Prevalence, Causes, and Predictors of 30-Day Readmissions Following Hospitalization With Acute Myocardial Infarction Complicated By Cardiogenic Shock

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Eliza Aisha

Jawad Ahmed

## Preamble:

* **Reference Studies:**
  + [Mahmoud et al., 2018](https://www.ahajournals.org/doi/10.1161/JAHA.117.008235)
* **Study Objective:**
* To identify patient- and hospital-level predictors of 30-day all-cause hospital readmission among adults patients hospitalized with acute myocardial infarction complicated by cardiogenic shock 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:
  + Patients aged ≤18 years
  + Principal diagnosis of acute myocardial infarction using ICD code I21 and secondary diagnosis of cardiogenic shock using ICD code R570
  + 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:
    - 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.
  + 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
    - Sex
    - Primary expected payer (Insurance; Medicare, Medicaid, Private, Other)
    - ZIP-based median income quartile
  + Clinical Characteristics:
    - Number of comorbidities
  + Hospital Characteristics:
    - Hospital bed size (Small, Medium, Large)
    - Urban/rural teaching status (Metropolitan, teaching vs non-teaching, etc.)
  + Disposition and Severity:
    - Discharge disposition
    - 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:

### Baseline Characteristics

| **Characteristic** | **Overall** N = 22,779*1* | **Without Readmission** N = 21,675*1* | **With 30-day readmission** N = 1,104*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) |  |  |  | 0.3 |
| 18–49 | 1,596 (7.0%) | 1,522 (7.0%) | 74 (6.7%) |  |
| 50–64 | 6,893 (30%) | 6,590 (30%) | 303 (27%) |  |
| 65–79 | 9,391 (41%) | 8,890 (41%) | 501 (45%) |  |
| 80+ | 4,899 (22%) | 4,672 (22%) | 226 (20%) |  |
| Sex |  |  |  | 0.10 |
| Male | 14,712 (65%) | 14,039 (65%) | 673 (61%) |  |
| Female | 8,067 (35%) | 7,636 (35%) | 431 (39%) |  |
| Median Income Quartile |  |  |  | 0.3 |
| 0-25th percentile | 6,549 (29%) | 6,205 (29%) | 344 (32%) |  |
| 26th to 50th percentile | 6,597 (29%) | 6,272 (29%) | 324 (30%) |  |
| 51st to 75th percentile | 5,444 (24%) | 5,218 (24%) | 226 (21%) |  |
| 76th to 100th percentile | 3,818 (17%) | 3,626 (17%) | 192 (18%) |  |
| Hospital Bed Size |  |  |  | 0.6 |
| Small | 2,285 (10%) | 2,162 (10.0%) | 123 (11%) |  |
| Large | 14,531 (64%) | 13,848 (64%) | 682 (62%) |  |
| Medium | 5,963 (26%) | 5,664 (26%) | 299 (27%) |  |
| Hospital Urbanization |  |  |  | 0.2 |
| Large metropolitan ≥1 million | 11,973 (53%) | 11,346 (52%) | 628 (57%) |  |
| Micropolitan | 1,063 (4.7%) | 1,008 (4.7%) | 55 (5.0%) |  |
| Non-urban | 80 (0.4%) | 78 (0.4%) | 2 (0.2%) |  |
| Small metropolitan <1 million | 9,662 (42%) | 9,243 (43%) | 419 (38%) |  |
| Hospital Teaching Status |  |  |  | 0.8 |
| Metropolitan, non-teaching | 4,717 (21%) | 4,479 (21%) | 238 (22%) |  |
| Metropolitan, teaching | 16,918 (74%) | 16,110 (74%) | 808 (73%) |  |
| Non-metropolitan | 1,143 (5.0%) | 1,086 (5.0%) | 57 (5.2%) |  |
| Insurance |  |  |  | 0.019 |
| Private | 4,896 (22%) | 4,694 (22%) | 202 (18%) |  |
| Medicaid | 1,963 (8.6%) | 1,868 (8.6%) | 95 (8.6%) |  |
| Medicare | 14,287 (63%) | 13,531 (63%) | 756 (68%) |  |
| Other | 1,600 (7.0%) | 1,550 (7.2%) | 50 (4.6%) |  |
| No. of comorbidities |  |  |  | <0.001 |
| One comorbidity | 2,402 (11%) | 2,349 (11%) | 53 (4.8%) |  |
| Two or more comorbidities | 20,377 (89%) | 19,326 (89%) | 1,051 (95%) |  |
| Hypertension | 10,463 (46%) | 10,015 (46%) | 448 (41%) | 0.014 |
| Diabetes | 7,335 (32%) | 6,940 (32%) | 395 (36%) | 0.10 |
| Hyperlipidemia | 12,917 (57%) | 12,251 (57%) | 666 (60%) | 0.10 |
| Chronic kidney disease | 6,788 (30%) | 6,373 (29%) | 415 (38%) | <0.001 |
| Coronary artery disease | 18,131 (80%) | 17,178 (79%) | 953 (86%) | <0.001 |
| Anemia | 9,549 (42%) | 8,993 (41%) | 556 (50%) | <0.001 |
| Heart failure | 13,759 (60%) | 12,970 (60%) | 789 (71%) | <0.001 |
| AIDS/HIV | 42 (0.2%) | 38 (0.2%) | 4 (0.4%) | 0.2 |
| Alcohol abuse | 1,022 (4.5%) | 965 (4.5%) | 57 (5.1%) | 0.4 |
| Drug abuse | 830 (3.6%) | 782 (3.6%) | 48 (4.3%) | 0.4 |
| Depression | 1,741 (7.6%) | 1,612 (7.4%) | 129 (12%) | <0.001 |
| Valvular Disease | 4,673 (21%) | 4,398 (20%) | 275 (25%) | 0.019 |
| Chronic pulmonary disease | 5,370 (24%) | 5,066 (23%) | 304 (28%) | 0.040 |
| Rheumatic Disease | 443 (1.9%) | 406 (1.9%) | 36 (3.3%) | 0.033 |
| Metastatic Cancer | 238 (1.0%) | 232 (1.1%) | 6 (0.6%) | 0.2 |
| Lymphoma | 119 (0.5%) | 112 (0.5%) | 7 (0.6%) | 0.7 |
| Obesity | 3,643 (16%) | 3,450 (16%) | 192 (17%) | 0.4 |
| Hypothyroidism | 2,586 (11%) | 2,480 (11%) | 106 (9.6%) | 0.2 |
| Fluid and electrolyte disorders | 13,024 (57%) | 12,384 (57%) | 640 (58%) | 0.7 |
| Peptic ulcer disease | 295 (1.3%) | 265 (1.2%) | 29 (2.7%) | 0.028 |
| Cerebrovascular Disease | 2,057 (9.0%) | 1,946 (9.0%) | 111 (10%) | 0.4 |
| Peripheral vascular disease | 3,950 (17%) | 3,727 (17%) | 223 (20%) | 0.073 |
| Coagulopathy | 4,648 (20%) | 4,441 (20%) | 207 (19%) | 0.3 |
| *1*n (%) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment | | | | |

### Outcomes of Index Hospitalizations

| **Characteristic** | **Overall** N = 22,779*1* | **Without Readmission** N = 21,675*1* | **With 30-day readmission** N = 1,104*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| In-Hospital Mortality | 7,789 (34%) | 7,789 (36%) | 0 (0%) | <0.001 |
| Length of Stay (days) | 7 (3, 12) | 6 (3, 12) | 10 (6, 18) | <0.001 |
| Inflation-Adjusted Total Charges ($) | 149,614 (80,930, 278,080) | 147,394 (79,607, 273,624) | 198,365 (110,143, 370,149) | <0.001 |
| Discharged to Non-Home Setting | 12,816 (56%) | 12,355 (57%) | 460 (42%) | <0.001 |
| Undergoing CABG | 4,057 (18%) | 3,792 (17%) | 265 (24%) | <0.001 |
| Undergoing PCI | 12,898 (57%) | 12,241 (56%) | 657 (59%) | 0.2 |
| Mechanical Ventilation | 10,380 (46%) | 9,966 (46%) | 414 (37%) | <0.001 |
| Venous thromboembolism | 962 (4.2%) | 915 (4.2%) | 46 (4.2%) | >0.9 |
| Stroke | 1,374 (6.0%) | 1,314 (6.1%) | 60 (5.5%) | 0.6 |
| Sepsis | 2,370 (10%) | 2,255 (10%) | 115 (10%) | >0.9 |
| AcuteKidneyInjury | 11,528 (51%) | 10,962 (51%) | 566 (51%) | 0.8 |
| *1*n (%); Median (Q1, Q3) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; Design-based KruskalWallis test | | | | |

## Readmission Hospitalization Characteristics

### Resource Utilization During Readmission

Readmission hospitalizations resulted in:

1. Median Length of Stay (IQR), days: 4 (IQR: 2–8)
2. Median Total Charges (IQR): $40,339 (IQR: $19,984–$88,325)

## Multivariable Analyses

### 30-Day Readmission:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age (years) |  |  |  |
| 18–49 | — | — |  |
| 50–64 | 0.89 | 0.60, 1.32 | 0.6 |
| 65–79 | 0.99 | 0.64, 1.53 | >0.9 |
| 80+ | 0.96 | 0.60, 1.56 | 0.9 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 1.18 | 0.96, 1.46 | 0.12 |
| Insurance |  |  |  |
| Private | — | — |  |
| Medicaid | 1.03 | 0.70, 1.51 | 0.9 |
| Medicare | 1.29 | 0.94, 1.78 | 0.12 |
| Other | 0.80 | 0.50, 1.26 | 0.3 |
| Median Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.91 | 0.70, 1.18 | 0.5 |
| 51st to 75th percentile | 0.78 | 0.60, 1.01 | 0.060 |
| 76th to 100th percentile | 0.93 | 0.71, 1.21 | 0.6 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 0.82 | 0.60, 1.13 | 0.2 |
| Medium | 0.88 | 0.63, 1.21 | 0.4 |
| Hospital Urbanization |  |  |  |
| Large metropolitan ≥1 million | — | — |  |
| Micropolitan | 0.95 | 0.58, 1.54 | 0.8 |
| Non-urban | 0.49 | 0.08, 2.87 | 0.4 |
| Small metropolitan <1 million | 0.82 | 0.66, 1.01 | 0.066 |
| Hospital Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.85 | 0.68, 1.05 | 0.14 |
| Discharged to Non-Home Setting |  |  |  |
| No | — | — |  |
| Yes | 0.47 | 0.39, 0.57 | <0.001 |
| No. of comorbidities |  |  |  |
| One comorbidity | — | — |  |
| Two or more comorbidities | 1.52 | 0.96, 2.43 | 0.075 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.81 | 0.67, 0.99 | 0.038 |
| Diabetes |  |  |  |
| No | — | — |  |
| Yes | 1.13 | 0.92, 1.40 | 0.2 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.82, 1.23 | >0.9 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 1.27 | 1.04, 1.55 | 0.018 |
| Coronary artery disease |  |  |  |
| No | — | — |  |
| Yes | 1.42 | 1.11, 1.81 | 0.005 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.25 | 1.03, 1.52 | 0.022 |
| Heart failure |  |  |  |
| No | — | — |  |
| Yes | 1.30 | 1.02, 1.66 | 0.031 |
| AIDS/HIV |  |  |  |
| No | — | — |  |
| Yes | 1.36 | 0.34, 5.44 | 0.7 |
| Alcohol abuse |  |  |  |
| No | — | — |  |
| Yes | 1.24 | 0.81, 1.91 | 0.3 |
| Drug abuse |  |  |  |
| No | — | — |  |
| Yes | 1.16 | 0.74, 1.84 | 0.5 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 1.34 | 0.98, 1.83 | 0.064 |
| Valvular Disease |  |  |  |
| No | — | — |  |
| Yes | 1.07 | 0.85, 1.34 | 0.6 |
| Chronic pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.07 | 0.85, 1.33 | 0.6 |
| Rheumatic Disease |  |  |  |
| No | — | — |  |
| Yes | 1.60 | 0.91, 2.80 | 0.10 |
| Metastatic Cancer |  |  |  |
| No | — | — |  |
| Yes | 0.55 | 0.20, 1.50 | 0.2 |
| Lymphoma |  |  |  |
| No | — | — |  |
| Yes | 1.17 | 0.33, 4.18 | 0.8 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 1.06 | 0.82, 1.36 | 0.7 |
| Hypothyroidism |  |  |  |
| No | — | — |  |
| Yes | 0.75 | 0.56, 1.00 | 0.050 |
| Fluid and electrolyte disorders |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.83, 1.22 | >0.9 |
| Peptic ulcer disease |  |  |  |
| No | — | — |  |
| Yes | 2.16 | 1.02, 4.56 | 0.044 |
| Cerebrovascular Disease |  |  |  |
| No | — | — |  |
| Yes | 1.14 | 0.84, 1.54 | 0.4 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 1.09 | 0.87, 1.35 | 0.5 |
| Coagulopathy |  |  |  |
| No | — | — |  |
| Yes | 0.79 | 0.62, 1.01 | 0.061 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |