Prevalence, Causes and Predictors of 30-Day Readmissions Following Hospitalization for Acute Myocardial Infarction Complicated by Ventricular Arrhythmias: Insights From the 2016–2017 Nationwide Readmissions Database

Analysis for NRD June A2

Muhammad Umer Sohail

## Preamble:

* **Reference Studies:**
  + [VH Tran et al., 2024](https://pmc.ncbi.nlm.nih.gov/articles/PMC11250869/)
* **Study Objective:**
* To identify patient- and hospital-level predictors of 30-day all-cause hospital readmission among adults hospitalized with acute myocaridal infarction complicated with ventricular arrhythmias 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 AMI, identified using ICD-10-CM codes for Acute myocardial infarction (isAMI pattern, including I2101, I2102, I2109, I2111, I2119, I2121, I2129, I213, I214, I219, I21A1, I21A9, I21B, I220, I221, I222, I228, I229 )
  + Evidence of ventricular arrhythmias, derived from secondary diagnosis fields using ICD-10-CM patterns I470, I472, I4901, I4902
  + 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 AMI 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:
    - Congestive Heart failure
    - Anemia
    - Peripheral vascular disease
    - Chronic obstructive pulmonary disease
    - Diabetes mellitus
    - Hypertension
    - End stage renal disease
    - Previous stroke
    - Smoking
    - Obesity
    - Alcohol use disorder
  + Additional clinical risk factors (non-Elixhauser)
    - Family history of sudden cardiac death
    - Personal history of sudden cardiac arrest
    - Dilated cardiomyopathy
    - Atrial fibrillation
    - Previous Myocardial Infarction
  + Acute complications identified via ICD-10 code matching:
    - Acute Kidney Injury (AKI)
    - Cardiogenic Shock (CS)
  + 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): 8154
2. Readmission Rate (%): 8.71%
3. Readmission Rate (95% CI): 8.41% to 9.02%

### In-Hospital Mortality by Readmission Status:

Index hospitalizations resulted in:

1. Deaths (n): 15375
2. Death Rate (%): 16.43%
3. Death Rate (95% CI): 15.96% to 16.91%

Readmission hospitalizations resulted in:

1. Deaths (n): 485
2. Death Rate (%): 5.92%
3. Death Rate (95% CI): 5.16% to 6.68%

### LOS and Cost by Readmission Status:

Index hospitalizations resulted in:

1. Mean Length of Stay (days): 6.71
2. Mean Length of Stay (95% CI): 6.56 to 6.85
3. Mean Charge ($): 151722
4. Mean Charge (95% CI): 146479 to 156966

Readmission hospitalizations resulted in:

1. Mean Length of Stay (days): 5.11
2. Mean Length of Stay (95% CI): 4.92 to 5.3
3. Mean Charge ($): 103571
4. Mean Charge (95% CI): 16387 to 190756

## Baseline table:

| **Characteristic** | **Without Readmission** N = 85,433*1* | **With 30-day readmission** N = 8,154*1* | **p-value***2* | **Overall** N = 93,588*1* |
| --- | --- | --- | --- | --- |
| Age (years) | 65 (13) | 68 (13) | <0.001 | 65 (13) |
| Sex |  |  | <0.001 |  |
| Male | 63,013 (74%) | 5,676 (70%) |  | 68,689 (73%) |
| Female | 22,420 (26%) | 2,479 (30%) |  | 24,899 (27%) |
| Median Income Quartile |  |  | <0.001 |  |
| 0-25th percentile | 23,145 (28%) | 2,511 (31%) |  | 25,656 (28%) |
| 26th to 50th percentile | 23,135 (28%) | 2,214 (28%) |  | 25,348 (28%) |
| 51st to 75th percentile | 21,242 (25%) | 1,968 (24%) |  | 23,210 (25%) |
| 76th to 100th percentile | 16,561 (20%) | 1,344 (17%) |  | 17,905 (19%) |
| Admission day |  |  | 0.5 |  |
| Monday-Friday | 60,908 (71%) | 5,854 (72%) |  | 66,762 (71%) |
| Saturday-Sunday | 24,525 (29%) | 2,301 (28%) |  | 26,826 (29%) |
| Hospital Bed Size |  |  | 0.7 |  |
| Small | 10,060 (12%) | 977 (12%) |  | 11,037 (12%) |
| Large | 51,690 (61%) | 4,984 (61%) |  | 56,674 (61%) |
| Medium | 23,683 (28%) | 2,193 (27%) |  | 25,877 (28%) |
| Teaching Status |  |  | 0.8 |  |
| Metropolitan, non-teaching | 19,824 (23%) | 1,929 (24%) |  | 21,753 (23%) |
| Metropolitan, teaching | 61,597 (72%) | 5,847 (72%) |  | 67,444 (72%) |
| Non-metropolitan | 4,012 (4.7%) | 378 (4.6%) |  | 4,391 (4.7%) |
| Previous heart failure | 12,806 (15%) | 1,831 (22%) | <0.001 | 14,637 (16%) |
| Anemia | 20,164 (24%) | 2,655 (33%) | <0.001 | 22,820 (24%) |
| Peripheral vascular disease | 7,951 (9.3%) | 1,170 (14%) | <0.001 | 9,121 (9.7%) |
| Chronic obstructive pulmonary disease | 13,714 (16%) | 2,084 (26%) | <0.001 | 15,799 (17%) |
| Family history of sudden cardiac death | 140 (0.2%) | 17 (0.2%) | 0.4 | 157 (0.2%) |
| Personal history of sudden cardiac arrest | 1,835 (2.1%) | 132 (1.6%) | 0.021 | 1,967 (2.1%) |
| Dilated cardiomyopathy | 1,681 (2.0%) | 251 (3.1%) | <0.001 | 1,933 (2.1%) |
| Atrial fibrillation | 21,474 (25%) | 2,910 (36%) | <0.001 | 24,384 (26%) |
| Diabetes mellitus | 26,755 (31%) | 3,420 (42%) | <0.001 | 30,175 (32%) |
| Hypertension | 46,885 (55%) | 4,322 (53%) | 0.022 | 51,207 (55%) |
| Previous myocardial infarction | 13,103 (15%) | 1,557 (19%) | <0.001 | 14,660 (16%) |
| End stage renal disease | 2,932 (3.4%) | 586 (7.2%) | <0.001 | 3,518 (3.8%) |
| Previous stroke | 6,649 (7.8%) | 959 (12%) | <0.001 | 7,608 (8.1%) |
| Current or past smoking history | 20,929 (24%) | 1,789 (22%) | 0.001 | 22,718 (24%) |
| Obesity | 15,252 (18%) | 1,511 (19%) | 0.3 | 16,763 (18%) |
| Alcohol use disorder | 3,920 (4.6%) | 335 (4.1%) | 0.2 | 4,255 (4.5%) |
| Acute kidney injury | 23,825 (28%) | 2,682 (33%) | <0.001 | 26,507 (28%) |
| Cardiogenic shock | 19,924 (23%) | 1,590 (19%) | <0.001 | 21,514 (23%) |
| Length of stay category |  |  | <0.001 |  |
| ≤4 | 49,488 (58%) | 3,137 (38%) |  | 52,626 (56%) |
| >4 | 35,945 (42%) | 5,017 (62%) |  | 40,962 (44%) |
| *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) | 1.01 | 1.01, 1.01 | <0.001 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 1.13 | 1.04, 1.22 | 0.002 |
| Median Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.91 | 0.83, 1.01 | 0.066 |
| 51st to 75th percentile | 0.90 | 0.81, 1.00 | 0.041 |
| 76th to 100th percentile | 0.79 | 0.71, 0.88 | <0.001 |
| Admission day |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.02 | 0.95, 1.10 | 0.6 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 0.93 | 0.82, 1.04 | 0.2 |
| Medium | 0.93 | 0.81, 1.06 | 0.2 |
| Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.93 | 0.86, 1.01 | 0.068 |
| Non-metropolitan | 0.96 | 0.78, 1.18 | 0.7 |
| Previous heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.28 | 1.17, 1.40 | <0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.96, 1.13 | 0.3 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 1.18 | 1.06, 1.31 | 0.002 |
| Chronic obstructive pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.43 | 1.31, 1.57 | <0.001 |
| Family history of sudden cardiac death |  |  |  |
| No | — | — |  |
| Yes | 1.54 | 0.71, 3.35 | 0.3 |
| Personal history of sudden cardiac arrest |  |  |  |
| No | — | — |  |
| Yes | 0.72 | 0.56, 0.92 | 0.009 |
| Dilated cardiomyopathy |  |  |  |
| No | — | — |  |
| Yes | 1.11 | 0.90, 1.37 | 0.3 |
| Atrial fibrillation |  |  |  |
| No | — | — |  |
| Yes | 1.24 | 1.14, 1.35 | <0.001 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 1.29 | 1.20, 1.40 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.02 | 0.95, 1.10 | 0.5 |
| Previous myocardial infarction |  |  |  |
| No | — | — |  |
| Yes | 1.12 | 1.03, 1.23 | 0.009 |
| End stage renal disease |  |  |  |
| No | — | — |  |
| Yes | 1.52 | 1.29, 1.78 | <0.001 |
| Previous stroke |  |  |  |
| No | — | — |  |
| Yes | 1.23 | 1.09, 1.38 | <0.001 |
| Current or past smoking history |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.90, 1.10 | >0.9 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.96 | 0.88, 1.05 | 0.4 |
| Alcohol use disorder |  |  |  |
| No | — | — |  |
| Yes | 0.90 | 0.75, 1.07 | 0.2 |
| Acute kidney injury |  |  |  |
| No | — | — |  |
| Yes | 0.99 | 0.91, 1.07 | 0.8 |
| Cardiogenic shock |  |  |  |
| No | — | — |  |
| Yes | 0.67 | 0.61, 0.73 | <0.001 |
| Length of stay category |  |  |  |
| ≤4 | — | — |  |
| >4 | 1.94 | 1.78, 2.11 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |