Impact of Dementia on In-Hospital Outcomes Among Patients Admitted for Acute Stroke

Analysis for RCOP NIS Neuro18

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## Preamble:

* **Reference Papers:**
  + [Sherzai et al. 2018](https://doi.org/10.1016/j.jstrokecerebrovasdis.2017.12.029)
  + [Salman et al. 2025](https://doi.org/10.1097/MCA.0000000000001479)
* **Study Objective**: To assess the impact of pre-existing dementia on in-hospital clinical and resource utilization outcomes among adult patients hospitalized for acute stroke in the United States.
* **Data Source**: Cross-sectional analysis using the National Inpatient Sample (NIS) database from 2018 to 2020, a representative sample of all-payer inpatient hospitalizations in the U.S.
* **Patient Selection**: We identified hospitalizations for adult patients (aged 18 years and older) with a principal diagnosis of acute stroke using the National Inpatient Sample (NIS) from 2018 to 2020. Acute stroke was defined based on ICD-10-CM codes and included three major subtypes: ischemic stroke (I63.x), intracerebral hemorrhage (I61.x), and subarachnoid hemorrhage (I60.x). The principal diagnosis field (I10\_DX1) was used to ensure that stroke was the primary reason for admission. To define the key exposure, we identified pre-existing dementia based on secondary diagnosis codes using ICD-10-CM classifications. These included codes for Alzheimer’s disease (G30.x), vascular dementia (F01.x), frontotemporal dementia (G31.01), dementia with Lewy bodies (G31.83), and other specified or unspecified dementias (F02.x, F03.x). Dementia was classified as present if any qualifying code appeared in a secondary diagnosis field.
* **Outcomes of Interest**:
  + In-hospital Mortality
  + Length of Stay (LOS) in days
  + Inflation-adjusted Total Charges (converted to 2020 U.S. dollars using Consumer Price Index data)
  + Non-Home Discharge, defined as any discharge destination other than routine discharge to home or self-care
* **Statistical Analysis**: Univariable and multivariable analyses were conducted to assess the association between pre-existing dementia and the outcomes of interest:
  + **Univariable Analysis:**
    - Continuous variables: Design-based Kruskal-Wallis test.
    - Categorical variables: Pearson’s X² test with Rao & Scott adjustment to account for survey design.
  + **Multivariable Analysis:**
    - Logistic regression for binary outcomes (e.g., mortality, non-home discharge).
    - Linear regression for continuous outcomes (e.g., length of stay, total charges).
  + **Adjustments:** Models controlled for the following covariates:
    - **Demographics and Socioeconomic Factors**: Age, Sex, Race, Residential income, Expected primary payer.
    - **Clinical Factors:** A summary measure of comorbidity (Elixhauser comorbidity index) and Stroke Subtype
    - **Hospital-Level Factors:** Hospital Region, Hospital Bed Size, and Hospital Location/Teaching Status
* **Software:** All statistical analyses were performed using 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 = 1,899,015*1* | **Stroke without Dementia** N = 1,678,440*1* | **Stroke with Dementia** N = 220,575*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age, y | 69 (14) | 68 (14) | 81 (9) | <0.001 |
| Sex |  |  |  | <0.001 |
| Female | 938,735 (49%) | 806,070 (48%) | 132,665 (60%) |  |
| Male | 960,190 (51%) | 872,295 (52%) | 87,895 (40%) |  |
| Race |  |  |  | <0.001 |
| White | 1,231,495 (67%) | 1,080,065 (66%) | 151,430 (70%) |  |
| Asian or Pacific Islander | 64,825 (3.5%) | 57,575 (3.5%) | 7,250 (3.4%) |  |
| Black | 325,130 (18%) | 291,880 (18%) | 33,250 (15%) |  |
| Hispanic | 165,510 (9.0%) | 148,425 (9.1%) | 17,085 (7.9%) |  |
| Other | 61,280 (3.3%) | 54,940 (3.4%) | 6,340 (2.9%) |  |
| Median ZIP Code Income Quartile |  |  |  | <0.001 |
| $1 - $51,999 | 570,300 (31%) | 509,555 (31%) | 60,745 (28%) |  |
| $52,000 - $65,999 | 496,630 (27%) | 440,270 (27%) | 56,360 (26%) |  |
| $66,000 - $87,999 | 441,780 (24%) | 389,110 (24%) | 52,670 (24%) |  |
| $88,000 or more | 359,405 (19%) | 311,360 (19%) | 48,045 (22%) |  |
| Primary Expected Payer |  |  |  | <0.001 |
| Private | 376,115 (20%) | 362,040 (22%) | 14,075 (6.4%) |  |
| Medicaid | 192,820 (10%) | 186,295 (11%) | 6,525 (3.0%) |  |
| Medicare | 1,190,585 (63%) | 996,075 (59%) | 194,510 (88%) |  |
| Other | 136,785 (7.2%) | 131,470 (7.8%) | 5,315 (2.4%) |  |
| Hospital Region |  |  |  | 0.004 |
| Midwest | 404,425 (21%) | 356,175 (21%) | 48,250 (22%) |  |
| Northeast | 325,890 (17%) | 286,995 (17%) | 38,895 (18%) |  |
| South | 799,160 (42%) | 708,305 (42%) | 90,855 (41%) |  |
| West | 369,540 (19%) | 326,965 (19%) | 42,575 (19%) |  |
| Hospital Bed Size |  |  |  | <0.001 |
| Large | 1,043,150 (55%) | 930,775 (55%) | 112,375 (51%) |  |
| Medium | 533,835 (28%) | 468,050 (28%) | 65,785 (30%) |  |
| Small | 322,030 (17%) | 279,615 (17%) | 42,415 (19%) |  |
| Hospital Location and Teaching Status |  |  |  | <0.001 |
| Rural | 121,390 (6.4%) | 104,240 (6.2%) | 17,150 (7.8%) |  |
| Urban, non-teaching | 313,480 (17%) | 272,130 (16%) | 41,350 (19%) |  |
| Urban, teaching | 1,464,145 (77%) | 1,302,070 (78%) | 162,075 (73%) |  |
| Elixhauser Comorbidity Index | 4.59 (2.16) | 4.53 (2.16) | 5.03 (2.12) | <0.001 |
| Type of Stroke |  |  |  | <0.001 |
| Intracerebral Hemorrhage | 225,045 (12%) | 199,915 (12%) | 25,130 (11%) |  |
| Ischemic Stroke | 1,599,690 (84%) | 1,408,135 (84%) | 191,555 (87%) |  |
| Subarachnoid Hemorrhage | 74,280 (3.9%) | 70,390 (4.2%) | 3,890 (1.8%) |  |
| Myocardial Infarction | 186,150 (9.8%) | 163,785 (9.8%) | 22,365 (10%) | 0.014 |
| Hypertension | 1,597,645 (84%) | 1,404,280 (84%) | 193,365 (88%) | <0.001 |
| Diabetes Mellitus | 711,705 (37%) | 631,460 (38%) | 80,245 (36%) | <0.001 |
| Congestive Heart Failure | 344,435 (18%) | 296,065 (18%) | 48,370 (22%) | <0.001 |
| Renal Failure | 350,130 (18%) | 296,170 (18%) | 53,960 (24%) | <0.001 |
| Atrial Fibrillation | 450,135 (24%) | 373,840 (22%) | 76,295 (35%) | <0.001 |
| Hyperlipidemia | 1,094,485 (58%) | 963,330 (57%) | 131,155 (59%) | <0.001 |
| Depression | 221,540 (12%) | 185,750 (11%) | 35,790 (16%) | <0.001 |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

## Univariable Analysis:

| **Characteristic** | **Overall** N = 1,899,015*1* | **Stroke without Dementia** N = 1,678,440*1* | **Stroke with Dementia** N = 220,575*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| In-hospital Mortality | 123,240 (6.5%) | 108,715 (6.5%) | 14,525 (6.6%) | 0.4 |
| Length of Stay (days) | 4.0 (2.0, 6.0) | 3.0 (2.0, 6.0) | 4.0 (3.0, 7.0) | <0.001 |
| Inflation-Adjusted Total Charges ($) | 48,102 (27,498, 92,250) | 48,643 (27,629, 94,340) | 44,652 (26,531, 78,877) | <0.001 |
| Non-Home Discharge | 966,275 (51%) | 817,075 (49%) | 149,200 (68%) | <0.001 |
| *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** |
| --- | --- | --- | --- |
| Dementia Categories |  |  |  |
| Stroke without Dementia | — | — |  |
| Stroke with Dementia | 0.83 | 0.79, 0.87 | <0.001 |
| Type of Stroke |  |  |  |
| Intracerebral Hemorrhage | — | — |  |
| Ischemic Stroke | 0.15 | 0.14, 0.15 | <0.001 |
| Subarachnoid Hemorrhage | 1.02 | 0.97, 1.08 | 0.4 |
| Age, y | 1.03 | 1.02, 1.03 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 1.00 | 0.97, 1.03 | >0.9 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.00 | 0.93, 1.07 | >0.9 |
| Black | 0.81 | 0.78, 0.85 | <0.001 |
| Hispanic | 0.85 | 0.80, 0.90 | <0.001 |
| Other | 1.09 | 1.01, 1.18 | 0.036 |
| Median ZIP Code Income Quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.93 | 0.89, 0.97 | <0.001 |
| $66,000 - $87,999 | 0.88 | 0.84, 0.92 | <0.001 |
| $88,000 or more | 0.85 | 0.81, 0.89 | <0.001 |
| Primary Expected Payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.16 | 1.09, 1.23 | <0.001 |
| Medicare | 0.97 | 0.92, 1.02 | 0.2 |
| Other | 1.65 | 1.54, 1.77 | <0.001 |
| Hospital Region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.25 | 1.17, 1.33 | <0.001 |
| South | 1.04 | 0.98, 1.09 | 0.2 |
| West | 1.20 | 1.13, 1.27 | <0.001 |
| Hospital Bed Size |  |  |  |
| Large | — | — |  |
| Medium | 0.84 | 0.81, 0.88 | <0.001 |
| Small | 0.72 | 0.68, 0.76 | <0.001 |
| Hospital Location and Teaching Status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.86 | 0.79, 0.94 | <0.001 |
| Urban, teaching | 1.11 | 1.03, 1.20 | 0.004 |
| Elixhauser Comorbidity Index | 1.10 | 1.09, 1.11 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Non-Home Discharge:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Dementia Categories |  |  |  |
| Stroke without Dementia | — | — |  |
| Stroke with Dementia | 1.55 | 1.52, 1.59 | <0.001 |
| Type of Stroke |  |  |  |
| Intracerebral Hemorrhage | — | — |  |
| Ischemic Stroke | 0.32 | 0.31, 0.33 | <0.001 |
| Subarachnoid Hemorrhage | 0.62 | 0.60, 0.65 | <0.001 |
| Age, y | 1.02 | 1.02, 1.02 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.97 | 0.96, 0.98 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.02 | 0.98, 1.07 | 0.3 |
| Black | 1.11 | 1.08, 1.13 | <0.001 |
| Hispanic | 0.85 | 0.82, 0.88 | <0.001 |
| Other | 1.02 | 0.98, 1.07 | 0.3 |
| Median ZIP Code Income Quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.97 | 0.95, 0.99 | 0.011 |
| $66,000 - $87,999 | 0.94 | 0.92, 0.96 | <0.001 |
| $88,000 or more | 0.90 | 0.88, 0.93 | <0.001 |
| Primary Expected Payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.22 | 1.18, 1.26 | <0.001 |
| Medicare | 1.25 | 1.22, 1.27 | <0.001 |
| Other | 0.78 | 0.75, 0.80 | <0.001 |
| Hospital Region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.19 | 1.15, 1.23 | <0.001 |
| South | 0.90 | 0.87, 0.93 | <0.001 |
| West | 0.87 | 0.84, 0.91 | <0.001 |
| Hospital Bed Size |  |  |  |
| Large | — | — |  |
| Medium | 0.93 | 0.90, 0.95 | <0.001 |
| Small | 0.91 | 0.88, 0.94 | <0.001 |
| Hospital Location and Teaching Status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.92 | 0.89, 0.97 | <0.001 |
| Urban, teaching | 0.98 | 0.95, 1.02 | 0.4 |
| Elixhauser Comorbidity Index | 1.19 | 1.18, 1.19 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

## Multivariable Linear Regression:

### Length of Stay:

| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Dementia Categories |  |  |  |
| Stroke without Dementia | — | — |  |
| Stroke with Dementia | 0.81 | 0.72, 0.89 | <0.001 |
| Type of Stroke |  |  |  |
| Intracerebral Hemorrhage | — | — |  |
| Ischemic Stroke | -3.2 | -3.3, -3.1 | <0.001 |
| Subarachnoid Hemorrhage | 3.8 | 3.6, 4.1 | <0.001 |
| Age, y | -0.02 | -0.03, -0.02 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.32 | 0.27, 0.37 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.0 | 0.81, 1.2 | <0.001 |
| Black | 1.0 | 0.94, 1.1 | <0.001 |
| Hispanic | 0.61 | 0.48, 0.74 | <0.001 |
| Other | 0.93 | 0.74, 1.1 | <0.001 |
| Median ZIP Code Income Quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | -0.12 | -0.20, -0.05 | 0.002 |
| $66,000 - $87,999 | -0.14 | -0.23, -0.05 | 0.002 |
| $88,000 or more | -0.14 | -0.24, -0.03 | 0.011 |
| Primary Expected Payer |  |  |  |
| Private | — | — |  |
| Medicaid | 2.3 | 2.1, 2.5 | <0.001 |
| Medicare | -0.13 | -0.21, -0.06 | <0.001 |
| Other | 0.54 | 0.39, 0.69 | <0.001 |
| Hospital Region |  |  |  |
| Midwest | — | — |  |
| Northeast | 1.1 | 0.95, 1.2 | <0.001 |
| South | 0.52 | 0.41, 0.64 | <0.001 |
| West | -0.19 | -0.33, -0.06 | 0.004 |
| Hospital Bed Size |  |  |  |
| Large | — | — |  |
| Medium | -0.74 | -0.85, -0.62 | <0.001 |
| Small | -1.2 | -1.3, -1.1 | <0.001 |
| Hospital Location and Teaching Status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.14 | 0.00, 0.27 | 0.054 |
| Urban, teaching | 1.1 | 0.95, 1.2 | <0.001 |
| Elixhauser Comorbidity Index | 0.78 | 0.76, 0.80 | <0.001 |
| Abbreviation: CI = Confidence Interval | | | |

### Inflation-adjusted Total Charge:

| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Dementia Categories |  |  |  |
| Stroke without Dementia | — | — |  |
| Stroke with Dementia | -5,871 | -6,992, -4,751 | <0.001 |
| Type of Stroke |  |  |  |
| Intracerebral Hemorrhage | — | — |  |
| Ischemic Stroke | -48,850 | -51,476, -46,224 | <0.001 |
| Subarachnoid Hemorrhage | 152,127 | 144,966, 159,287 | <0.001 |
| Age, y | -850 | -906, -794 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 3,027 | 2,180, 3,874 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 17,922 | 12,580, 23,264 | <0.001 |
| Black | 6,971 | 4,716, 9,225 | <0.001 |
| Hispanic | 24,370 | 20,547, 28,194 | <0.001 |
| Other | 22,834 | 18,464, 27,204 | <0.001 |
| Median ZIP Code Income Quartile |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 312 | -1,364, 1,988 | 0.7 |
| $66,000 - $87,999 | 453 | -1,681, 2,587 | 0.7 |
| $88,000 or more | 6,698 | 3,533, 9,863 | <0.001 |
| Primary Expected Payer |  |  |  |
| Private | — | — |  |
| Medicaid | 15,731 | 13,150, 18,311 | <0.001 |
| Medicare | -1,646 | -3,214, -78 | 0.040 |
| Other | -2,525 | -4,928, -121 | 0.040 |
| Hospital Region |  |  |  |
| Midwest | — | — |  |
| Northeast | 30,217 | 25,068, 35,365 | <0.001 |
| South | 14,934 | 12,110, 17,759 | <0.001 |
| West | 37,740 | 33,059, 42,420 | <0.001 |
| Hospital Bed Size |  |  |  |
| Large | — | — |  |
| Medium | -12,150 | -15,670, -8,631 | <0.001 |
| Small | -21,093 | -24,849, -17,337 | <0.001 |
| Hospital Location and Teaching Status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 25,316 | 21,854, 28,779 | <0.001 |
| Urban, teaching | 37,031 | 34,961, 39,100 | <0.001 |
| Elixhauser Comorbidity Index | 11,055 | 10,549, 11,561 | <0.001 |
| Abbreviation: CI = Confidence Interval | | | |