Nationwide Analysis of 30-Day Readmission After Bariatric Surgery in Patients With Ischemic Heart Disease, Heart Failure, or Cardiomyopathy

RCOP NRD A25

Muhammad Saad

Shurjeel Uddin Qazi

## Preamble:

* **Reference Studies:**
  + [Rios-Diaz et al., 2019](https://doi.org/10.1016/j.surg.2019.06.003)
  + [Yeo et al., 2019](https://doi.org/10.1001/jamanetworkopen.2019.12208)
* **Study Objective:**
* To assess predictors of 30-day readmission following bariatric surgery in adults with ischemic heart disease, heart failure, or cardiomyopathy, using a nationally representative cohort from the Nationwide Readmissions Database (NRD). Specific objectives include:
  + Estimating the national 30-day readmission rate after bariatric procedures in this high-risk cardiovascular population.
  + Evaluating in-hospital complications and healthcare utilization during index and readmission hospitalizations.
  + Identifying independent predictors of 30-day readmission using survey-adjusted time-to-event modeling.
* **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 hospitalizations were defined using the following criteria:
  + Adults aged ≥18 years
  + Underwent one of the following bariatric procedures, identified using ICD-10-PCS codes:
    - Roux-en-Y Gastric Bypass
    - Sleeve Gastrectomy
    - Gastric Banding
  + Diagnosed with ischemic heart disease, heart failure, or cardiomyopathy, defined as presence of at least one of the following:
    - Unstable Angina
    - Myocardial Infarction
    - Heart Failure
    - Cardiomyopathy
    - Chronic Ischemic Heart Disease
  + 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:
    - All-cause 30-day readmission (Yes/No), flagged using NRD linkage variables
  + Secondary Outcomes (index admission):
    - In-hospital mortality (DIED)
    - Length of stay (LOS, in days)
    - Total hospitalization charges (TOTCHG), inflation-adjusted to 2017 USD
    - Non-home discharge
    - Surgical Complications
    - Medical Complications
  + Readmission Characteristics:
    - In-hospital mortality
    - Length of stay (LOS, in days)
    - Total hospitalization charges (inflation-adjusted to 2017 USD)
    - Time to readmission (in days)
    - Top causes of readmission
* **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
  + Surgical Complications:
* - Postoperative Bleeding  
    
  - Postoperative Infection  
    
  - Postoperative Ileus
  + Medical Complications:
* - Venous Thromboembolism (VTE)  
    
  - Sepsis  
    
  - Acute Kidney Injury (AKI)  
    
  - Acute Respiratory Failure
* **Covariates and Variable Construction:**
  + Demographic & Socioeconomic Factors:
    - Age (continuous)
    - Sex (FEMALE; ref = Male)
    - Primary expected payer (Insurance; Medicare, Medicaid, Private, Other)
    - Income quartile based on ZIP code (ZIPINC\_QRTL)
    - Weekend vs weekday admission (AWEEKEND)
    - Elective vs non-elective admission (ELECTIVE)
  + Clinical Variables:
    - Elixhauser Comorbidity Index (elixsum), modeled as a continuous variable
    - Comorbidities:
      * Diabetes Mellitus
      * Renal Failure
      * Chronic Pulmonary Disease
      * Liver Disease
      * Hypertension
      * Depression
      * Atrial Fibrillation
  + 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
* **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 30-day readmission status (“With” vs “Without readmission”).
    - Survey-weighted means and proportions were reported.
    - P-values from design-based statistical tests (Rao–Scott adjusted chi-square for categorical variables; design-based Kruskal–Wallis test for continuous variables).
  + Multivariable Modeling:
    - A survey-weighted Cox proportional hazards model was used to identify predictors of 30-day readmission.
    - The model included demographic, clinical, hospital-level, and index-stay factors.
    - Hazard ratios (HRs) with 95% confidence intervals (CIs) were reported
  + Readmission Characteristics:
  + Among readmitted patients, the following were summarized using survey-weighted statistics:
    - Time to readmission
    - In-hospital mortality during readmission
    - Length of stay and total charges during the readmission
    - Top principal diagnoses at readmission (I10\_DX1)
* **Software:** All analyses were conducted in R Statistical Language (Version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria).

## Baseline Characteristics

| **Characteristic** | **Overall** N = 34,341*1* | **Without Readmission** N = 31,153*1* | **With 30-day readmission** N = 3,187*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) | 63 (13) | 62 (13) | 66 (13) | <0.001 |
| Sex |  |  |  | 0.3 |
| Male | 17,276 (50%) | 15,631 (50%) | 1,645 (52%) |  |
| Female | 17,065 (50%) | 15,522 (50%) | 1,543 (48%) |  |
| Primary Expected Payer |  |  |  | <0.001 |
| Private | 9,291 (27%) | 8,673 (28%) | 619 (19%) |  |
| Medicaid | 3,370 (9.8%) | 3,084 (9.9%) | 286 (9.0%) |  |
| Medicare | 20,278 (59%) | 18,077 (58%) | 2,202 (69%) |  |
| Other | 1,369 (4.0%) | 1,290 (4.1%) | 79 (2.5%) |  |
| Median Household Income Quartile |  |  |  | 0.4 |
| 0-25th percentile | 9,813 (29%) | 8,847 (29%) | 966 (31%) |  |
| 26th to 50th percentile | 9,370 (28%) | 8,517 (28%) | 853 (27%) |  |
| 51st to 75th percentile | 8,433 (25%) | 7,696 (25%) | 737 (23%) |  |
| 76th to 100th percentile | 6,266 (18%) | 5,682 (18%) | 584 (19%) |  |
| Admission Day |  |  |  | <0.001 |
| Monday-Friday | 31,957 (93%) | 29,117 (93%) | 2,840 (89%) |  |
| Saturday-Sunday | 2,384 (6.9%) | 2,036 (6.5%) | 347 (11%) |  |
| Admission Type |  |  |  | <0.001 |
| Elective | 23,376 (69%) | 21,777 (70%) | 1,599 (51%) |  |
| Non-elective | 10,715 (31%) | 9,149 (30%) | 1,566 (49%) |  |
| Hospital Bed Size |  |  |  | 0.4 |
| Small | 4,331 (13%) | 3,961 (13%) | 371 (12%) |  |
| Large | 20,549 (60%) | 18,577 (60%) | 1,973 (62%) |  |
| Medium | 9,460 (28%) | 8,616 (28%) | 844 (26%) |  |
| Hospital Location/Teaching Status |  |  |  | 0.2 |
| Metropolitan, non-teaching | 7,404 (22%) | 6,768 (22%) | 636 (20%) |  |
| Metropolitan, teaching | 25,622 (75%) | 23,210 (75%) | 2,413 (76%) |  |
| Non-metropolitan | 1,314 (3.8%) | 1,176 (3.8%) | 139 (4.3%) |  |
| Type of Bariatric Surgery |  |  |  | <0.001 |
| Gastric Banding | 172 (0.5%) | 157 (0.5%) | 16 (0.5%) |  |
| Roux-en-Y Gastric Bypass | 11,671 (34%) | 10,409 (33%) | 1,263 (40%) |  |
| Sleeve Gastrectomy | 22,497 (66%) | 20,588 (66%) | 1,909 (60%) |  |
| Diabetes Mellitus | 17,070 (50%) | 15,492 (50%) | 1,578 (50%) | 0.9 |
| Renal Failure | 7,109 (21%) | 6,177 (20%) | 932 (29%) | <0.001 |
| Chronic Pulmonary Disease | 10,036 (29%) | 9,031 (29%) | 1,005 (32%) | 0.049 |
| Liver Disease | 4,183 (12%) | 3,798 (12%) | 386 (12%) | >0.9 |
| Hypertension | 29,223 (85%) | 26,538 (85%) | 2,685 (84%) | 0.3 |
| Depression | 6,634 (19%) | 6,087 (20%) | 547 (17%) | 0.046 |
| Atrial Fibrillation | 7,567 (22%) | 6,622 (21%) | 945 (30%) | <0.001 |
| Unstable Angina | 350 (1.0%) | 315 (1.0%) | 35 (1.1%) | 0.8 |
| Myocardial Infarction | 1,064 (3.1%) | 937 (3.0%) | 127 (4.0%) | 0.035 |
| Heart Failure | 13,200 (38%) | 11,782 (38%) | 1,418 (44%) | <0.001 |
| Cardiomyopathy | 3,842 (11%) | 3,512 (11%) | 330 (10%) | 0.3 |
| Chronic Ischemic Heart Disease | 24,282 (71%) | 22,080 (71%) | 2,202 (69%) | 0.2 |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

## Unadjusted Outcomes

### Outcomes of Index Hospitalizations

| **Characteristic** | **Overall** N = 34,341*1* | **Without Readmission** N = 31,153*1* | **With 30-day readmission** N = 3,187*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Length of Stay (days) | 3 (2, 9) | 3 (2, 8) | 7 (3, 15) | <0.001 |
| Inflation-Adjusted Total Charges ($) | 61,841 (39,163, 120,213) | 60,189 (38,720, 115,258) | 85,608 (46,608, 174,501) | <0.001 |
| Discharged to Non-Home Setting | 5,663 (16%) | 4,879 (16%) | 784 (25%) | <0.001 |
| Any Surgical Complication | 1,487 (4.3%) | 1,316 (4.2%) | 171 (5.4%) | 0.045 |
| Any Medical Complication | 7,791 (23%) | 6,683 (21%) | 1,108 (35%) | <0.001 |
| Venous Thromboembolism | 1,019 (3.0%) | 843 (2.7%) | 176 (5.5%) | <0.001 |
| Sepsis | 2,769 (8.1%) | 2,418 (7.8%) | 351 (11%) | <0.001 |
| Postoperative Bleeding | 569 (1.7%) | 494 (1.6%) | 74 (2.3%) | 0.034 |
| Acute Kidney Injury | 5,313 (15%) | 4,569 (15%) | 744 (23%) | <0.001 |
| Postoperative Infection | 604 (1.8%) | 545 (1.7%) | 59 (1.9%) | 0.7 |
| Postoperative Ileus | 438 (1.3%) | 382 (1.2%) | 56 (1.8%) | 0.086 |
| Acute Respiratory Failure | 3,553 (10%) | 3,119 (10%) | 434 (14%) | <0.001 |
| *1*Median (Q1, Q3); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

### 30-Day Readmission Timing

The median time to 30-day readmission following index hospitalization was 10 days (IQR: 4–18).

### In-Hospital Mortality by Readmission Status:

Index hospitalizations resulted in:

1. Deaths (n): 1305
2. Death Rate (%): 3.8%
3. Death Rate (95% CI): 3.44% to 4.16%

Readmission hospitalizations resulted in:

1. Deaths (n): 135
2. Death Rate (%): 4.27%
3. Death Rate (95% CI): 3.3% to 5.25%

### Resource Utilization for Readmission (LOS, Cost)

Readmission hospitalizations resulted in:

1. Median Length of Stay (IQR), days: 4 (IQR: 2–7)
2. Median Total Charges (IQR): $34,422 (IQR: $18,164–$67,880)

## Multivariable Analyses

### Multivariable Predictors of 30-Day Readmission

Stratified 1 - level Cluster Sampling design (with replacement)  
With (925) clusters.  
subset(nrd\_design, IndexEvent == 1)  
Sampling variables:  
 - ids: HOSP\_NRD   
 - strata: NRD\_STRATUM   
 - weights: DISCWT

| **Characteristic** | **HR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Age (years) | 1.00 | 0.99, 1.00 | 0.5 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 1.02 | 0.92, 1.13 | 0.7 |
| Primary Expected Payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.11 | 0.92, 1.35 | 0.3 |
| Medicare | 0.96 | 0.82, 1.12 | 0.6 |
| Other | 1.19 | 0.79, 1.78 | 0.4 |
| Median Household Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 1.00 | 0.87, 1.15 | >0.9 |
| 51st to 75th percentile | 1.06 | 0.92, 1.23 | 0.4 |
| 76th to 100th percentile | 1.23 | 1.06, 1.43 | 0.005 |
| Admission Type |  |  |  |
| Elective | — | — |  |
| Non-elective | 0.97 | 0.86, 1.10 | 0.6 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 0.87 | 0.73, 1.04 | 0.12 |
| Medium | 0.94 | 0.77, 1.14 | 0.5 |
| Hospital Location/Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 1.04 | 0.92, 1.18 | 0.5 |
| Non-metropolitan | 1.24 | 0.96, 1.62 | 0.10 |
| Type of Bariatric Surgery |  |  |  |
| Gastric Banding | — | — |  |
| Roux-en-Y Gastric Bypass | 0.98 | 0.65, 1.47 | >0.9 |
| Sleeve Gastrectomy | 0.93 | 0.62, 1.39 | 0.7 |
| Any Surgical Complication |  |  |  |
| No | — | — |  |
| Yes | 1.21 | 0.97, 1.51 | 0.089 |
| Any Medical Complication |  |  |  |
| No | — | — |  |
| Yes | 0.99 | 0.86, 1.13 | 0.9 |
| Discharged to Non-Home Setting |  |  |  |
| No | — | — |  |
| Yes | 0.95 | 0.81, 1.11 | 0.5 |
| Elixhauser Comorbidity Index | 0.99 | 0.97, 1.02 | 0.7 |
| Length of Stay (days) | 1.00 | 1.00, 1.01 | 0.4 |
| Abbreviations: CI = Confidence Interval, HR = Hazard Ratio | | | |

## Top Causes of Readmission

Diagnosis Percentage  
I10\_DX1A419 A419 8.056903  
I10\_DX1N179 N179 3.947400  
I10\_DX1E860 E860 3.143455  
I10\_DX1K922 K922 2.463721  
I10\_DX1K9589 K9589 2.374195  
I10\_DX1J189 J189 2.226116  
I10\_DX1K9189 K9189 1.764553  
I10\_DX1K91840 K91840 1.569715  
I10\_DX1K921 K921 1.442831  
I10\_DX1I130 I130 1.407328