Heart Failure Readmissions in Patients With Iron Deficiency Anemia: Insights From the 2016–2017 Nationwide Readmissions Database

Analysis for NRD June A7

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## Preamble:

* **Reference Studies:**
  + [Alharbi et al., 2024](https://pubmed.ncbi.nlm.nih.gov/38563807/)
  + [Khan et al., 2021](https://www.ahajournals.org/doi/10.1161/CIRCHEARTFAILURE.121.008335)
* **Study Objective:**
* To identify patient- and hospital-level predictors of 30-day all-cause hospital readmission among adults hospitalized with heart failure and iron deficiency anemia 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 Heart failure (HF), identified using ICD-10-CM codes for HF (isHF pattern, including I501, I5021, I5023, I5031, I5033, I5041, I5043 )
  + Evidence of Iron deficiency anemia (IDA), derived from secondary diagnosis fields using ICD-10-CM patterns D500, D501, D508, D509
  + 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 HF 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:
    - Peripheral vascular disease
    - Chronic pulmonary disease
    - Diabetes mellitus
    - Hypertension
    - Renal failure
    - Obesity
    - Alcohol abuse
  + Additional clinical risk factors (non-Elixhauser)
    - Smoking
    - HIV
    - Previous Myocardial Infarction
    - Atrial fibrillation
    - Hyperlipidemia
    - Previous stroke
  + 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): 11990
2. Readmission Rate (%): 20.25%
3. Readmission Rate (95% CI): 19.71% to 20.8%

### In-Hospital Mortality by Readmission Status:

Index hospitalizations resulted in:

1. Deaths (n): 1564
2. Death Rate (%): 2.64%
3. Death Rate (95% CI): 2.42% to 2.87%

Readmission hospitalizations resulted in:

1. Deaths (n): 772
2. Death Rate (%): 6.46%
3. Death Rate (95% CI): 5.75% to 7.18%

### LOS and Cost by Readmission Status:

Index hospitalizations resulted in:

1. Mean Length of Stay (days): 6.54
2. Mean Length of Stay (95% CI): 6.41 to 6.67
3. Mean Charge ($): 57435
4. Mean Charge (95% CI): 54975 to 59894

Readmission hospitalizations resulted in:

1. Mean Length of Stay (days): 6.38
2. Mean Length of Stay (95% CI): 6.19 to 6.58
3. Mean Charge ($): 62899
4. Mean Charge (95% CI): 58434 to 67365

## Baseline table:

| **Characteristic** | **Without Readmission** N = 47,213*1* | **With 30-day readmission** N = 11,991*1* | **p-value***2* | **Overall** N = 59,204*1* |
| --- | --- | --- | --- | --- |
| Age (years) | 72 (15) | 70 (15) | <0.001 | 72 (15) |
| Sex |  |  | 0.005 |  |
| Male | 20,824 (44%) | 5,563 (46%) |  | 26,387 (45%) |
| Female | 26,389 (56%) | 6,428 (54%) |  | 32,817 (55%) |
| Median Income Quartile |  |  | <0.001 |  |
| 0-25th percentile | 15,088 (32%) | 4,156 (35%) |  | 19,244 (33%) |
| 26th to 50th percentile | 12,296 (26%) | 3,217 (27%) |  | 15,513 (27%) |
| 51st to 75th percentile | 11,077 (24%) | 2,652 (22%) |  | 13,729 (24%) |
| 76th to 100th percentile | 8,106 (17%) | 1,810 (15%) |  | 9,916 (17%) |
| Admission day |  |  | 0.3 |  |
| Monday-Friday | 36,170 (77%) | 9,100 (76%) |  | 45,269 (76%) |
| Saturday-Sunday | 11,044 (23%) | 2,891 (24%) |  | 13,935 (24%) |
| Hospital Bed Size |  |  | 0.057 |  |
| Small | 8,413 (18%) | 1,972 (16%) |  | 10,385 (18%) |
| Large | 26,088 (55%) | 6,850 (57%) |  | 32,938 (56%) |
| Medium | 12,712 (27%) | 3,169 (26%) |  | 15,881 (27%) |
| Teaching Status |  |  | 0.7 |  |
| Metropolitan, non-teaching | 11,743 (25%) | 3,054 (25%) |  | 14,796 (25%) |
| Metropolitan, teaching | 30,874 (65%) | 7,790 (65%) |  | 38,664 (65%) |
| Non-metropolitan | 4,596 (9.7%) | 1,147 (9.6%) |  | 5,743 (9.7%) |
| Non-home discharge | 12,329 (26%) | 3,025 (25%) | 0.2 | 15,354 (26%) |
| Diabetes mellitus | 22,904 (49%) | 6,318 (53%) | <0.001 | 29,222 (49%) |
| Smoking | 4,814 (10%) | 1,416 (12%) | 0.001 | 6,230 (11%) |
| Peripheral vascular disease | 10,084 (21%) | 2,989 (25%) | <0.001 | 13,073 (22%) |
| Hypertension | 16,224 (34%) | 3,441 (29%) | <0.001 | 19,664 (33%) |
| Hyperlipidemia | 24,576 (52%) | 6,308 (53%) | 0.5 | 30,884 (52%) |
| Prior stroke or Transient ischemic attack | 6,027 (13%) | 1,672 (14%) | 0.040 | 7,699 (13%) |
| Chronic kidney disease | 24,398 (52%) | 7,041 (59%) | <0.001 | 31,439 (53%) |
| End-stage renal disease | 1,614 (3.4%) | 542 (4.5%) | <0.001 | 2,156 (3.6%) |
| Alcohol abuse | 1,529 (3.2%) | 424 (3.5%) | 0.3 | 1,954 (3.3%) |
| HIV infection | 120 (0.3%) | 60 (0.5%) | <0.001 | 181 (0.3%) |
| Previous myocardial infarction | 7,106 (15%) | 1,989 (17%) | 0.010 | 9,094 (15%) |
| Atrial fibrillation | 22,427 (48%) | 5,838 (49%) | 0.2 | 28,264 (48%) |
| Obesity | 12,163 (26%) | 2,958 (25%) | 0.11 | 15,120 (26%) |
| Chronic pulmonary disease | 19,696 (42%) | 5,601 (47%) | <0.001 | 25,296 (43%) |
| Liver disease | 2,984 (6.3%) | 842 (7.0%) | 0.065 | 3,826 (6.5%) |
| Cardiogenic shock | 1,238 (2.6%) | 263 (2.2%) | 0.13 | 1,502 (2.5%) |
| Acute kidney injury | 16,621 (35%) | 4,706 (39%) | <0.001 | 21,327 (36%) |
| Length of stay category |  |  | 0.001 |  |
| ≤4 | 22,326 (47%) | 5,365 (45%) |  | 27,691 (47%) |
| >4 | 24,887 (53%) | 6,626 (55%) |  | 31,513 (53%) |
| *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 | 0.99, 0.99 | <0.001 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 0.98 | 0.92, 1.05 | 0.6 |
| Median Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.98 | 0.91, 1.07 | 0.7 |
| 51st to 75th percentile | 0.91 | 0.83, 1.00 | 0.044 |
| 76th to 100th percentile | 0.87 | 0.78, 0.95 | 0.004 |
| Admission day |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.03 | 0.95, 1.11 | 0.5 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 1.08 | 0.97, 1.20 | 0.2 |
| Medium | 1.05 | 0.94, 1.18 | 0.3 |
| Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.94 | 0.87, 1.01 | 0.094 |
| Non-metropolitan | 0.92 | 0.82, 1.03 | 0.2 |
| Non-home discharge |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.93, 1.08 | >0.9 |
| Diabetes mellitus |  |  |  |
| No | — | — |  |
| Yes | 1.13 | 1.06, 1.21 | <0.001 |
| Smoking |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.93, 1.16 | 0.5 |
| Peripheral vascular disease |  |  |  |
| No | — | — |  |
| Yes | 1.15 | 1.06, 1.24 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.93 | 0.84, 1.02 | 0.12 |
| Hyperlipidemia |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.94, 1.09 | 0.7 |
| Prior stroke or Transient ischemic attack |  |  |  |
| No | — | — |  |
| Yes | 1.09 | 0.99, 1.21 | 0.094 |
| Chronic kidney disease |  |  |  |
| No | — | — |  |
| Yes | 1.23 | 1.12, 1.36 | <0.001 |
| End-stage renal disease |  |  |  |
| No | — | — |  |
| Yes | 1.11 | 0.96, 1.28 | 0.2 |
| Alcohol abuse |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.88, 1.24 | 0.7 |
| HIV infection |  |  |  |
| No | — | — |  |
| Yes | 1.79 | 1.18, 2.72 | 0.006 |
| Previous myocardial infarction |  |  |  |
| No | — | — |  |
| Yes | 1.07 | 0.98, 1.17 | 0.14 |
| Atrial fibrillation |  |  |  |
| No | — | — |  |
| Yes | 1.15 | 1.07, 1.24 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.82 | 0.76, 0.89 | <0.001 |
| Chronic pulmonary disease |  |  |  |
| No | — | — |  |
| Yes | 1.23 | 1.15, 1.31 | <0.001 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.92, 1.17 | 0.6 |
| Cardiogenic shock |  |  |  |
| No | — | — |  |
| Yes | 0.70 | 0.55, 0.89 | 0.003 |
| Acute kidney injury |  |  |  |
| No | — | — |  |
| Yes | 1.07 | 1.00, 1.15 | 0.065 |
| Length of stay category |  |  |  |
| ≤4 | — | — |  |
| >4 | 1.05 | 0.99, 1.12 | 0.12 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |