Predictors and Outcomes of 30-Day Readmission in Patients Hospitalized for Acute Ischemic Stroke Undergoing Mechanical Thrombectomy

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## Preamble:

* **Reference Studies:**
  + [Ramchand et al., 2018](https://pubmed.ncbi.nlm.nih.gov/30042034/)
* **Study Objective:**
* To identify patient- and hospital-level predictors of 30-day all-cause hospital readmission among adults hospitalized with acute ischemic stroke undergoing mechanical thrombectomy using a nationally representative dataset. This study also evaluates the clinical and economic burden of readmission in this high-risk population, including its associations with in-hospital mortality, length of stay (LOS), and hospital charges.
* **Data Source:**
* A retrospective cohort study using the 2016–2017 Nationwide Readmissions Database (NRD), developed by the Healthcare Cost and Utilization Project (HCUP). The NRD enables tracking of individual patients across hospitalizations within a given year via synthetic identifiers, capturing discharges from U.S. community hospitals and supporting survey-weighted national estimates through complex sampling design.
* **Cohort Definition:**
* Index hospitalizations were included if they met all of the following criteria:
  + Adults aged ≥18 years
  + Principal diagnosis of acute ischemic stroke, identified using ICD-10-CM code: I63
  + Undergoing mechanical thrombectomy, using ICD-10-PCS code: 03C[A-Z]3ZZ
  + Non-elective admission
  + Index discharge by the end of November to allow for a complete 30-day follow-up period
  + Complete data on LOS and NRD\_DAYSTOEVENT, required to compute discharge dates
* **Outcomes of Interest:**
  + Primary Outcome:
    - Binary indicator of 30-day readmission (Yes/No)
  + Secondary Outcomes:
    - In-hospital mortality (binary)
    - Length of stay (LOS, in days)
    - Total hospitalization charges (inflation-adjusted to 2017 USD)
* **Outcome Definitions:**
  + Readmission:
    - Defined using NRD’s linkage variables. Readmissions were identified only among patients with qualifying index events.
    - Trauma-related hospitalizations were excluded only from the readmission pool to avoid injury-related returns unrelated to sepsis care.
  + Mortality:
    - In-hospital death recorded during index or readmission (DIED = 1)
  + LOS:
    - Reported in days; modeled as count outcome
  + Charge:
    - Derived from HCUP’s TOTCHG variable and adjusted to 2017 dollars using Consumer Price Index (CPI) data
* **Covariates:**
  + Demographic & Socioeconomic Factors:
    - Age (categorized: 18–49, 50–64, 65–79, 80+)
    - Sex (FEMALE; ref = Male)
    - Primary expected payer (Insurance; Medicare, Medicaid, Private, Other)
    - ZIP-based median income quartile
  + Clinical Characteristics:
    - Deficiency\_anemia
    - Congestive\_HF
    - Chronic\_pulmonary\_disease
    - PVD
    - Diabetes
    - Obesity
    - Depression
    - Valvular disease
    - Hypothyroidism
    - Cardiac arrhythmia
    - Renal disease
    - Cancer
    - Liver disease
    - Fluid and electrolyte imbalance
  + Hospital Characteristics:
    - Hospital bed size (Small, Medium, Large)
    - Urban/rural teaching status (Metropolitan, teaching vs non-teaching, etc.)
  + Disposition and Severity:
    - Discharge disposition
    - Number of comorbidities
    - Length of stay (categorized as above)
* **Statistical Methods:**
  + Survey Design and Weighting:
    - All analyses incorporated NRD’s complex sampling design via the survey and srvyr packages.
  + Descriptive Statistics:
    - Weighted baseline characteristics of index hospitalizations were summarized and stratified by 30-day readmission status to compare patients who were readmitted versus those who were not.
    - Stratification was performed using a derived binary variable, which categorized patients as:
      * With 30-day readmission
      * Without readmission
    - P-values from statistical tests (Rao–Scott adjusted chi-square for categorical variables; Kruskal–Wallis test for continuous variables).
  + Multivariable Regression:
    - A survey-weighted logistic regression modeled predictors of 30-day readmission.
    - The model included demographic, clinical, hospital-level, and index-stay factors.
    - Results were exponentiated to yield odds ratios (ORs) with 95% confidence intervals.
* **Software:**  
  All analyses were conducted in R Statistical Language (Version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria).

## Descriptive Statistics:

### Readmission Rate:

Index hospitalizations resulted in:

1. Readmission (n): 2511
2. Readmission Rate (%): 2.29%
3. Readmission Rate (95% CI): 1.39% to 3.18%

### In-Hospital Mortality by Readmission Status:

Index hospitalizations resulted in:

1. Deaths (n): 405
2. Death Rate (%): 16.24%
3. Death Rate (95% CI): 13.43% to 19.05%

Readmission hospitalizations resulted in:

1. Deaths (n): 0
2. Death Rate (%): 0%
3. Death Rate (95% CI): NaN% to NaN%

### LOS and Cost by Readmission Status:

Index hospitalizations resulted in:

1. Mean Length of Stay (days): 8.97
2. Mean Length of Stay (95% CI): 8.22 to 9.72
3. Mean Charge ($): 190863
4. Mean Charge (95% CI): 178351 to 203374

Readmission hospitalizations resulted in:

1. Mean Length of Stay (days): 0
2. Mean Length of Stay (95% CI): NaN to NaN
3. Mean Charge ($): 0
4. Mean Charge (95% CI): NA to NA

## Baseline table:

| **Characteristic** | **Without Readmission** N = 2,454*1* | **With 30-day readmission** N = 57*1* | **p-value***2* | **Overall** N = 2,512*1* |
| --- | --- | --- | --- | --- |
| Age (years) |  |  | 0.6 |  |
| 18–49 | 216 (8.8%) | 9 (16%) |  | 225 (9.0%) |
| 50–64 | 660 (27%) | 14 (25%) |  | 675 (27%) |
| 65–79 | 847 (35%) | 15 (27%) |  | 863 (34%) |
| 80+ | 730 (30%) | 18 (32%) |  | 749 (30%) |
| Sex |  |  | 0.3 |  |
| Male | 1,241 (51%) | 35 (60%) |  | 1,276 (51%) |
| Female | 1,213 (49%) | 23 (40%) |  | 1,235 (49%) |
| Median Income Quartile |  |  | 0.4 |  |
| 0-25th percentile | 640 (26%) | 14 (24%) |  | 654 (26%) |
| 26th to 50th percentile | 667 (27%) | 22 (39%) |  | 689 (28%) |
| 51st to 75th percentile | 623 (26%) | 15 (26%) |  | 638 (26%) |
| 76th to 100th percentile | 497 (20%) | 6 (11%) |  | 503 (20%) |
| Urban-Rural Location |  |  | 0.6 |  |
| Central metro ≥1 million | 708 (29%) | 18 (32%) |  | 727 (29%) |
| Fringe metro ≥1 million | 686 (28%) | 19 (33%) |  | 704 (28%) |
| Metro 250,000-999,999 | 477 (20%) | 12 (21%) |  | 489 (20%) |
| Metro 50,000-249,999 | 169 (6.9%) | 4 (6.3%) |  | 173 (6.9%) |
| Micropolitan | 159 (6.5%) | 5 (8.0%) |  | 164 (6.6%) |
| Other | 244 (10.0%) | 0 (0%) |  | 244 (9.8%) |
| Urban Category |  |  | 0.8 |  |
| Large metropolitan ≥1 million | 1,627 (66%) | 39 (68%) |  | 1,666 (66%) |
| Micropolitan | 15 (0.6%) | 0 (0%) |  | 15 (0.6%) |
| Small metropolitan <1 million | 813 (33%) | 18 (32%) |  | 831 (33%) |
| Hospital Bed Size |  |  | 0.10 |  |
| Small | 86 (3.5%) | 5 (9.0%) |  | 92 (3.6%) |
| Large | 1,973 (80%) | 49 (86%) |  | 2,022 (81%) |
| Medium | 395 (16%) | 3 (5.0%) |  | 398 (16%) |
| Teaching Status |  |  | 0.4 |  |
| Metropolitan, non-teaching | 300 (12%) | 4 (7.1%) |  | 305 (12%) |
| Metropolitan, teaching | 2,139 (87%) | 53 (93%) |  | 2,192 (87%) |
| Non-metropolitan | 15 (0.6%) | 0 (0%) |  | 15 (0.6%) |
| Primary expected payer |  |  | 0.9 |  |
| Private | 533 (22%) | 12 (22%) |  | 546 (22%) |
| Medicaid | 198 (8.1%) | 6 (11%) |  | 204 (8.2%) |
| Medicare | 1,564 (64%) | 37 (65%) |  | 1,601 (64%) |
| Other | 80 (3.3%) | 2 (2.7%) |  | 82 (3.3%) |
| Self-pay | 71 (2.9%) | 0 (0%) |  | 71 (2.8%) |
| Discharge Disposition |  |  | 0.032 |  |
| Left against medical advice | 7 (0.3%) | 0 (0%) |  | 7 (0.3%) |
| No | 1,301 (53%) | 16 (28%) |  | 1,317 (52%) |
| skilled nursing facility, intermediate care, and another type of facility | 1,102 (45%) | 41 (72%) |  | 1,143 (46%) |
| Transfer to another short-term hospital | 44 (1.8%) | 0 (0%) |  | 44 (1.7%) |
| No. of comorbidities |  |  | 0.4 |  |
| One comorbidity | 195 (8.0%) | 2 (3.5%) |  | 197 (7.8%) |
| Two or more comorbidities | 2,259 (92%) | 55 (96%) |  | 2,314 (92%) |
| *1*n (%) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment | | | | |

## Multivariable Regression

### 30-Day Readmission:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age (years) |  |  |  |
| 18–49 | — | — |  |
| 50–64 | 0.98 | 0.75, 1.27 | 0.9 |
| 65–79 | 1.04 | 0.82, 1.33 | 0.7 |
| 80+ | 1.04 | 0.79, 1.38 | 0.8 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 0.99 | 0.86, 1.14 | >0.9 |
| Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.99 | 0.81, 1.22 | >0.9 |
| 51st to 75th percentile | 0.97 | 0.78, 1.22 | 0.8 |
| 76th to 100th percentile | 1.04 | 0.78, 1.39 | 0.8 |
| Urbanicity |  |  |  |
| Central metro ≥1 million | — | — |  |
| Fringe metro ≥1 million | 0.93 | 0.72, 1.18 | 0.5 |
| Metro 250,000-999,999 | 1.00 | 0.77, 1.29 | >0.9 |
| Metro 50,000-249,999 | 0.94 | 0.66, 1.33 | 0.7 |
| Micropolitan | 0.89 | 0.61, 1.30 | 0.5 |
| Other | 0.78 | 0.53, 1.15 | 0.2 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 0.96 | 0.69, 1.33 | 0.8 |
| Medium | 0.91 | 0.56, 1.47 | 0.7 |
| Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.96 | 0.72, 1.30 | 0.8 |
| Non-metropolitan | 0.84 | 0.55, 1.30 | 0.4 |
| 30-Day Readmission |  |  |  |
| Without Readmission | — | — |  |
| With 30-day readmission | 120,377,839,810,460,264,796,260 | 72,565,938,439,213,983,738,846, 199,691,820,006,865,922,688,086 | <0.001 |
| Deficiency anemia |  |  |  |
| No | — | — |  |
| Yes | 1.07 | 0.76, 1.49 | 0.7 |
| Congestive heart failure |  |  |  |
| No | — | — |  |
| Yes | 0.98 | 0.83, 1.16 | 0.8 |
| Chronic pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 0.97 | 0.81, 1.16 | 0.7 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 0.97 | 0.79, 1.20 | 0.8 |
| Diabetes |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.86, 1.18 | >0.9 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.96 | 0.76, 1.22 | 0.8 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 1.05 | 0.83, 1.33 | 0.7 |
| Valvular disease |  |  |  |
| No | — | — |  |
| Yes | 0.98 | 0.80, 1.21 | 0.9 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.84, 1.21 | >0.9 |
| Arrhythmia |  |  |  |
| No | — | — |  |
| Yes | 0.99 | 0.86, 1.14 | 0.9 |
| Renal disease |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.81, 1.25 | >0.9 |
| Cancer |  |  |  |
| No | — | — |  |
| Yes | 0.91 | 0.65, 1.27 | 0.6 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 1.02 | 0.64, 1.63 | >0.9 |
| Fluid and electrolyte imbalance |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.84, 1.20 | >0.9 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |