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:
    - Deficiency 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).
  + 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): 2676
2. Readmission Rate (%): 8.99%
3. Readmission Rate (95% CI): 8.48% to 9.49%

### In-Hospital Mortality by Readmission Status:

Index hospitalizations resulted in:

1. Deaths (n): 4230
2. Death Rate (%): 14.21%
3. Death Rate (95% CI): 13.45% to 14.97%

Readmission hospitalizations resulted in:

1. Deaths (n): 171
2. Death Rate (%): 6.44%
3. Death Rate (95% CI): 5.01% to 7.87%

### LOS and Cost by Readmission Status:

Index hospitalizations resulted in:

1. Mean Length of Stay (days): 11.57
2. Mean Length of Stay (95% CI): 11.18 to 11.96
3. Mean Charge ($): 203889
4. Mean Charge (95% CI): 195557 to 212221

Readmission hospitalizations resulted in:

1. Mean Length of Stay (days): 6.89
2. Mean Length of Stay (95% CI): 6.43 to 7.36
3. Mean Charge ($): 65778
4. Mean Charge (95% CI): 61679 to 69878

## Baseline Characteristics

| **Characteristic** | **Overall** N = 29,783*1* | **Without Readmission** N = 27,107*1* | **With 30-day readmission** N = 2,676*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) |  |  |  | 0.001 |
| 18–49 | 3,144 (11%) | 2,935 (11%) | 209 (7.8%) |  |
| 50–64 | 7,407 (25%) | 6,782 (25%) | 625 (23%) |  |
| 65–79 | 10,823 (36%) | 9,765 (36%) | 1,058 (40%) |  |
| 80+ | 8,410 (28%) | 7,625 (28%) | 785 (29%) |  |
| Sex |  |  |  | 0.4 |
| Male | 14,684 (49%) | 13,395 (49%) | 1,289 (48%) |  |
| Female | 15,099 (51%) | 13,711 (51%) | 1,387 (52%) |  |
| Median Income Quartile |  |  |  | 0.2 |
| 0-25th percentile | 8,392 (29%) | 7,568 (28%) | 824 (31%) |  |
| 26th to 50th percentile | 7,601 (26%) | 6,919 (26%) | 682 (26%) |  |
| 51st to 75th percentile | 7,573 (26%) | 6,927 (26%) | 646 (24%) |  |
| 76th to 100th percentile | 5,827 (20%) | 5,335 (20%) | 492 (19%) |  |
| Hospital Bed Size |  |  |  | 0.5 |
| Small | 1,323 (4.4%) | 1,211 (4.5%) | 112 (4.2%) |  |
| Large | 23,575 (79%) | 21,485 (79%) | 2,091 (78%) |  |
| Medium | 4,885 (16%) | 4,411 (16%) | 474 (18%) |  |
| Hospital Teaching Status |  |  |  | 0.4 |
| Metropolitan, non-teaching | 3,447 (12%) | 3,158 (12%) | 289 (11%) |  |
| Metropolitan, teaching | 26,094 (88%) | 23,722 (88%) | 2,372 (89%) |  |
| Non-metropolitan | 243 (0.8%) | 227 (0.8%) | 15 (0.6%) |  |
| Insurance |  |  |  | 0.004 |
| Private | 6,404 (22%) | 5,948 (22%) | 457 (17%) |  |
| Medicaid | 2,674 (9.0%) | 2,458 (9.1%) | 216 (8.1%) |  |
| Medicare | 18,838 (63%) | 16,976 (63%) | 1,862 (70%) |  |
| Other | 1,829 (6.2%) | 1,689 (6.2%) | 141 (5.3%) |  |
| Discharged to Non-Home Setting | 17,393 (58%) | 15,706 (58%) | 1,687 (63%) | <0.001 |
| No. of comorbidities |  |  |  | 0.011 |
| One comorbidity | 1,974 (6.6%) | 1,840 (6.8%) | 134 (5.0%) |  |
| Two or more comorbidities | 27,809 (93%) | 25,267 (93%) | 2,543 (95%) |  |
| Anemia | 6,925 (23%) | 6,231 (23%) | 694 (26%) | 0.011 |
| Congestive heart failure | 7,775 (26%) | 6,913 (26%) | 862 (32%) | <0.001 |
| Chronic pulmonary disease | 4,573 (15%) | 4,095 (15%) | 478 (18%) | 0.013 |
| Peripheral vascular disease | 3,310 (11%) | 2,966 (11%) | 344 (13%) | 0.056 |
| Diabetes | 8,386 (28%) | 7,515 (28%) | 870 (33%) | 0.002 |
| Obesity | 4,120 (14%) | 3,769 (14%) | 351 (13%) | 0.5 |
| Depression | 3,595 (12%) | 3,271 (12%) | 324 (12%) | >0.9 |
| Valvular disease | 3,984 (13%) | 3,562 (13%) | 422 (16%) | 0.005 |
| Hypothyroidism | 4,021 (14%) | 3,675 (14%) | 347 (13%) | 0.5 |
| Arrhythmia | 16,634 (56%) | 15,020 (55%) | 1,614 (60%) | 0.002 |
| Renal disease | 4,123 (14%) | 3,634 (13%) | 488 (18%) | <0.001 |
| Liver disease | 524 (1.8%) | 456 (1.7%) | 68 (2.5%) | 0.083 |
| Fluid and electrolyte imbalance | 9,460 (32%) | 8,515 (31%) | 945 (35%) | 0.004 |
| Coronary artery disease | 7,128 (24%) | 6,339 (23%) | 789 (29%) | <0.001 |
| *1*n (%) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment | | | | |

## Top causes of readmission

| Diagnosis 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 urinary system | 0.0239 |
| I50 | Heart failure | 0.0208 |

## Multivariable Regression

### 30-Day Readmission:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age (years) |  |  |  |
| 18–49 | — | — |  |
| 50–64 | 1.21 | 0.95, 1.54 | 0.12 |
| 65–79 | 1.09 | 0.84, 1.42 | 0.5 |
| 80+ | 0.99 | 0.75, 1.31 | >0.9 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 1.07 | 0.93, 1.22 | 0.4 |
| Insurance |  |  |  |
| Private | — | — |  |
| Medicaid | 1.05 | 0.76, 1.44 | 0.8 |
| Medicare | 1.33 | 0.97, 1.82 | 0.078 |
| Other | 1.02 | 0.71, 1.49 | 0.9 |
| Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.91 | 0.77, 1.08 | 0.3 |
| 51st to 75th percentile | 0.86 | 0.73, 1.02 | 0.075 |
| 76th to 100th percentile | 0.86 | 0.70, 1.05 | 0.13 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 1.06 | 0.76, 1.47 | 0.7 |
| Medium | 1.15 | 0.81, 1.63 | 0.4 |
| Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 1.13 | 0.92, 1.38 | 0.2 |
| Non-metropolitan | 0.75 | 0.35, 1.61 | 0.5 |
| No. of comorbidities |  |  |  |
| One comorbidity | — | — |  |
| Two or more comorbidities | 1.10 | 0.84, 1.45 | 0.5 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.07 | 0.94, 1.21 | 0.3 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 1.06 | 0.87, 1.28 | 0.6 |
| Congestive heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.14 | 1.00, 1.31 | 0.058 |
| Chronic pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.12 | 0.95, 1.32 | 0.2 |
| Diabetes |  |  |  |
| No | — | — |  |
| Yes | 1.11 | 0.95, 1.30 | 0.2 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.90 | 0.74, 1.11 | 0.3 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.81, 1.23 | >0.9 |
| Valvular disease |  |  |  |
| No | — | — |  |
| Yes | 1.15 | 0.98, 1.35 | 0.10 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 0.89 | 0.75, 1.05 | 0.2 |
| Arrhythmia |  |  |  |
| No | — | — |  |
| Yes | 1.09 | 0.95, 1.26 | 0.2 |
| Renal disease |  |  |  |
| No | — | — |  |
| Yes | 1.21 | 1.03, 1.42 | 0.019 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | 1.20 | 1.02, 1.42 | 0.027 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 1.38 | 0.88, 2.18 | 0.2 |
| Fluid and electrolyte imbalance |  |  |  |
| No | — | — |  |
| Yes | 1.13 | 1.00, 1.27 | 0.048 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |