Thirty-Day Readmission in Patients With Brain Cancer and Venous Thromboembolism: A Nationwide Analysis Using the National Readmissions Database

Analysis for NRD June A22

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## Preamble:

* **Reference Studies:**
  + [Mallick et al., 2022](https://pmc.ncbi.nlm.nih.gov/articles/PMC8792793/)
  + [Jarvis et al., 2020](https://www.sciencedirect.com/science/article/abs/pii/S0960740420303960)
* **Study Objective:**
* To identify patient and hospital-level predictors of 30-day all-cause hospital readmission among adults hospitalized with brain cancer and Venous thromboembolism (VTE) 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 or a secondary diagnosis of Brain cancer and VTE, identified using ICD-10-CM codes for BC (isBC pattern, including C710, C711, C712, C713, C714, C715, C716, C717, C718, C719, C7931) and VTE (isVTE pattern, including I2602, I2609, I2692, I2693, I2694, I2699, I82210, I82220, I82290, I823, I82401, I82402, I82403, I82409, I82411, I82412, I82413, I82419, I82421, I82422, I82423, I82429, I82431, I82432, I82433, I82439, I82441, I82442, I82443, I82449, I82451, I82452, I82453, I82459, I82461, I82462, I82463, I82469, I82491, I82492, I82493, I82499, I824Y1, I824Y2, I824Y3, I824Y9, I824Z1, I824Z2, I824Z3, I824Z9, I82601, I82602, I82603, I82609, I82611, I82612, I82613, I82619, I82621, I82622, I82623, I82629, I82A11, I82A12, I82A13, I82A19, I82B11, I82B12, I82B13, I82B19, I82C11, I82C12, I82C13, I82C19, I82811, I82812, I82813, I82819, I82890, I8290)
  + 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 planned or injury-related returns unrelated to BC and VTE hospitalizations.
  + Mortality:
    - In-hospital death recorded during index or readmission (DIED = 1)
  + LOS:
    - Reported in days; modeled as count outcome
  + Cost:
    - Derived from HCUP’s TOTCHG variable and adjusted to 2017 dollars using Consumer Price Index (CPI) data
* **Covariates and Variable Construction:**
  + Demographic & Socioeconomic Factors:
    - Sex (FEMALE; ref = Male)
    - Primary expected payer (Insurance; Medicare, Medicaid, Private, Other)
    - ZIP-based median income quartile (ZIPINC\_QRTL)
    - Weekend admission (AWEEKEND)
  + Clinical Characteristics:
    - Standard comorbidities (from Elixhauser Index), using binary indicators:
    - Anemia
    - Congestive heart failure
    - Chronic pulmonary disease
    - Diabetes mellitus
    - Hypertension
    - Renal failure
    - Liver disease
    - Obesity
  + Additional clinical risk factors (non-Elixhauser)
    - Previous stroke
    - Acute myocardial infarction
    - Smoking
    - Hyperlipidemia
    - Atrial Fibrillation
  + Acute complications identified via ICD-10 code matching:
    - Hemorrhage (Intracerebral and Subarachnoid)
  + Hospital Characteristics:
    - Hospital bed size (Small, Medium, Large)
    - Urban/rural teaching status (Metropolitan, teaching vs non-teaching, etc.)
  + Disposition and Severity:
    - Non-home discharge (e.g., SNF, hospice, other facilities, or death)
    - Length of stay (categorized as above)
* **Statistical Methods:**
  + Survey Design and Weighting:
    - All analyses incorporated NRD’s complex sampling design using discharge weights (DISCWT), strata (NRD\_STRATUM), and clustering (HOSP\_NRD) 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 design-based statistical tests (Rao–Scott adjusted chi-square for categorical variables; design-based 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.
    - Reference levels were explicitly set (e.g., Male, LOS ≤4 days).
    - 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): 3515
2. Readmission Rate (%): 16.22%
3. Readmission Rate (95% CI): 15.4% to 17.05%

### In-Hospital Mortality by Readmission Status:

Index hospitalizations resulted in:

1. Deaths (n): 3033
2. Death Rate (%): 14.02%
3. Death Rate (95% CI): 13.27% to 14.76%

Readmission hospitalizations resulted in:

1. Deaths (n): 522
2. Death Rate (%): 14.98%
3. Death Rate (95% CI): 13.28% to 16.68%

### LOS and Cost by Readmission Status:

### Index Hospitalizations

1. Median Length of Stay (IQR), days: 6 (IQR: 3–11)
2. Median Total Charges (IQR): $53,709 (IQR: $27,645–$115,391)

### Readmission Hospitalizations

1. Median Length of Stay (IQR), days: 4 (IQR: 2–7)
2. Median Total Charges (IQR): $36,305 (IQR: $19,815–$68,287)

## Baseline table:

| **Characteristic** | **Without Readmission** N = 18,153*1* | **With 30-day readmission** N = 3,516*1* | **p-value***2* | **Overall** N = 21,669*1* |
| --- | --- | --- | --- | --- |
| Age (years) | 63 (12) | 61 (12) | <0.001 | 62 (12) |
| Sex |  |  | 0.3 |  |
| Male | 9,093 (50%) | 1,715 (49%) |  | 10,808 (50%) |
| Female | 9,060 (50%) | 1,801 (51%) |  | 10,861 (50%) |
| Median Income Quartile |  |  | 0.019 |  |
| 0-25th percentile | 4,363 (24%) | 971 (28%) |  | 5,334 (25%) |
| 26th to 50th percentile | 4,734 (26%) | 820 (24%) |  | 5,554 (26%) |
| 51st to 75th percentile | 4,467 (25%) | 841 (24%) |  | 5,308 (25%) |
| 76th to 100th percentile | 4,369 (24%) | 844 (24%) |  | 5,213 (24%) |
| Admission day |  |  | 0.010 |  |
| Monday-Friday | 14,384 (79%) | 2,677 (76%) |  | 17,061 (79%) |
| Saturday-Sunday | 3,769 (21%) | 839 (24%) |  | 4,608 (21%) |
| Hospital Bed Size |  |  | 0.6 |  |
| Small | 2,099 (12%) | 375 (11%) |  | 2,474 (11%) |
| Large | 11,906 (66%) | 2,329 (66%) |  | 14,235 (66%) |
| Medium | 4,148 (23%) | 811 (23%) |  | 4,959 (23%) |
| Teaching Status |  |  | 0.046 |  |
| Metropolitan, non-teaching | 3,215 (18%) | 600 (17%) |  | 3,815 (18%) |
| Metropolitan, teaching | 14,070 (78%) | 2,797 (80%) |  | 16,867 (78%) |
| Non-metropolitan | 868 (4.8%) | 118 (3.4%) |  | 986 (4.6%) |
| Chronic pulmonary disease | 4,595 (25%) | 988 (28%) | 0.032 | 5,583 (26%) |
| Liver disease | 738 (4.1%) | 134 (3.8%) | 0.7 | 873 (4.0%) |
| Non-home discharge | 8,122 (45%) | 884 (25%) | <0.001 | 9,006 (42%) |
| Diabetes mellitus | 3,910 (22%) | 796 (23%) | 0.3 | 4,706 (22%) |
| Anemia | 6,878 (38%) | 1,317 (37%) | 0.7 | 8,195 (38%) |
| Hypertension | 8,059 (44%) | 1,637 (47%) | 0.12 | 9,697 (45%) |
| Congestive heart failure | 1,653 (9.1%) | 362 (10%) | 0.2 | 2,014 (9.3%) |
| Acute myocardial infarction | 445 (2.5%) | 60 (1.7%) | 0.060 | 505 (2.3%) |
| Previous stroke | 1,174 (6.5%) | 241 (6.9%) | 0.5 | 1,415 (6.5%) |
| Atrial fibrillation | 2,149 (12%) | 369 (10%) | 0.2 | 2,518 (12%) |
| End-stage renal disease | 97 (0.5%) | 13 (0.4%) | 0.3 | 109 (0.5%) |
| Current or past smoking history | 1,895 (10%) | 390 (11%) | 0.4 | 2,285 (11%) |
| Obesity | 1,775 (9.8%) | 389 (11%) | 0.12 | 2,164 (10.0%) |
| Hyperlipidemia | 5,006 (28%) | 1,008 (29%) | 0.4 | 6,013 (28%) |
| Chronic kidney disease | 1,317 (7.3%) | 242 (6.9%) | 0.6 | 1,559 (7.2%) |
| Hemorrhage subtype |  |  | >0.9 |  |
| Intracerebral | 1,135 (94%) | 175 (94%) |  | 1,310 (94%) |
| Subarachnoid | 69 (5.7%) | 10 (5.6%) |  | 79 (5.7%) |
| Length of stay category |  |  | 0.8 |  |
| ≤4 | 6,950 (38%) | 1,333 (38%) |  | 8,283 (38%) |
| >4 | 11,203 (62%) | 2,183 (62%) |  | 13,386 (62%) |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

## Multivariable Regression

### 30-Day Readmission:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age (years) | 0.99 | 0.97, 1.01 | 0.4 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 0.93 | 0.56, 1.53 | 0.8 |
| Median Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.65 | 0.30, 1.37 | 0.3 |
| 51st to 75th percentile | 0.84 | 0.42, 1.65 | 0.6 |
| 76th to 100th percentile | 1.21 | 0.63, 2.35 | 0.6 |
| Admission day |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.10 | 0.64, 1.89 | 0.7 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 1.96 | 0.72, 5.33 | 0.2 |
| Medium | 1.29 | 0.41, 4.08 | 0.7 |
| Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.89 | 0.47, 1.70 | 0.7 |
| Non-metropolitan | 0.51 | 0.04, 6.48 | 0.6 |
| Chronic pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.38 | 0.78, 2.44 | 0.3 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 0.98 | 0.32, 3.03 | >0.9 |
| Non-home discharge |  |  |  |
| No | — | — |  |
| Yes | 0.41 | 0.26, 0.65 | <0.001 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 1.24 | 0.73, 2.09 | 0.4 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 0.68 | 0.40, 1.17 | 0.2 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.40 | 0.87, 2.27 | 0.2 |
| Congestive heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.13 | 0.44, 2.88 | 0.8 |
| Acute myocardial infarction |  |  |  |
| No | — | — |  |
| Yes | 2.74 | 0.66, 11.3 | 0.2 |
| Previous stroke |  |  |  |
| No | — | — |  |
| Yes | 0.53 | 0.19, 1.53 | 0.2 |
| Atrial fibrillation |  |  |  |
| No | — | — |  |
| Yes | 1.26 | 0.59, 2.70 | 0.6 |
| End-stage renal disease |  |  |  |
| No | — | — |  |
| Yes | 5.27 | 0.53, 52.9 | 0.2 |
| Smoking |  |  |  |
| No | — | — |  |
| Yes | 1.24 | 0.57, 2.70 | 0.6 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 1.37 | 0.59, 3.17 | 0.5 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | 1.05 | 0.57, 1.91 | 0.9 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 1.26 | 0.46, 3.42 | 0.7 |
| Length of stay category |  |  |  |
| ≤4 | — | — |  |
| >4 | 1.44 | 0.82, 2.51 | 0.2 |
| Hemorrhage subtype |  |  |  |
| Intracerebral | — | — |  |
| Subarachnoid | 1.13 | 0.45, 2.80 | 0.8 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |