09 | 0.4 |
| $66,000 - $87,999 | 0.84 | 0.72, 0.99 | 0.038 |
| $88,000 or more | 0.78 | 0.66, 0.94 | 0.007 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.12 | 0.91, 1.37 | 0.3 |
| South | 0.95 | 0.80, 1.12 | 0.5 |
| West | 1.04 | 0.85, 1.26 | 0.7 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.99 | 0.85, 1.15 | 0.8 |
| Small | 0.92 | 0.72, 1.18 | 0.5 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.01 | 0.27, 3.74 | >0.9 |
| Urban, teaching | 0.86 | 0.23, 3.17 | 0.8 |
| Elixhauser comorbidity index | 1.02 | 1.00, 1.05 | 0.080 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Mechanical ventilation:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Weekend admission |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.01 | 0.92, 1.11 | 0.9 |
| Age, y | 0.99 | 0.99, 1.00 | 0.002 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.16 | 1.07, 1.26 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.03 | 0.81, 1.30 | 0.8 |
| Black | 1.15 | 1.01, 1.31 | 0.034 |
| Hispanic | 1.33 | 1.13, 1.56 | <0.001 |
| Other | 1.35 | 1.08, 1.70 | 0.009 |
| Thrombolytic drugs given |  |  |  |
| No | — | — |  |
| Yes | 0.98 | 0.89, 1.08 | 0.7 |
| Insurance payer |  |  |  |
| Medicaid | — | — |  |
| Medicare | 0.91 | 0.77, 1.07 | 0.2 |
| Other | 0.86 | 0.70, 1.06 | 0.2 |
| Private | 0.80 | 0.69, 0.94 | 0.007 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.84 | 0.74, 0.95 | 0.004 |
| $66,000 - $87,999 | 0.81 | 0.71, 0.92 | <0.001 |
| $88,000 or more | 0.76 | 0.66, 0.88 | <0.001 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.96 | 0.80, 1.14 | 0.6 |
| South | 1.16 | 1.00, 1.35 | 0.045 |
| West | 1.33 | 1.12, 1.59 | 0.001 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.95 | 0.83, 1.09 | 0.5 |
| Small | 1.16 | 0.93, 1.45 | 0.2 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.41 | 0.21, 0.79 | 0.008 |
| Urban, teaching | 0.51 | 0.27, 0.98 | 0.043 |
| Elixhauser comorbidity index | 1.13 | 1.10, 1.16 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Intracranial hemorrhage:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Weekend admission |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.04 | 0.94, 1.15 | 0.4 |
| Age, y | 1.00 | 0.99, 1.00 | 0.4 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.10 | 1.00, 1.21 | 0.047 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.99 | 0.76, 1.28 | >0.9 |
| Black | 0.86 | 0.75, 1.00 | 0.046 |
| Hispanic | 1.17 | 0.98, 1.39 | 0.078 |
| Other | 0.97 | 0.75, 1.24 | 0.8 |
| Thrombolytic drugs given |  |  |  |
| No | — | — |  |
| Yes | 0.97 | 0.88, 1.08 | 0.6 |
| Insurance payer |  |  |  |
| Medicaid | — | — |  |
| Medicare | 1.02 | 0.85, 1.23 | 0.8 |
| Other | 0.96 | 0.76, 1.23 | 0.8 |
| Private | 1.02 | 0.85, 1.22 | 0.8 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.89 | 0.78, 1.01 | 0.061 |
| $66,000 - $87,999 | 0.90 | 0.79, 1.02 | 0.10 |
| $88,000 or more | 0.89 | 0.77, 1.03 | 0.13 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.42 | 1.20, 1.68 | <0.001 |
| South | 1.00 | 0.87, 1.17 | >0.9 |
| West | 1.01 | 0.85, 1.20 | 0.9 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 1.08 | 0.96, 1.21 | 0.2 |
| Small | 0.85 | 0.69, 1.05 | 0.14 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.73 | 0.32, 1.63 | 0.4 |
| Urban, teaching | 0.81 | 0.37, 1.79 | 0.6 |
| Elixhauser comorbidity index | 1.05 | 1.03, 1.07 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Favorable discharge:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Weekend admission |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 0.95 | 0.87, 1.04 | 0.3 |
| Age, y | 0.98 | 0.97, 0.98 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.97 | 0.89, 1.05 | 0.5 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.20 | 0.96, 1.51 | 0.12 |
| Black | 0.89 | 0.79, 1.01 | 0.063 |
| Hispanic | 1.03 | 0.88, 1.22 | 0.7 |
| Other | 0.99 | 0.79, 1.22 | 0.9 |
| Thrombolytic drugs given |  |  |  |
| No | — | — |  |
| Yes | 1.28 | 1.17, 1.40 | <0.001 |
| Insurance payer |  |  |  |
| Medicaid | — | — |  |
| Medicare | 0.85 | 0.72, 1.01 | 0.069 |
| Other | 1.60 | 1.31, 1.95 | <0.001 |
| Private | 1.03 | 0.88, 1.21 | 0.7 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 1.13 | 1.00, 1.26 | 0.042 |
| $66,000 - $87,999 | 1.14 | 1.01, 1.28 | 0.035 |
| $88,000 or more | 1.10 | 0.96, 1.25 | 0.2 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.81 | 0.70, 0.95 | 0.010 |
| South | 1.19 | 1.05, 1.34 | 0.005 |
| West | 1.09 | 0.95, 1.26 | 0.2 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.99 | 0.89, 1.11 | 0.9 |
| Small | 0.81 | 0.67, 0.98 | 0.031 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.82 | 0.40, 1.69 | 0.6 |
| Urban, teaching | 0.97 | 0.48, 1.95 | >0.9 |
| Elixhauser comorbidity index | 0.90 | 0.88, 0.92 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

## Multivariable linear regression:

### Length of Stay:

| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Weekend admission |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | -0.16 | -0.52, 0.19 | 0.4 |
| Age, y | -0.03 | -0.05, -0.02 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.82 | 0.47, 1.2 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.0 | 0.09, 1.9 | 0.032 |
| Black | 2.1 | 1.5, 2.7 | <0.001 |
| Hispanic | 1.5 | 0.65, 2.4 | <0.001 |
| Other | 2.5 | 1.2, 3.8 | <0.001 |
| Thrombolytic drugs given |  |  |  |
| No | — | — |  |
| Yes | -0.65 | -1.0, -0.29 | <0.001 |
| Insurance payer |  |  |  |
| Medicaid | — | — |  |
| Medicare | -4.5 | -5.7, -3.3 | <0.001 |
| Other | -3.6 | -5.0, -2.2 | <0.001 |
| Private | -4.7 | -5.9, -3.4 | <0.001 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | -0.03 | -0.55, 0.49 | >0.9 |
| $66,000 - $87,999 | -0.28 | -0.75, 0.19 | 0.2 |
| $88,000 or more | -0.40 | -0.91, 0.11 | 0.12 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 2.0 | 1.3, 2.7 | <0.001 |
| South | 0.92 | 0.48, 1.4 | <0.001 |
| West | 0.01 | -0.50, 0.52 | >0.9 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | -0.53 | -0.98, -0.09 | 0.019 |
| Small | -0.37 | -1.2, 0.46 | 0.4 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | -0.57 | -2.6, 1.5 | 0.6 |
| Urban, teaching | -0.31 | -2.3, 1.6 | 0.8 |
| Elixhauser comorbidity index | 0.85 | 0.75, 0.95 | <0.001 |
| Abbreviation: CI = Confidence Interval | | | |

### Inflation-adjusted total charge:

| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Weekend admission |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 286 | -6,747, 7,320 | >0.9 |
| Age, y | -873 | -1,242, -504 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 18,018 | 11,148, 24,887 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 11,406 | -11,599, 34,412 | 0.3 |
| Black | 27,308 | 14,467, 40,150 | <0.001 |
| Hispanic | 59,300 | 38,860, 79,739 | <0.001 |
| Other | 61,315 | 32,460, 90,171 | <0.001 |
| Thrombolytic drugs given |  |  |  |
| No | — | — |  |
| Yes | 26,140 | 18,082, 34,198 | <0.001 |
| Insurance payer |  |  |  |
| Medicaid | — | — |  |
| Medicare | -40,087 | -58,383, -21,790 | <0.001 |
| Other | -41,723 | -62,955, -20,491 | <0.001 |
| Private | -33,163 | -51,044, -15,282 | <0.001 |
| Income quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | -4,893 | -14,262, 4,476 | 0.3 |
| $66,000 - $87,999 | -3,864 | -14,986, 7,258 | 0.5 |
| $88,000 or more | 567 | -13,706, 14,840 | >0.9 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 70,395 | 50,005, 90,784 | <0.001 |
| South | 34,187 | 22,678, 45,697 | <0.001 |
| West | 98,984 | 81,297, 116,671 | <0.001 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 14,251 | -962, 29,463 | 0.066 |
| Small | 36,129 | 6,975, 65,282 | 0.015 |
| Hospital location/teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 85,183 | 42,803, 127,563 | <0.001 |
| Urban, teaching | 44,029 | 15,261, 72,796 | 0.003 |
| Elixhauser comorbidity index | 13,532 | 11,361, 15,703 | <0.001 |
| Abbreviation: CI = Confidence Interval | | | |