30-Day All-Cause Readmissions After Coronary Revascularization in Patients With Inflammatory Bowel Disease

RCOP NRD A10

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## Preamble:

* **Reference Studies:**
  + [Zahid et al., 2023](https://doi.org/10.1016/j.cjco.2023.04.007)
  + [Yeo et al., 2019](https://doi.org/10.1001/jamanetworkopen.2019.12208)
* **Study Objective:**
* To evaluate the risk of 30-day all-cause hospital readmission in patients with inflammatory bowel disease (IBD) who underwent coronary revascularization, comparing percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG). The study also characterizes index hospitalization outcomes and readmission stay features. A secondary objective is to identify risk factors associated with 30-day readmission in this high-risk population using a Cox proportional hazards model.
* **Data Source:**
* This retrospective cohort study used data from the 2016–2017 Nationwide Readmissions Database (NRD), developed by the Healthcare Cost and Utilization Project (HCUP). The NRD is a nationally representative, all-payer database of U.S. hospitalizations that allows linkage of patients across hospital stays within a calendar year. Survey weights, stratification, and clustering variables support complex sampling design for national estimates.
* **Cohort Definition:**
* Index admissions were selected based on the following inclusion criteria:
  + Adults aged ≥18 years
  + Diagnosis of IBD, including Crohn’s disease or Ulcerative colitis, identified via ICD-10-CM codes in any diagnosis field
  + Underwent coronary revascularization, defined as:
    - PCI: e.g., 0270346, 0270356 (ICD-10-PCS codes)
    - CABG: e.g., 02100A9, 02100J8 (ICD-10-PCS codes)
  + 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
* Readmissions were defined as:
  + Any non-trauma hospitalization within 30 days of discharge
* **Outcomes of Interest:**
  + Primary Outcome:
    - 30-day all-cause readmission (Yes/No), flagged using NRD linkage variables
  + Secondary Outcomes (index admission):
    - In-hospital mortality (DIED)
    - Length of stay (LOS, continuous in days and also categorized as ≤4 vs >4 days)
    - Total hospitalization charges (TOTCHG), inflation-adjusted to 2017 USD
    - Non-home discharge
  + Outcomes during readmission:
    - In-hospital mortality
    - Length of stay (LOS, in days)
    - Total hospitalization charges (inflation-adjusted to 2017 USD)
* **Outcome Definitions:**
  + Readmission:
    - Defined using HCUP NRD’s methodology. Readmissions were identified only among patients with qualifying index events.
    - Trauma-related hospitalizations were excluded only from the readmission pool to avoid unrelated admissions.
  + Mortality:
    - In-hospital death recorded during index or readmission (DIED = 1)
  + 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
  + Non-Home Discharge:
    - Defined as any disposition other than home/self-care, specifically:
      * Transfer to another short-term hospital
      * Transfer to skilled nursing facility (SNF), intermediate, or other facility
      * Left against medical advice
      * Died in hospital
      * Alive, destination unknown
* **Covariates and Variable Construction:**
  + Demographic & Socioeconomic Factors:
    - Age (continuous)
    - Sex (FEMALE; ref = Male)
    - Primary expected payer (Insurance; Medicare, Medicaid, Private, Other)
    - ZIP-based median income quartile (ZIPINC\_QRTL)
    - Weekend admission (AWEEKEND)
  + Clinical Comorbidities:
    - Elixhauser comorbidity variables:
      * Diabetes
      * Chronic pulmonary disease
      * Renal failure
      * Hypertension
      * Depression
      * Congestive heart failure
      * Coagulopathy
    - Additional Conditions:
      * History of myocardial infarction — identified using ICD-10-CM codes from secondary diagnoses
    - IBD Type:
      * Crohn’s disease vs ulcerative colitis, based on ICD-10-CM patterns
  + 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 accounted for NRD’s complex survey design using weights (DISCWT), strata (NRD\_STRATUM), and clustering (HOSP\_NRD). Survey-adjusted methods were implemented via survey and srvyr packages.
  + Descriptive Analyses:
    - Baseline characteristics were summarized by procedure type (PCI vs CABG) among index admissions.
    - P-values from design-based statistical tests (Rao–Scott adjusted chi-square for categorical variables; design-based Kruskal–Wallis test for continuous variables).
  + Multivariable Analysis:
    - A survey-weighted Cox proportional hazards model estimated the hazard of 30-day readmission
    - Model covariates included demographics, comorbidities, procedure type, and hospital factors.
    - Hazard ratios (HRs) with 95% confidence intervals (CIs) were reported
  + Readmission Characteristics:
    - A sub-analysis among patients with 30-day readmissions summarized readmission hospitalization characteristics descriptively using weighted survey statistics.
* **Software:** All analyses were conducted in R Statistical Language (Version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria).

## Descriptive Analyses:

### Baseline Characteristics

| **Characteristic** | **Overall** N = 5,037*1* | **PCI** N = 3,953*1* | **CABG** N = 1,084*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) | 66 (12) | 65 (12) | 66 (10) | 0.033 |
| Sex |  |  |  | 0.036 |
| Male | 3,328 (66%) | 2,564 (65%) | 764 (70%) |  |
| Female | 1,710 (34%) | 1,389 (35%) | 320 (30%) |  |
| Primary Expected Payer |  |  |  | 0.007 |
| Private | 1,484 (29%) | 1,226 (31%) | 258 (24%) |  |
| Medicaid | 310 (6.2%) | 253 (6.4%) | 57 (5.2%) |  |
| Medicare | 2,979 (59%) | 2,267 (57%) | 711 (66%) |  |
| Other | 260 (5.2%) | 203 (5.1%) | 57 (5.3%) |  |
| Median Household Income Quartile |  |  |  | 0.4 |
| 0-25th percentile | 1,130 (23%) | 858 (22%) | 272 (25%) |  |
| 26th to 50th percentile | 1,452 (29%) | 1,137 (29%) | 315 (29%) |  |
| 51st to 75th percentile | 1,311 (26%) | 1,055 (27%) | 256 (24%) |  |
| 76th to 100th percentile | 1,069 (22%) | 834 (21%) | 235 (22%) |  |
| Admission Day |  |  |  | 0.003 |
| Monday-Friday | 3,811 (76%) | 2,932 (74%) | 878 (81%) |  |
| Saturday-Sunday | 1,226 (24%) | 1,021 (26%) | 206 (19%) |  |
| Hospital Bed Size |  |  |  | 0.017 |
| Small | 513 (10%) | 439 (11%) | 74 (6.8%) |  |
| Large | 3,098 (62%) | 2,374 (60%) | 724 (67%) |  |
| Medium | 1,426 (28%) | 1,140 (29%) | 286 (26%) |  |
| Hospital Location and Teaching Status |  |  |  | 0.002 |
| Metropolitan, non-teaching | 1,085 (22%) | 908 (23%) | 177 (16%) |  |
| Metropolitan, teaching | 3,760 (75%) | 2,881 (73%) | 879 (81%) |  |
| Non-metropolitan | 192 (3.8%) | 164 (4.1%) | 28 (2.6%) |  |
| Inflammatory Bowel Disease Subtype |  |  |  | 0.002 |
| Crohn’s disease | 2,642 (52%) | 2,148 (54%) | 495 (46%) |  |
| Ulcerative colitis | 2,395 (48%) | 1,805 (46%) | 589 (54%) |  |
| Diabetes | 1,771 (35%) | 1,289 (33%) | 482 (44%) | <0.001 |
| Hypertension | 3,963 (79%) | 3,043 (77%) | 919 (85%) | <0.001 |
| Renal Failure | 1,070 (21%) | 785 (20%) | 285 (26%) | 0.002 |
| Congestive Heart Failure | 1,826 (36%) | 1,391 (35%) | 434 (40%) | 0.061 |
| Chronic Pulmonary Disease | 1,168 (23%) | 873 (22%) | 295 (27%) | 0.015 |
| Depression | 678 (13%) | 494 (12%) | 184 (17%) | 0.014 |
| Coagulopathy | 424 (8.4%) | 201 (5.1%) | 223 (21%) | <0.001 |
| History of Myocardial Infarction | 1,012 (20%) | 795 (20%) | 217 (20%) | >0.9 |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

### Outcomes of Index Hospitalization

| **Characteristic** | **Overall** N = 5,037*1* | **PCI** N = 3,953*1* | **CABG** N = 1,084*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| 30-Day Readmission | 583 (12%) | 474 (12%) | 109 (10%) | 0.3 |
| In-Hospital Mortality | 166 (3.3%) | 123 (3.1%) | 43 (3.9%) | 0.4 |
| Length of Stay (days) | 7 (10) | 5 (6) | 14 (15) | <0.001 |
| Inflation-Adjusted Total Charges ($) | 149,021 (181,515) | 113,618 (119,839) | 278,540 (282,295) | <0.001 |
| Discharged to Non-Home Setting | 736 (15%) | 425 (11%) | 311 (29%) | <0.001 |
| *1*n (%); Mean (SD) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; Design-based KruskalWallis test | | | | |

## Multivariable Analyses

### Risk Factors for 30-Day Readmission

Stratified 1 - level Cluster Sampling design (with replacement)  
With (261) clusters.  
subset(nrd\_design, IndexEvent == 1)  
Sampling variables:  
 - ids: HOSP\_NRD   
 - strata: NRD\_STRATUM   
 - weights: DISCWT

| **Characteristic** | **HR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Procedure Type |  |  |  |
| PCI | — | — |  |
| CABG | 1.17 | 0.81, 1.68 | 0.4 |
| Age (years) | 1.00 | 0.99, 1.02 | 0.6 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 0.64 | 0.47, 0.86 | 0.003 |
| Primary Expected Payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.84 | 0.52, 1.37 | 0.5 |
| Medicare | 1.14 | 0.78, 1.67 | 0.5 |
| Other | 0.93 | 0.57, 1.50 | 0.8 |
| Median Household Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.84 | 0.61, 1.16 | 0.3 |
| 51st to 75th percentile | 1.18 | 0.85, 1.62 | 0.3 |
| 76th to 100th percentile | 1.29 | 0.86, 1.92 | 0.2 |
| Admission Day |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.73 | 1.24, 2.42 | 0.001 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 1.32 | 0.89, 1.96 | 0.2 |
| Medium | 1.76 | 1.16, 2.67 | 0.007 |
| Hospital Location and Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.93 | 0.68, 1.26 | 0.6 |
| Non-metropolitan | 1.81 | 0.92, 3.60 | 0.088 |
| Inflammatory Bowel Disease Subtype |  |  |  |
| Crohn’s disease | — | — |  |
| Ulcerative colitis | 1.32 | 1.01, 1.72 | 0.043 |
| Diabetes |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.76, 1.33 | >0.9 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.99 | 0.71, 1.38 | >0.9 |
| Renal Failure |  |  |  |
| No | — | — |  |
| Yes | 0.82 | 0.60, 1.12 | 0.2 |
| Congestive Heart Failure |  |  |  |
| No | — | — |  |
| Yes | 0.96 | 0.74, 1.25 | 0.8 |
| Chronic Pulmonary Disease |  |  |  |
| No | — | — |  |
| Yes | 0.70 | 0.53, 0.92 | 0.012 |
| Depression |  |  |  |
| No | — | — |  |
| Yes | 0.90 | 0.63, 1.27 | 0.5 |
| Coagulopathy |  |  |  |
| No | — | — |  |
| Yes | 0.97 | 0.68, 1.37 | 0.9 |
| History of Myocardial Infarction |  |  |  |
| No | — | — |  |
| Yes | 1.18 | 0.90, 1.55 | 0.2 |
| Discharged to Non-Home Setting |  |  |  |
| No | — | — |  |
| Yes | 0.79 | 0.57, 1.10 | 0.2 |
| Length of Stay (days) | 1.00 | 0.97, 1.02 | 0.9 |
| Abbreviations: CI = Confidence Interval, HR = Hazard Ratio | | | |

## Readmission Hospitalization Characteristics

### In-Hospital Mortality Among Readmitted Patients

Readmission hospitalizations resulted in:

1. Deaths (n): 17
2. Death Rate (%): 2.94%
3. Death Rate (95% CI): 1.19% to 4.7%

### Resource Utilization During Readmission

Readmission hospitalizations resulted in:

1. Mean Length of Stay (days): 4.84
2. Mean Length of Stay (95% CI): 4.21 to 5.47
3. Mean Charge ($): 56127
4. Mean Charge (95% CI): 47073 to 65181