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 stroke 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:
    - Anemia
    - Congestive heart failure
    - Chronic pulmonary disease
    - Peripheral Vascular Disease
    - Coronary artery disease
    - Diabetes
    - Obesity
    - Depression
    - Valvular disease
    - Hypothyroidism
    - Cardiac arrhythmia
    - Renal disease
    - 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).
    - The ten most common principle diagnoses for readmission were reported according to decreasing prevalence.
  + 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): 338
2. Readmission Rate (%): 3.34%
3. Readmission Rate (95% CI): 2.82% to 3.86%

### Baseline Characteristics

| **Characteristic** | **Overall** N = 10,137*1* | **Without Readmission** N = 9,798*1* | **With 30-day readmission** N = 339*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) |  |  |  | 0.7 |
| 18–49 | 1,054 (10%) | 1,020 (10%) | 34 (10%) |  |
| 50–64 | 2,571 (25%) | 2,484 (25%) | 86 (26%) |  |
| 65–79 | 3,637 (36%) | 3,504 (36%) | 133 (39%) |  |
| 80+ | 2,874 (28%) | 2,790 (28%) | 85 (25%) |  |
| Sex |  |  |  | >0.9 |
| Male | 4,969 (49%) | 4,802 (49%) | 167 (49%) |  |
| Female | 5,168 (51%) | 4,997 (51%) | 172 (51%) |  |
| Median Income Quartile |  |  |  | 0.3 |
| 0-25th percentile | 2,888 (29%) | 2,771 (29%) | 117 (35%) |  |
| 26th to 50th percentile | 2,700 (27%) | 2,609 (27%) | 91 (27%) |  |
| 51st to 75th percentile | 2,451 (25%) | 2,377 (25%) | 74 (22%) |  |
| 76th to 100th percentile | 1,965 (20%) | 1,909 (20%) | 55 (16%) |  |
| Hospital Bed Size |  |  |  | 0.009 |
| Small | 508 (5.0%) | 474 (4.8%) | 33 (9.8%) |  |
| Large | 8,000 (79%) | 7,728 (79%) | 272 (80%) |  |
| Medium | 1,629 (16%) | 1,596 (16%) | 33 (9.8%) |  |
| Hospital Teaching Status |  |  |  | 0.5 |
| Metropolitan, non-teaching | 1,133 (11%) | 1,103 (11%) | 30 (9.0%) |  |
| Metropolitan, teaching | 8,927 (88%) | 8,619 (88%) | 308 (91%) |  |
| Non-metropolitan | 77 (0.8%) | 77 (0.8%) | 0 (0%) |  |
| Insurance |  |  |  | 0.044 |
| Private | 2,264 (22%) | 2,218 (23%) | 46 (14%) |  |
| Medicaid | 886 (8.8%) | 852 (8.7%) | 34 (10%) |  |
| Medicare | 6,337 (63%) | 6,106 (62%) | 231 (68%) |  |
| Other | 639 (6.3%) | 612 (6.3%) | 27 (8.0%) |  |
| Discharged to Non-Home Setting | 5,898 (58%) | 5,675 (58%) | 223 (66%) | 0.043 |
| No. of comorbidities |  |  |  | >0.9 |
| One comorbidity | 664 (6.6%) | 642 (6.6%) | 23 (6.7%) |  |
| Two or more comorbidities | 9,473 (93%) | 9,157 (93%) | 316 (93%) |  |
| Anemia | 2,415 (24%) | 2,326 (24%) | 89 (26%) | 0.4 |
| Congestive heart failure | 2,690 (27%) | 2,588 (26%) | 102 (30%) | 0.3 |
| Chronic pulmonary disease | 1,601 (16%) | 1,556 (16%) | 45 (13%) | 0.4 |
| Peripheral vascular disease | 1,099 (11%) | 1,060 (11%) | 39 (12%) | 0.8 |
| Diabetes | 2,880 (28%) | 2,767 (28%) | 114 (34%) | 0.13 |
| Obesity | 1,447 (14%) | 1,411 (14%) | 35 (10%) | 0.13 |
| Depression | 1,213 (12%) | 1,177 (12%) | 36 (10%) | 0.6 |
| Valvular disease | 1,311 (13%) | 1,250 (13%) | 61 (18%) | 0.053 |
| Hypothyroidism | 1,357 (13%) | 1,312 (13%) | 45 (13%) | >0.9 |
| Arrhythmia | 5,710 (56%) | 5,512 (56%) | 198 (58%) | 0.6 |
| Renal disease | 1,357 (13%) | 1,308 (13%) | 50 (15%) | 0.6 |
| Liver disease | 193 (1.9%) | 181 (1.8%) | 12 (3.5%) | 0.2 |
| Fluid and electrolyte imbalance | 3,270 (32%) | 3,158 (32%) | 112 (33%) | 0.8 |
| Coronary artery disease | 2,393 (24%) | 2,308 (24%) | 85 (25%) | 0.6 |
| *1*n (%) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment | | | | |

### Outcomes of Index Hospitalizations

| **Characteristic** | **Overall** N = 10,137*1* | **Without Readmission** N = 9,798*1* | **With 30-day readmission** N = 339*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| In-hospital Death | 1,440 (14%) | 1,440 (15%) | 0 (0%) | <0.001 |
| Length of Stay | 7 (4, 15) | 7 (4, 15) | 11 (5, 17) | <0.001 |
| Inflation Adjusted Total Charges ($) | 161,109 (104,861, 250,760) | 159,909 (104,601, 249,065) | 196,485 (117,638, 291,016) | 0.002 |
| *1*n (%); Median (Q1, Q3) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; Design-based KruskalWallis test | | | | |

### Resource Utilization During Readmission

Readmission hospitalizations resulted in:

1. Median Length of Stay (IQR), days: 5 (IQR: 3–7)
2. Median Total Charges (IQR): $46,731 (IQR: $26,209–$88,326)

## Top Causes of Readmission

| ICD-10 Code | ICD-10 Description | Proportion |
| --- | --- | --- |
| I63 | Cerebral infarction | 0.1415 |
| A41 | Other Sepsis | 0.1372 |
| I69 | Sequelae of cerebrovascular disease | 0.0758 |
| I48 | Atrial fibrillation and flutter | 0.0474 |
| I61 | Nontraumatic Intracerebral hemorrhage | 0.0474 |
| J69 | Pneumonitis due to solids and liquids | 0.0437 |
| I65 | Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction | 0.0371 |
| N17 | Acute kidney failure | 0.0295 |
| N39 | Other disorders of the urinary system | 0.0239 |
| I50 | Heart failure | 0.0208 |

## Multivariable Analyses

### 30-Day Readmission:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age (years) |  |  |  |
| 18–49 | — | — |  |
| 50–64 | 1.02 | 0.57, 1.85 | >0.9 |
| 65–79 | 0.70 | 0.35, 1.40 | 0.3 |
| 80+ | 0.50 | 0.25, 1.01 | 0.053 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 1.03 | 0.72, 1.46 | 0.9 |
| Insurance |  |  |  |
| Private | — | — |  |
| Medicaid | 1.77 | 0.96, 3.25 | 0.066 |
| Medicare | 2.39 | 1.26, 4.56 | 0.008 |
| Other | 2.11 | 1.03, 4.31 | 0.042 |
| Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.86 | 0.57, 1.31 | 0.5 |
| 51st to 75th percentile | 0.78 | 0.51, 1.18 | 0.2 |
| 76th to 100th percentile | 0.70 | 0.44, 1.12 | 0.14 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 0.50 | 0.29, 0.87 | 0.014 |
| Medium | 0.30 | 0.14, 0.66 | 0.003 |
| Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 1.25 | 0.77, 2.04 | 0.4 |
| Non-metropolitan | 0.00 | 0.00, 0.00 | <0.001 |
| No. of comorbidities |  |  |  |
| One comorbidity | — | — |  |
| Two or more comorbidities | 0.92 | 0.47, 1.81 | 0.8 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.12 | 0.80, 1.57 | 0.5 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 0.97 | 0.58, 1.63 | >0.9 |
| Congestive heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.06 | 0.75, 1.52 | 0.7 |
| Chronic pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 0.73 | 0.46, 1.18 | 0.2 |
| Diabetes |  |  |  |
| No | — | — |  |
| Yes | 1.26 | 0.91, 1.76 | 0.2 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.64 | 0.40, 1.04 | 0.073 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 0.83 | 0.49, 1.41 | 0.5 |
| Valvular disease |  |  |  |
| No | — | — |  |
| Yes | 1.52 | 0.98, 2.36 | 0.064 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 0.98 | 0.58, 1.66 | >0.9 |
| Arrhythmia |  |  |  |
| No | — | — |  |
| Yes | 1.10 | 0.79, 1.53 | 0.6 |
| Renal disease |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.60, 1.72 | >0.9 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.72, 1.49 | 0.8 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 1.83 | 0.53, 6.28 | 0.3 |
| Fluid and electrolyte imbalance |  |  |  |
| No | — | — |  |
| Yes | 0.99 | 0.69, 1.42 | >0.9 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |